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Acknowledgements

People often ask me when I first knew I wanted to work on Africa. I always answer that I don't know exactly, but that somehow I have been passionate about Africa for as long as I remember. However, it takes much more than passion to write a doctoral dissertation in economics. I am indebted to many people for offering me the opportunities, guidance, support and encouragements that I needed during my doctoral work.

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General Introduction

The Effects of Violent Conflict

The chapters in this dissertation relate to several strands of literature, but the common theme that emerges is the study of the effects of violent conflict. Attention of development economists for this theme has grown over the years, not in the least because in the course of the twentieth century especially developing countries have experienced an increase in civil strife (Steward and Fitzgerald, 2001).

It is clear that violent conflict entails a cost for the parties involved. Human lives are lost, both in combat and due to the hardship of war, such as lack of food, drinking water and medical care. Additional welfare costs stem from the destruction of physical assets, the disruption of economic activities, the collapse of public services, and from the weakening of economic institutions such as property rights and the rule of law.

It is less clear how we should quantify these war-related costs and identify their underlying mechanisms. There is no uniform way to measure the psychological burden of war. Furthermore, although the loss of human lives is countable, estimates of the death toll often lack precision. Even when focusing only on material welfare losses, the measurement remains difficult.

At the macro-economic level, comprehensive indicators are used to evaluate the material welfare cost of violent conflict. Among them are GDP per capita, GDP growth and the fiscal balance (Easterly and Levine, 1997; Collier, 1999). The war and post-war trend in human development indicators, such as education, nutrition and mortality, has also been the topic of research (Ichino and Winter-Ebmer, 2004; Ghobarah, et al. 2003).

Studies using such aggregate indicators show a negative effect of violent conflict on welfare, but the underlying mechanisms of this relationship remain vague. Which households or groups in society face the largest welfare losses? Do households have access to strategies that allow them to cope with adverse income shocks during wartime?

How do the affected households recover from war-related shocks? In order to answer these questions, data on households in wartime are needed. The scarcity of such data has limited the micro-economic research on the consequences of violent conflict to a handful of studies (Deininger, 2003, Brück, 2004).

Quantifying the war-related costs and identifying their underlying mechanisms may serve three distinct policy goals. First, it allows policy makers to take into account the cost of violent conflict, while deciding whether or not to seize arms to resolve a conflict, or to put an end to a violent conflict. Second, upon the outbreak of a war, a thorough understanding of the mechanisms through which war affects human welfare may help international institutions and aid organizations in designing relief and rescue operations. Finally, an understanding of the consequences of violent conflict may guide reconstruction efforts in the post-war years.

Using data from Rwanda, this study seeks to contribute to the micro-economic literature on violent conflict. I focus on rural households in Rwanda during 1990-2002, a period characterized by inter-ethnic violence, war and genocide. Rwanda is one of the poorest countries in the world, and surviving in rural Rwanda is a struggle, also after the 1994 genocide. In this dissertation, I aim to understand certain aspects of this struggle.

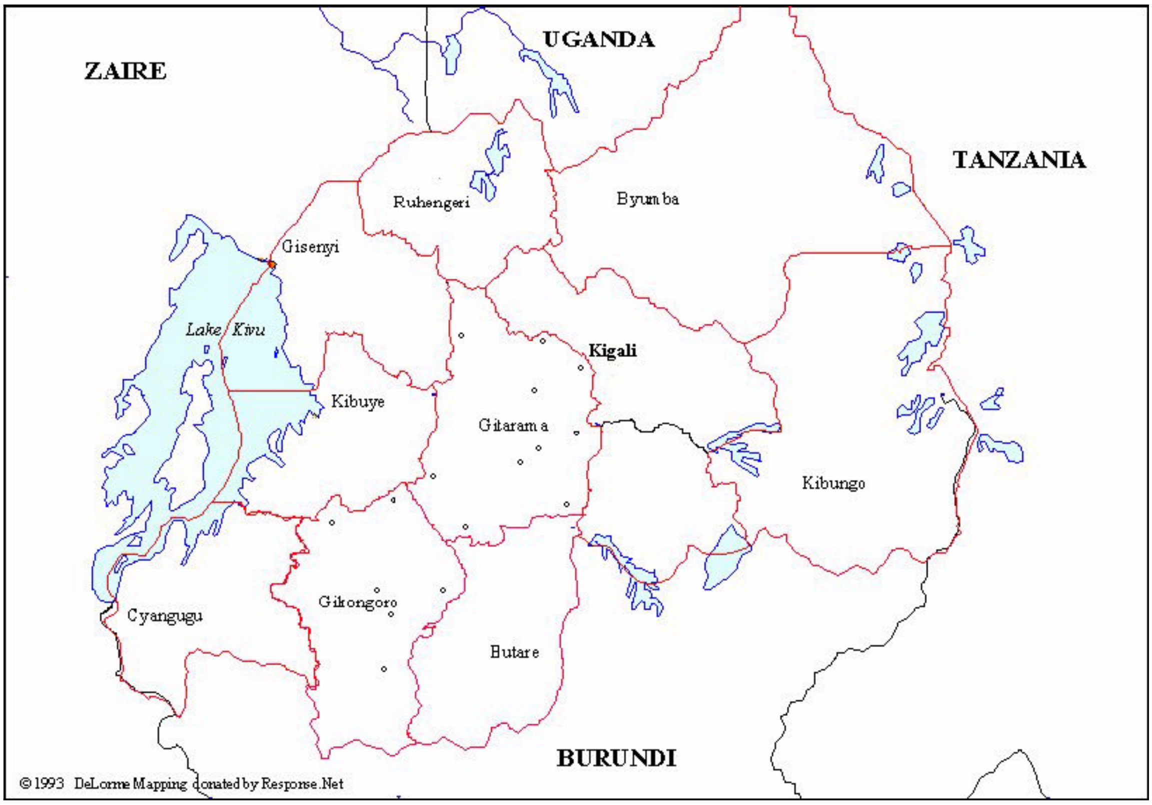
In the first chapter, I take "surviving" literally, and use demographic data to estimate the probability of Tutsi men and women to survive the genocide. Chapter two explores how households tried to smooth consumption. In particular, I examine if Rwandan rural households sold cattle in response to war-related shocks and other adverse income shocks. The third chapter focuses on the longer term consequences of the genocide, by analyzing its effect on the economic mobility of rural households between 1990 and 2002.

Ethnicity, War and Genocide in Rwanda

Rwanda is a small, land-locked country in Central Africa (see figure 1), with approximately eight million inhabitants, of which the large majority still depends on rainfed agriculture. The Rwandan population consists of three groups: Hutu, Tutsi and a small minority of Twa. According to the official population census of 1991 the Tutsi made up approximately 10% of the population and the Twa 1%.

In the early days of the Rwandan state, the boundary between Hutu and Tutsi was flexible and permeable. Families could change status, for example from Hutu to Tutsi, as they acquired more power and cattle. But, in the course of the nineteenth century the governing elite began to think of themselves as superior to ordinary people. The identification of Tutsi pastoralists as power-holders and of Hutu cultivators as subjects was becoming general and more fixed (Des Forges, 1999; Prunier, 1998; Newbury, 1998).

Figure 1: Administrative map of Rwanda



Note: the dots indicate the location of the 16 administrative sectors in Gikongoro and Gitarama Province that were the survey sites of the household dataset used in Chapter 2 and Chapter 3

Under Belgian colonial rule the distinction between the two groups became even more rigid. Believing that Tutsi were a superior race, Belgians systematically removed Hutu from positions of power and decreed that Tutsi alone should be officials. The myth of Tutsi superiority was reinforced and disseminated through the schools and seminaries in the first written history of Rwanda. The latter was based on inaccurate information of Rwandan poets and historians who saw the advantage in European favoritism for the Tutsi (Des Forges, 1999). Around the same time, the colonial administration registered the Rwandan population as Tutsi, Hutu, or Twa and indicated the ethnic affiliation on identity cards.

Only from the 1950s onwards, and partly under pressure from the United Nations, the colonial administrators named several Hutu to responsible positions in the administration and began to admit more Hutu into secondary schools. Both ethnic groups now had their own elite and their own political party: the Parmehutu (Parti du mouvement de l'émancipation des Bahutu) for the Hutu and the Union Nationale Rwandaise (UNAR) for the Tutsi.

In 1959 the ethnic polarizations lead to reciprocal attacks between Hutu and Tutsi. In a response to these attacks, the colonial administrators replaced several Tutsi local authorities by Hutu. Thereafter, the Parmehutu won the first elections in 1960 and 1961. The new government abolished the monarchy and replaced it by a republic. They continued labeling all Rwandans as Hutu, Tutsi, or Twa, but the identity cards which had once served to guarantee privilege to Tutsi now served as a means to discriminate against them, both in employment and in education. The revenge on Tutsi was also manifested in sporadic massacres between 1962 and 1964, killing an estimated 20,000 people and forcing the flight of many more[1].

Besides divided along ethnic lines, Rwanda was also divided between the South, the home of the Parmehutu elite, and the North, which felt that power was more and more monopolized to their disadvantage. This led to a coup, in which General Juvénal Habyarimana seized power. From 1973 onwards he governed Rwanda under a one party system, the single party being the MRND (Mouvement Révolutionaire National pour le Développement).

Rwanda has a history of ethnic rivalry dating back to the pre-colonial period, but the scale of the ethnic violence in the nineties was unprecedented. Unrest in Rwanda broke out at the end of 1990, when the RPF (Rwandan Patriotic Front), founded by Tutsi exiles, started launching attacks from Uganda. Soon thereafter, President Habyarimana opened the perspective of a multiparty system, and new parties were formed in opposition to the MRND[2]. Intermittent hostilities and negotiations between the government and the RPF resulted in a power sharing agreement, signed in Arusha (Tanzania) on August

[1] Von Meijenfeldt (1995) mentions that in early 1994, there were about 600,000 Rwandan Tutsi living in exile.

[2] In April 1992 a coalition government was formed, under a prime minister not belonging to the MRND, but out of 20 ministerial portfolios the MRND held nine, including that of defense. Later on the most important parties split over their attitude towards the RPF and the peace negotiations.

4, 1993.

But on April 6, 1994 the plane carrying President Habyarimana of Rwanda on his way back from negotiations in Dar-es-Salaam in the company of President Ntaryamira of Burundi was shot down, killing the crew and both presidents. Thereafter, Rwanda sunk into chaos. Within hours, the military, administrators, the MRND's militia (called Interahamwe[3]), and ordinary people started to kill Tutsi, moderate Hutu and Hutu leaders from political parties rival to the president's MRND. Simultaneously the war between the Rwandan army and the RPF was restarted. Late in June 1994 the massive killings and the war came to an end.

Although the Rwandan genocide took place in a relatively short time span (April – June 1994), it was one of the most devastating African conflicts of the twentieth century. The balance of the events was shocking: an estimated 800,000 Tutsi killed, two million people displaced and more than 100,000 prisoners suspected of participation in the genocide (Des Forges, 1999, Prunier, 1995). In addition, tens of thousands of people died from deprivation in the refugee camps.

Apart from causing extreme human suffering, the genocide had a high economic cost. A large fraction of the population left their fields unattended causing a standstill in food production. Livestock was decimated, coffee and tea production dropped to unprecedented low levels, the processing infrastructure was rendered non-functional and the forest sub-sector incurred massive losses. Consequently, 1994 was characterized by a steep fall of per capita GDP[4].

Even when relative peace was established in July 1994, food insecurity remained high and many people were dependent on food aid, among them the two million people who were internally displaced or sought exile in neighboring countries. Within Rwanda, several regions faced problems such as the lack of labor (many people were killed, imprisoned or in refugee camps) and the lack of manure (due to the huge losses of livestock). Late in 1996, forced by fighting around the refugee camps, most refugees returned to Rwanda, putting a heavy strain on the country's limited food resources. (Prunier, 1998; FAO, 1997)[5]. A fraction of them took refuge deeper into Congo, where many of them were killed (Reyntjens, 1997).

[3] *Interahamwe* literally means "those who stand together" or "those who attack together". This militia was formed by Habyarimana's political party in 1992, when the party started giving military training to its youth.

[4] Expressed in local currency units at prices of 2000; see World Bank World Development Indicators.

[5] Most of these refugees had fled their country during the upheavals in April 1994. Statistics refer to them as the "new caseload", as opposed to the "old caseload" referring to refugees who had fled the

The study at hand focuses on the consequences of the war and the genocide in Rwanda. However, nobody can reflect on the genocide without asking "how is this possible?". The underlying causes of ethnic violence have been studied by several authors. Among the determinants mentioned are the outbreak of civil war with the RPF invasion in October 1990 and the radicalization of Hutu power politics in response to the perceived RPF threat, the creation of opposition parties combined with the slow process of democratic liberalization, and a feeling of Hutu inferiority that led to ethnic hatred (Baines, 2003; Mamdani, 2001; Newbury, 1998; Prunier, 1998; Uvin, 1998). André and Platteau (1998) and Verwimp (2003) discuss land scarcity and increasing poverty and income inequality as underlying economic causes for the violence.

The Data

The data used in this dissertation are unique in the sense that they cover a period of extreme and widespread violence. For the first chapter, I use population data from the local administration for 1990 and 2002. The empirics in the second chapter rely on socio-economic data of 258 households, collected in 2002, but including retrospective information for the years 1991-2001. The third chapter is based on a subsample of 188 households in that dataset, for which I have two time observations, one prior to the genocide, in 1990, and one after the genocide, in 2002. The type and quality of information provided in these datasets are detailed in the respective chapters. Here, I provide some information on the history of the data collection.

Prior to the genocide, in the eighties and early nineties, the Rwandan Department of Agricultural Statistics (DSA) and Michigan State University (MSU) conducted nationally representative rural household surveys in Rwanda. Their data collection efforts were interrupted and eventually suspended because of the civil war that broke out in the beginning of the nineties. This dissertation makes use of a part of the DSA/MSU survey

country in several waves since 1959. Many of the latter already returned since the second half of 1994. The refugees who returned between June 1996 and June 1997 belonged almost all to the "new caseload". Returnees were eligible for emergency assistance, including up to six monthly food rations. Despite the increase of food imports for these rations, prices soared. Between June 1996 and June 1997, prices of pulses tripled, cassava prices doubled, those of sweet potatoes more than doubled; and sorghum and potato prices increased between 45 and 65 percent. In addition, many returnees found their homesteads, which they fled in 1994, occupied by those who remained behind or by new-comers who had been in exile until 1994. This sometimes led to land disputes between residents and returnees, which impeded cultivation (FAO, 1997).

data collected in 1990 from 1248 rural households in the ten Rwandan rural prefectures.

In the course of his doctoral work (1999-2001), Philip Verwimp traced several hundreds of the 1248 households who were interviewed in 1990 in three provinces of central and southwest Rwanda: Gitarama, Kibuye and Gikongoro, with 160 households (10 clusters) in the former and 96 (6 clusters) in each of the latter two provinces. Reasons for choosing these provinces included among others the availability of information needed to locate the households in the sample. During the tracing all attention was directed towards the localization or re-localization of the original households and the consequences of the genocide and civil war, leaving no time for a detailed rural household survey (Verwimp, 2003a).

With the help of a field research budget provided by the Flemish Interuniversity Council (VLIR), Philip Verwimp and I went to Rwanda in 2002 to re-survey the 256 rural households that were initially interviewed in Gitarama and Gikongoro Province (see Figure 1). We conducted a detailed survey including questions on household composition, assets, economic activities and market transactions. In addition, we collected recall information on the shocks of the war and genocide, other adverse income shocks, cattle transactions and consumption shortfalls during the period 1990-2002.

However, due to the high drop out of households from the sample, the 2002 survey only included 188 households who were also part of the 1990 survey. The panel data for these 188 households is used for the study of economic mobility in chapter 3.

Since the survey budget was worked out for 256 households, we decided to add some households. Most households that dropped out were Tutsi-headed. Therefore, we added mostly Tutsi-headed households, lifting their share in the sample from below 10 percent (12/188) to 22.5 percent (58/258). This sample of 258 households, including the 188 households interviewed in 1990 and 2002 and the newly added ones, is used for the analysis in chapter 2.

In 2003, I went back to Rwanda to visit approximately 30 households in two administrative sectors in Gikongoro. The main goal of this visit was to deepen the understanding of some quantitative results that were found after the first analysis of the survey data of 2002. Besides having semi-structured interviews with households, traders, public servants, and NGO co-operators, I looked for additional quantitative data from the public administration and NGO's. This is how I obtained the population data from the local administration of Gikongoro Province, which I use in chapter 1.

Summary of Results

The questions addressed in this dissertation are: How many Tutsi were killed in the genocide? Which factors determined the survival chances of Tutsi in Gikongoro Province? What kind of adverse income shocks hit the Rwandan rural households during the nineties? Did households deplete their cattle stock in response to these shocks? Did the shocks of the war and genocide have short term as well as long term effects on the material welfare of Rwandan rural households?

In the first chapter, I study the death toll of the Rwandan genocide and the spatial pattern of killings in Gikongoro Province. The death toll of the genocide remains highly debatable. The frequently quoted estimate of 500,000 Tutsi killed is based on the population census of 1991. However, two unanswered questions make this estimate unreliable. First, how many Tutsi lived in Rwanda prior to the genocide? Second, how many Tutsi survived? With respect to the first question, critics say that the proportion of Tutsi was under-reported in the 1991 census. By comparing the census data with population data of the local administration of Gikongoro Province, I provide evidence for this allegation and study how the under-reporting may affect the estimate of the genocide death toll. I also use the local population data for 117 administrative sectors within Gikongoro Province to make a detailed analysis of the spatial pattern of killings in Gikongoro. I find that Tutsi in Gikongoro had, on average, a 25% chance of surviving the genocide. The survival rate for women was slightly higher than for men, 29% versus 21%. The location of huge massacres and the way violence spread across sectors were more decisive for the Tutsi survival rate than the attitude of local authorities towards the genocide.

In chapter two, I study the ex post consumption smoothing behavior of Rwandan households during the period 1991-2001. The focus lies on the hypothesis that households use livestock as a buffer stock to smooth consumption in response to political unrest and other adverse income shocks. In the theoretical part of this chapter, I extend Deaton's buffer stock model for precautionary savings to a setting of violent conflict by including the (expected) risk of livestock raiding and the terms of trade risk. The empirical part of this chapter uses data on 258 rural Rwandan households. I give an overview of the type of shocks that affected these households during the years 1991-2001 and, using a fixed effects logit model, I test for the use of cattle sales to smooth consumption in response to war-related and other shocks. I find that the probability of selling cattle increased upon the occurrence of an adverse income shock. In peacetime these cattle sales are explained by household portfolio choice rather than by consumption smoothing motives. In contrast, in wartime, Rwandan rural households used cattle sales to buffer consumption. However, the analysis suggests that the lack of safety on the roads prevented the households most targeted in the violence from selling their cattle. Households less affected by the violence depleted their cattle stock in 1994, but received a very low price in exchange.

Chapter three seeks to understand welfare gains and losses in a sample of 188 rural households in two Rwandan provinces over the time span 1990-2002. An economic mobility analysis is used to identify the impact of the shocks of the war, the genocide and their aftermath on long term household welfare. To measure economic mobility between 1990 and 2002, I use both net income per adult equivalent and an asset index. I find that households with a member in prison in 2002 moved considerably downward in the income distribution. However, there is no evidence of an impact of other war-related shocks such as the number of members killed in 1994, the loss of physical capital, and the number of months taken refuge on household income and assets in 2002.

Chapter 1

The Death Toll of the Rwandan Genocide: A Detailed Analysis for Gikongoro Province

1.1 Introduction

Many human tragedies of the 20th century have illustrated that establishing an accurate death toll estimate is extremely difficult. This is true, even for the most intensively studied tragedy of the 20th century, the Nazi Holocaust (1938-1945), for which estimates range between 4.2 and 6.3 million Jews exterminated (Reitlinger, 1953; Davies, 1998). The margin of error increases for less studied tragedies. For example, the estimates of the number of Cambodians who died under the Khmer Rouge (1975-1979) lie in a range between 750.000 and 2.6 million (Vickery, 1984; Sliwinski, 1995).

Also the death tolls of other human tragedies, besides genocides, are difficult to establish. For example economists, demographers and historians have made attempts to estimate the number of Chinese that died during the “secret famine” of the Great Leap Forward (1959-1961), resulting in estimates between 20 and 40 million (Banister, 1987; Becker, 1996). Another well-known demographic puzzle is the one of Asia’s missing women due to excess female mortality, where estimates range between 80 million and 100 million "missing" women (Sen, 1990; Klasen, 1994).

The estimates put forward differ depending on the method used (body counting, testimonies and/or demographic analysis) and the sources consulted. The definition of the death toll, including or excluding indirect deaths, is also determinant for the estimate put forward. Although counting the number of victims of genocide or other human tragedies is an extremely hazardous exercise, it is a historical and political necessity. Using population data of the administration of Gikongoro Province, this chapter seeks to narrow the range of estimates of the death toll amongst the Tutsi population living in Rwanda in 1994.

During and after the Rwandan genocide, many tried to estimate the number of casualties, first by body count, later using demographic data. About 20 days after the start of the genocide, Human Rights Watch reported 100,000 casualties. Just a few days later, Médecins Sans Frontière (MSF) doubled this estimate. In May 1994, Radio Muhabura, the RPF radio, mentioned 500,000 persons killed, but adjusted the figure downwards to 300,000 several days later. These figures were guesses rather than estimates, since they were not based on any systematic counting (Prunier 1998, p.262). After the genocide, the accuracy of the estimates did not improve. The UN report of November 1994 (UN 1994) took a safe range between 500,000 and one million victims. These figures include both Tutsi and Hutu.

Demographic data provide a means to estimate the Tutsi death toll more accurately. The last population census prior to the genocide was conducted in 1991. This census reported 596,400 Tutsi living in Rwanda, representing 8.4% of the population. Based on an annual population growth of 3%, the number of Tutsi would have been 650,900 at the end of July 1994 (under the no-genocide scenario)[1]. The next step is to obtain an estimate of surviving Tutsi. At the end of July 1994, a head count in refugee camps resulted in an estimated 105,000 Tutsi survivors. According to Prunier (1998, p.265) 25,000 survivors who did not go to camps should also be added. Human Rights Watch (1999, p.15) adds another 20,000 surviving Tutsi in Zaire (now Democratic Republic of the Congo) and Tanzania. This gives a total of 150,000 Tutsi survivors[2]. By subtracting the number of survivors from the estimated Tutsi population under the no-genocide scenario, we obtain an estimate of 500,900 Tutsi killed in the genocide, a loss of 77.0% of the Tutsi population of Rwanda.

Many readers may question the estimates regarding the number of survivors. Indeed,

[1] $P_{July\ 1994} = (1 + 0.03)^{time\ span} \times P_{August\ 1991}$; $time\ span = 2.96$ years. A discussion of the assumption of 3% annual population growth can be found in Appendix III.

[2] IBUKA (a Rwandan association for the survivors of the genocide) talks about 300,000 survivors on their website. However, they also mention that the Tutsi population in 1994 amounted to 1,500,000. Maybe they included the Tutsi population living abroad prior to 1994 and counted also survivors among the Tutsi population in East Congo.

we will probably never really know how many Tutsi managed to survive without seeking refuge in camps. Counting in the camps was also prone to errors. Moreover, since it is no longer politically correct in Rwanda to talk about ethnicity, the latest census of 2002 does not provide information on the current size of the Tutsi population. Another problem is the reliability of the 1991 census. Two criticisms have been put forward. First, to avoid discrimination, an undetermined number of Tutsi registered as Hutu. Second, the Habyarimana regime is said to have deliberately under-reported the number of Tutsi in order to keep their school enrolment and public employment quotas low. Until now, this allegation has not been documented. However, this strong suspicion alone led G. Prunier (1998) to estimate the actual Tutsi population in 1994 at 12% of the total population instead of 8%, the estimate put forward by the Habyarimana regime. If we repeat the exercise above with this larger share, the death toll of the genocide increases from around 500,000 to some 800,000 Tutsi killed (Prunier 1998, p. 264), representing the annihilation of about 84% of the Tutsi population in 1994.

A number of Hutu also lost their lives during the genocide and its aftermath. Moderate Hutu were killed, especially in the first few weeks of the genocide. They were often adversaries of the MRND and the CDR (*Coalition pour la défense de la république*), the two political parties that most fanatically supported the idea of "Hutu Power". No figure has yet been put forward to quantify these killings, but the order of magnitude is likely to be small because, from 12 April onwards, political leaders of the MRND and the CDR tried to unify all Hutu in a common fight against Tutsi. Once the Tutsi population had been defined as the common target, murders of political opponents and moderate Hutu slowed down. (HRW 1999, p.201). However, many Hutu died in refugee camps in Zaire, Tanzania, and Burundi. The cholera epidemic in Goma is believed to have taken around 30,000 lives (Prunier 1998, p.303). Also, an unknown number of Hutu were killed by the RPF, both in the course of combat and in acts of revenge after the genocide. Estimates range between 6,000 and 60,000, but there is no data to confirm these figures (Prunier 1998, p.324 and HRW 1999, p.16)[3].

In short, estimating the victims of the war and the genocide in Rwanda is a hazardous

[3]Using population data from various sources, Reyntjens (1997) argues that the total number of Rwandans who "disappeared" from the population in 1994, whether Hutu, Tutsi or Twa, lies between 1,050,000 and 1,150,000. Subtracting the number of Tutsi casualties from this estimat, would give a reasonable approximation for the number of Hutu who "disappeared" since Twa accounted for only 0.4% of the population prior to April 1994. However, the disappearance of Hutu stems from several causes that cannot be disentangled: (1) killed by the perpetrators of the genocide, (2) killed by the RPF, (3) died from disease in refugee camps, or (4) fled to neighboring countries (to escape prosecution).

enterprise. The counting of Hutu and Tutsi casualties during the war and genocide was not systematic and the analysis of demographic data is hampered by two unanswered questions. First, how many Tutsi lived in Rwanda prior to the genocide? Second, how many Tutsi survived? The present study does not answer these questions, but it contributes to the debate on the death toll of the genocide in two ways. A first objective is to provide evidence for the under-reporting of Tutsi in the 1991 census. A second objective is to analyze the geographical pattern of killings during the genocide and estimate the survival chance of Tutsi in Gikongoro, a prefecture located in southern Rwanda (Map 1).

The first contribution is made by comparing the 1991 census data with population data of 1990 from the local administration of Gikongoro. The second contribution takes these latter data as a starting point. The 1990 local population data provide information on the proportion of Tutsi in 117 administrative sectors of Gikongoro Prefecture. These data are compared with local population data of 2002 for the same 117 administrative sectors. Since the local administration stopped recording ethnic identity after 1994, the death toll among Tutsi living in these sectors cannot be derived from a mere comparison between the number of Tutsi in 1990 and 2002. However, much can be revealed from a study of the sector's population growth between 1990 and 2002, and its 2002 sex ratio.

First, I present the local population data of Gikongoro Prefecture, discuss their reliability, and compare them with the census data of 1991. Next, a nonlinear least squares (NLS) regression analysis is used to explain population growth and changing sex ratios across the 117 sectors of Gikongoro, and estimate the proportion of Tutsi killed during the genocide. I will examine what factors explain the unequal impact of the genocide in Gikongoro. Lastly, in the conclusion, I present a new and better substantiated estimate of the number of Tutsi who were killed during the genocide.

1.2 Evidence for the under-reporting of Tutsi in the 1991 census

1.2.1 The 1991 population census

Since its independence in 1962, Rwanda organized three population censuses, in 1978, 1991 and in 2002. The first two censuses recorded the ethnic identity of the population. In 2002 this was not done. Since the census of 1991 was the last census prior to the genocide,

Table 1.1: Distribution of the population of Rwanda by prefecture and ethnic group in 1991 (de jure population of Rwandan nationalty)

Prefecture	Percentage distribution				Total population
	Hutu	Tutsi	Twa	Others	
Butare	82.0	17.3	0.7	0.0	753868
Byumba	98.2	1.5	0.2	0.0	775935
Cyangugu	88.7	10.5	0.5	0.3	551565
Gikongoro	86.3	12.8	0.8	0.1	465814
Gisenyi	96.8	2.9	0.3	0.1	731996
Gitarama	90.2	9.2	0.6	0.1	848027
Kibungo	92.0	7.7	0.2	0.1	648912
Kibuye	84.8	14.8	0.4	0.0	469494
Rural Kigali	90.8	8.8	0.4	0.1	905632
Kigali City	81.4	17.9	0.3	0.4	221806
Ruhengeri	99.0	0.5	0.4	0.1	766795
Total	91.1	8.4	0.4	0.1	7099844

Source: Census of Rwanda 1991 (SNR, 1994)

the information it provided concerning the size of the Tutsi population in Rwanda has been used to estimate the death toll of the genocide (Prunier, 1998, p.265; HRW, 1999, p.15). According to this information, shown in Table 1.1, the Tutsi population amounted to 8.4% of the total *de jure* population of Rwanda.

However, many scholars have raised and repeated the allegation that this percentage is unreliable (Prunier, 1998, p.265; HRW, 1999, p.15). In the early seventies, the Hutu regime introduced an ethnic quota system for the appointment of civil servants and for school enrolments. This policy required that places be distributed between Hutu and Tutsi according to their proportion to the total population (Reyntjens, 1985, pp. 501-503). As the government wanted to restrict the power of the Tutsi, they had a motive for keeping quotas for Tutsi in education and administration low, and to this end, may have under-reported the proportion of Tutsi. This accusation has often been levelled, but never proved. In addition, there are many stories of Tutsi reporting as Hutu in the population census in order to avoid discrimination. Therefore, even the census report itself urged caution with respect to the figures on ethnicity (SNR, April 1994, p. 114):

> "Given that the declaration of the ethnic group is not a simple matter in Rwanda, one may wonder whether the current proportion of Hutu is not overestimated. Indeed, some members of other ethnic groups report that they are Hutu. This practice has existed since the end of the Tutsi Monarchy (1961)"

The same reasons for caution apply to the 1978 census, according to which Tutsi made up 9.7% of the total population (SNR, 1982). But, the colonial rulers had no reason to misreport the relative size of ethnic groups. From 1930 onwards, the Belgian colonial administration counted the population almost every year using sample techniques. For three years, 1933, 1952 and 1956, data on ethnicity are available. These data show much higher proportions of Tutsi than under the Hutu regime: respectively 15.3%, 17.5% and 16.6% (Mamdani, 2001, p.98; HRW, 1999, p.40; Reyntjens, 1985, p.28; Inforcongo, 1959, pp. 31-40). However, this hardly constitutes evidence for the under-reporting of Tutsi in the 1978 and 1990 census. The percentages reported in 1978 and 1991 seem plausible if we take into account the number of Tutsi who left the country between 1959 and 1990, or who were killed during this period[4]. On the other hand, this extrapolation is not very convincing since the exact number of Tutsi exiles and casualties during this period is unknown[5]. In addition, prior to the Hutu revolution of 1959, a number of wealthy Hutu registered as Tutsi (SNR, 1994, p. 110).

1.2.2 The population data of the local administration

In the administrative subdivision of Rwanda, "prefectures" are followed by "communes", "sectors" and "cells". The cell is the smallest codified administrative unit, including on average 150 households. Even within the cell, households live in organized units of ten households, "*nyumbakumi*" or ten-house agglomerations. The structure is marked by the dominance of the national government all the way from the center via prefectures, communes, sectors and cells to the nyumbakumi[6]. Few African countries are so well organized and use existing structures so extensively as Rwanda[7].

One of the tasks of the local administration of each commune is to file reports on its population four times a year. A personal file recording all vital events and migration on each individual aged 17 and over is kept at the commune. The nyumbakumi leaders report to the leaders of the cells, who report to the leaders of the sector, and so on.

[4]Von Meijenfeldt (1995) mentions that in early 1994, there were about 600,000 Rwandan Tutsi living in exile.

[5]P. Uvin (1994) suggests that the Rwandan government sought to cover up these events and therefore did not put much effort in making population data available, apart from some censuses which were "far between, very partial and made by government officials".

[6]The nyumbakumi, the fifth administrative level at the bottom of the chain, is not codified by the law (Samset and Dalby, 2003).

[7]As a grim example of this, the organizers of the genocide exploited these structures to reach all Rwandans and to incite or force Hutu into participating in the slaughter. On the role of local authorities in the genocide and "Rwandan political tradition", see, among others, Mamdani, (2001, p.194, p.199 and p.218) and Prunier, (1998, p.138)

This dense administrative structure records all births, deaths, immigrations and emigrations. Prior to the genocide, in addition to the age and sex, the ethnic identity of every individual was recorded[8].

In contrast to the doubts concerning the reliability of the population censuses, there is no reason to suspect any systematic under-reporting of Tutsi in the local population data. Since everybody knows each other at the local level, it would have been almost impossible for Tutsi to deceive the local administration about their true ethnic identity. Whereas census interviewers sent by the central government were not allowed to ask for the respondent's identity card (on which ethnic identity was mentioned), no such restriction was imposed on the local administration (SNR, 1994, p. 109). In addition, the local administration had no incentive to misreport the size of the local Tutsi population. The quota policy was centralized and implemented at the national level. Even if the local administration had been inclined to influence this policy, it could not have done so by modifying its reports. Each of the reports made by the communes was filed to the Interior Ministry in Kigali, but none of these reports were ever made public, and the quota policy remained based solely on census reports as published. By comparing census data with local population data, we can assess the extent of under-reporting of Tutsi in the population census. Unfortunately, local population data are not readily available. The present study uses local population data of one single prefecture, Gikongoro[9].

1.2.3 The population data of the local administration of Gikongoro Prefecture

Before the administrative re-organization of Rwanda, Gikongoro was one of the country's eleven prefectures[10]. At the time of the genocide, Gikongoro counted 13 communes and 125 sectors (see Map 1.A.1 in the appendix). Authorized by the Rwandan government to do research on economic issues, I was able to get local population data for 1990 as well as for 2002 from the Statistical Unit of Gikongoro Prefecture.

[8] Children from an inter-ethnic marriage took the ethnicity of the father.

[9] If authorization could be obtained from the Rwandan authorities, it would be possible to put together much of the local population data by systematically checking the reports filed at the communes, prefectures and the Interior Ministry in Kigali.

[10] During the administrative reform of the Rwandan territory in December 2000, Umutare was added as the twelfth Prefecture. The terminology also changed. "Prefectures" became "provinces", and "communes" became "districts". In this paper, I use the old terminology and administrative subdivisions as they were in place at the time of the genocide.

The data for 1990 concerned the *de facto* population, distinguished by sex and ethnic group and were complete for 117 out of the 125 sectors. The eight missing sectors were those of Rwamiko Commune. A separate page with aggregated information by commune did provide some summary statistics for Rwamiko Commune, presenting population by sex, but not by ethnicity. The data of the 117 sectors were listed by commune, each time on a separate page, entitled "*Répartition de la population par sexe, ethnie et par secteur administratif au 31/12/1990*"[11]. Each page had a similar typewritten table. An example of such a table is given in the appendix (table 1.A.1)[12]. The local population data for 2002 show the de facto population by sector. They were complete for all 125 sectors and had a similar format as the 1990 data. These data included information by sex but not by ethnic group.

The information derived from the local population data is summarized in Table 1.2. Using data at the sector level, I obtained, at the commune level, the proportion of Tutsi in 1990, the total population in 1990 and 2002, the sex ratio in both of these years and average annual population growth between 1990 and 2002. For now, only ethnicity data listed in the first column are discussed. The other data presented in Table 1.2 will be used later.

According to the local population data, 17.5% of the population of Gikongoro was Tutsi in 1990. The geographical distribution of Tutsi in Gikongoro was very unequal. The commune with the highest proportion of Tutsi was Mubuga, with around 43%, followed by Nyamagabe and Muko. Map 1.A.1 in the appendix illustrates the ethnic distribution in more detail at the sector level. The western part of the prefecture counted many sectors with almost no Tutsi, whereas Tutsi were very well represented in the northern and eastern parts of Gikongoro. In five sectors a majority of the population was Tutsi[13]. In fact, the government created the prefecture of Gikongoro shortly after independence. The southern and western outskirts of the Nyanza region were attached to what is now

[11] "Population distribution according to sex, ethnicity and administrative commune on 31 December 1990"

[12] On eight of the twelve pages the population figures were handwritten. The mayor signed eight out of the twelve pages, four had an official stamp of the commune and on seven pages the date of the signature had been added. Although the title on each page mentioned 31/12/1990 as the survey date, the dates of signature differed. The seven dates mentioned were 17 January 1991, 19 January 1991, 16 March 1991, 14 May 1991, 19 December 1991, 27 December 1991, and 3 February 1992. The dates of signature probably correspond with the time of sending the reports form the commune to the prefecture. The delays might result from the fact that the commune had to wait for the data from each sector and, had to summarize them on one page.

[13] In Yonde, Gitondorero, Rususa, Muganza and Nyarusovu.

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, located in the north-western corner of Butare (HRW, 1999, p.303)[14].

This proportion of 17.5% is calculated without the data of Rwamiko. There are three reasons to suspect that the missing Rwamiko data cause an underestimation rather than an overestimation of the proportion of Tutsi in Gikongoro. First, Rwamiko was surrounded by areas with a large Tutsi population. Indeed, Rwamiko Commune borders Butare Prefecture (Map 1), the prefecture with the highest proportion of Tutsi (17.3% according to the 1991 census). Moreover, the population of most sectors surrounding Rwamiko were more than 40% Tutsi (Map 1.A.1 in the appendix)[15]. Second, the population decline of Rwamiko Commune is striking, with a decrease from 28,240 inhabitants in 1990 to 22,929 in 2002, corresponding to an annual decline of 1.8%. Given that women have six children on average (ONAPO, 2001), a decline of this size can only be explained by exceptionally high emigration or by a high death toll. A third piece of evidence for a high pre-genocide proportion of Tutsi in Rwamiko is provided by the change in the sex ratio. For Gikongoro, on average, the sex ratio decreased from 92.5 in 1990 to 88.6 in 2002[16]. The decline was much more pronounced in Rwamiko, were the sex ratio fell from 92.5 to 81.5 (Table 1.2). These three facts suggest that the proportion of Tutsi in Gikongoro would have been even higher if the population of Rwamiko had been included.

1.2.4 Evidence for the under-reporting of Tutsi in the 1991 census

According to the population census of 1991, the proportion of Tutsi in Gikongoro was 12.8% (Table 1.1). The local population data of 1990 revealed a much higher proportion, at least 17.5%. This suggests that the under-reporting of Tutsi in the 1991 census was quite high. However, to provide solid support for this argument, we must be sure that the local population data is reliable. To ascertain this end, I compared other aspects, besides ethnicity, such as the number of men and women and the total population, with

[14]The Rwandan kingdom actually had several "capitals" and the court would move around between them. In the beginning of the twentieth century the Germans forced the court to settle at Nyanza. I thank Alison Desforges for pointing this out.

[15]For example: Rususa, Buremera, Kibeho, Nyarushishi and Muganza.

[16]The decrease in the sex ratio may be explained both by emigration and by casualties of the war and genocide. Gikongoro as a whole is a net-emigration region (MINECOFIN, 2002).

Table 1.2: Ethnicity, population growth and sex ratio for the 13 communes of Gikongoro prefecture in 1990 and 2002

Commune	Proportion of Tutsi in 1990 (%)	Population in 1990	Population in 2002	Annual population growth (%) 1990-2002[a]	Sex ratio in 1990	Sex ratio 2002
Karama	13.3	30,347	30,710	0.104	93.2	87.0
Karambo	18.4	25,875	28,752	0.921	91.1	89.3
Kinyamakara	3.2	34,155	32,838	-0.341	93.8	90.0
Kivu	17.1	40,685	46,929	1.249	85.5	93.9
Mubuga	43.3	39,274	22,471	-4.739	93.4	83.6
Mudasomwa	4.5	44,399	59,791	2.622	90.7	89.9
Muko	34.6	40,952	56,436	2.828	100.8	86.1
Musange	16.7	29,722	34,392	1.277	96.1	88.6
Musebeya	0.9	36,777	49,809	2.673	87.6	91.0
Nshili	3.7	43,366	54,299	1.974	92.8	88.2
Nyamagabe	42.8	36,036	40,397	0.998	91.3	87.7
Rukondo	12.9	36,623	32,029	-1.159	95.4	88.9
Rwamiko	NA[b]	28,240	22,929	-1.798	92.5	81.5
Gikongoro	17.5	466,451	511,776	0.810	92.5	88.6

[a]The time span used to calculate the annual population growth is 11.5 years. [b]The local population data for Rwamiko were not available by ethnicity or sector.
Sources: Local population data for 117 sectors of Gikongoro, for 1990 and 2002

the census data. If the local population data are of good quality, I should find a close resemblance with the census data.

Table 1.3 shows figures for the total population, the male and female population, and the proportion of Tutsi for 117 sectors of Gikongoro. The first and second columns list the figures based on respectively the census of August 1991 and the local population data of December 1990. The third column provides an estimate of the population in August 1991 based on the local data of December 1990. In the calculations, I use an annual growth rate of 1.8% which corresponds to the growth rate for Gikongoro Prefecture between 1978 and 1991. This rate is quite low compared to the national average of 3.1% during the same period. Indeed, Gikongoro is a net-emigration region in Rwanda[17].

The last column of Table 1.3 shows by what percentage the prediction based on the local population data deviates above (+) or below (-) the census data of 1991. The deviation is less than 1% for the figures in the first three rows. Thus, local administration data for total population and population by sex match very well with the census data[18].

[17]For more details on the choice of the annual population growth rate used, see Appendix III.

[18]After this exercise of comparison I checked the local population data for outliers and found that 7 sectors had unusual sex ratios. I replaced these by the sex ratios of the census data. In two sectors, the number of inhabitants deviated strongly from the census. They were also substituted with figures from the census. Table 2 as well as the regression analysis of section 3 are based on the corrected data.

Table 1.3: Local population data of 1990 versus census data of 1991 for the 117 sectors of the prefecture of Gikongoro

	Population census August 1991 (de jure)[a] (1)	Local population data December 1990 (de facto)[a] (2)	Local population data Estimation for August 1991 [b] (3)	% Difference [(3) − (1)]/(1)
Total population	438,122	430,917	436,099	-0.46
Male	210,067	207,602	210,098	+0.01
Female	228,055	223,315	226,000	-0.90
% Tutsi	12.8[c]	17.5	17.5	+ 37

Note: Local population data by sector of Gikongoro Prefecture were complete for 117 out of 125 sectors. [a]The local administration used “present population” as a criterion whereas in the report of the population census of 1991 the residency criterion is almost always used. This could explain part of the difference between the first and third column. The census report does give present population at the commune level and according to these figures the present population of the 117 sectors was 436,291 in August 1991. Comparing this figure with 436,099 I find a difference of only 0.044%. [b]$P_{August\ 1991} = (1+r)^{time\ span}\ x\ P_{December\ 1990}$ with $r = 1.8\%$ (growth rate 1978-1991 for Gikongoro) and time span = 8 months or 0.67 years. We assume that the growth rate is independent of the ethnic group (see also table 1.A.2 in the appendix). [c]The sectors of Rwamiko are included in the 12.8% (since the census of 1991 does not provide the proportion of Tutsi per commune, only per prefecture). They are not included in the 17.5% (since local population data of Rwamiko were lost). *Sources*: Census of Rwanda 1991 (SNR, April 1994) and local administrative data (1990)

In sharp contrast, the proportion of Tutsi differs strongly: the deviation amounts to 37%. Since the local authorities had no reason to over-report the proportion of Tutsi in their population, this is convincing evidence that the proportion of Tutsi was under-reported in the census.

The question remains as to whether the government under-reported to restrict the quota for Tutsi in education and civil service or whether Tutsi themselves registered as Hutu in order to avoid discrimination. It is also unclear whether the under-reporting was systematic. It would greatly help if we could obtain local population data for other prefectures[19]. There is at least one argument supporting the idea that the under-reporting was not limited to Gikongoro Prefecture. In Rwanda, it is generally accepted that Butare is the rural prefecture with the highest proportion of Tutsi[20]. Therefore it is no surprise

[19]HRW has local population data by ethnicity for some communes of Butare Prefecture and repeatedly requested other data from the Rwandan government. Since several communes of Butare are missing, HRW’s current data cannot be used for comparison with the census data of 1991 that reported the size of ethnic groups only at the prefecture level.

[20]It is believed that Tutsi started to settle in Rwanda from the 8^{th} or 9^{th} century onwards. Coming from the east, they first settled in the dry eastern parts of present day Rwanda, but they gradually moved westwards to the wetter highlands. In the 14^{th} century the Tutsi feudal monarchy dominated

that in the census report Butare leads with 17.3% Tutsi (see Table 1.1). But, having found that the proportion of Tutsi in Gikongoro is actually at least 17.5% instead of 12.8%, the ranking would be reversed unless the figures of Butare and other prefectures were also misreported.

1.2.5 Implications for the estimation of the genocide death toll

In sum, the large gap between the officially reported proportion of Tutsi in Gikongoro (12.8%) and the estimate based on local population data (17.5%) confirms the suspicion that the 1991 census under-reported the proportion of Tutsi in the population. Admittedly, there is no good reason to assume that the under-reporting occurred on exactly the same scale in all prefectures. But interestingly, if the scale of under-reporting at the national level was the same as that found in Gikongoro - i.e. about 40%[21] - the calculated death toll would be close to 800,000, in the order of magnitude put forward by Gérard Prunier, taking account of speculations about the systematic under-reporting of Tutsi in the 1991 census report (Prunier 1998, p.265).

Indeed, with 40% under-reporting at the national level, the proportion of Tutsi at the national level would have been 11.8% instead of 8.4%. This would mean that there were 837,100 Tutsi in Rwanda in 1991 instead of 596,400, and, under the no-genocide scenario, 913,600 Tutsi at the end of July 1994. By subtracting the estimated 150,000 Tutsi survivors (see above), I obtain a death toll of 763,600 Tutsi, representing about 83.6% of the Tutsi population. However, there are several possible scenarios. Table 1.A.3 and 1.A.4 in the appendix summarize the results of different under-reporting scenarios. For example, one alternative scenario would be that there was only misreporting for the prefectures that had a relatively large proportion of Tutsi. If we assume, for example, that besides the figures for Gikongoro, only the figures of the prefectures with an even higher proportion of Tutsi were under-reported by 40% (Butare, Kibuye and Kigali City), this scenario leaves the ranking of prefectures by ethnicity intact. Rwanda would have counted 717,300 Tutsi in 1991, i.e. 10.1% of the population. The death toll would then be 632,900 Tutsi, a loss of about 80.8% of the Tutsi population in 1994.

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the central parts of the country and Nyanza, in the north-western corner of Butare, became its royal capital.

[21] For Gikongoro, I found a deviation of 37% (table 3), but I argued that the deviation would be even higher when including the sectors of Rwamiko. For example, if I assume that Rwamiko counted 28% Tutsi, Gikongoro would count 18% Tutsi and the deviation would increase from 37 to 40%.

The evidence presented here is far from able to answer the two questions needed to make a sound estimate for the genocide death toll. How many Tutsi lived in Rwanda prior to the genocide? How many Tutsi survived? Regarding the first question we can now safely say that the use of data from the 1991 census report leads to an underestimation of the death toll. With respect to the numbers of survivors, the estimation of their number is beyond the range of our data. However, the next section shows how the local population data can be used to estimate the average survival chance of Tutsi in Gikongoro and to study the geographical pattern of killings in this prefecture.

1.3 The Pattern of Killings in Gikongoro Prefecture

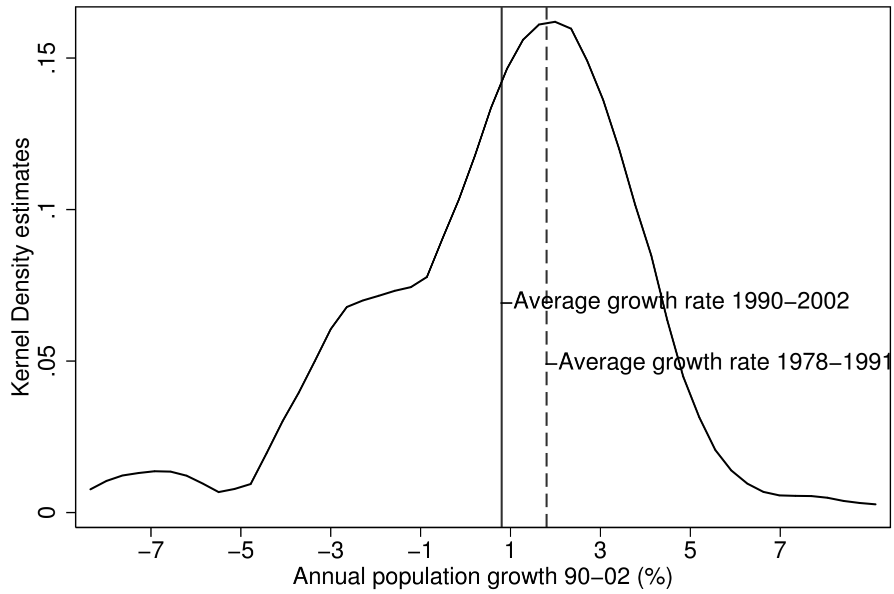
As a consequences of war and genocide, Rwanda has experienced population decline and a decrease in the sex ratio. For Rwanda as a whole, the annual population growth slowed down from 3.1% in 1978-1991, to 1.2% in 1991-2002. Comparing the years 1991 and 2002, the sex ratio decreased from 95.1 to 91.3 (SNR, 2003). These demographic changes vary across as well as within prefectures, at the commune and at the sector levels. Since Tutsi were targeted during the genocide, we expect to find that the larger the proportion of Tutsi in a sector in 1990, the stronger the sector's population decline and the lower its sex ratio in 2002. The local population data presented in the previous section can be used to assess this relationship for the sectors of Gikongoro Prefecture. I will now study the effect, in Gikongoro, of the proportion of Tutsi in a sector in 1990 on respectively population growth between 1990 and 2002 and the sex ratio in 2002. Three questions wil be addressed: what was the average survival chance of Tutsi (men/women) in Gikongoro? Which sectors deviated significantly from this average? and why did Tutsi (men/women) in these sectors have a higher or lower chance of survival?

1.3.1 The relationship between the proportion of Tutsi and population decline

Preliminary evidence

The local population data of Gikongoro reveal that the annual population growth rate for 1991-2002 varied across communes and sectors. For example, Table 1.2 shows that the communes Mubuga, Rukondo and Rwamiko experienced a sharp population decrease during this period, i.e. a yearly decline of respectively 4.74%, 1.16% and 1.80% percent.

Figure 1.1: Kernel density of annual population growth between 1990 and 2002, for 117 sectors in Gikongoro Prefecture



Sources: Local population data of Gikongoro; for 1990 and 2002; SNR (2003) for the average growth rate 1978-1991

At the sector level, the variation was even more pronounced. Figure 1.1 shows the estimated kernel density function of the annual population growth rate for 117 sectors of Gikongoro[22]. The range between the minimum and maximum annual population growth is very large. Moreover, we observe that the curve is asymmetrical.

The shape of the density function can largely be explained by three facts. First, during the 1990-2002 period, quite a few sectors had an annual population growth close to 1.8%. Second, only a handful of sectors had an annual population growth above 5%. This stems from the fact that Gikongoro has few trading centers and only one small urban hub, Gikongoro City. Finally, there were 37 sectors with a negative population growth, including six with an annual population decrease of more than 5%. This explains

[22]Kernel density estimators approximate the density function $f(x)$ from observations on x. So, basically they give the probability of observing x_i (population growth of sector i) in the sample. Consequently, the estimates of $f(x)$ integrate to 1. As opposed to frequency tables, kernel density estimates have the advantage of being smooth and of being independent of the choice of origin. More formally, the data is divided into intervals and estimates of the density at the centre of the interval are produced. The intervals are allowed to overlap. The smoothness of the figure depends on the width of the interval chosen. In Figure 1, the width is set at 0.84.

Table 1.4: Relationship between the proportion of Tutsi in 1990 and the mean annual population growth between 1990 and 2002 for 117 sectors of Gikongoro

Proportion of Tutsi in the sector (1990)	Number of observations	Mean annual population growth 1990-2002 (%)	95% confidence interval
<5%	46	2.02	[1.39 - 2.65]
5-10%	14	1.39	[0.76 - 2.02]
10-20%	17	0.62	[-0.40 - 1.63]
20-40%	17	-0.22	[-1.66 - 1.21]
>40%	23	-1.10	[-2.61 - 0.42]
Total	117	0.81	[0.29 - 1.32]

Source: Local population data for 117 sectors of Gikongoro, for 1990 and 2002

the bump in the left tail of the density function.

We expect to find that the sectors whose population growth rates are shown in the left tail of the figure were those with the largest proportion of Tutsi in 1990. A comparison between Maps 1.A.1 and 1.A.2 in the appendix provides us with preliminary evidence. The south-eastern part of Gikongoro is an especially striking illustration of the relationship between the proportion of Tutsi in 1990 and population decline. This relationship is somewhat less evident in the center of the prefecture, around Gikongoro City, but it is again pronounced in the north-eastern part of Gikongoro. This visual impression is confirmed by Table 1.4. Here the sectors were divided into five categories according to the proportion of Tutsi in the sector. The categories are the same as those used to color the sectors in Map A1. The mean annual population growth rate clearly declines across the five categories, from 2.02% for sectors with less than 5% Tutsi, to -1.10% for sectors with more than 40% Tutsi.

Estimation of the survival chance of Tutsi in Gikongoro

The relationship between the proportion of Tutsi in 1990 in a sector and population growth can be used to estimate the survival chance of Tutsi in Gikongoro Prefecture. The population in sector i in 2002 can be expressed as follows:

$$P_{2002,i} = P_{1990,i}(1 - T_i\delta_i)(1 + g_i)^{11.5}$$

with

$P_{2002,i}$: the population of sector i in June 2002

$P_{1990,i}$: the population of sector i in December 1990

T_i : the ratio of Tutsi to the total population in sector i in 1990

δ_i : the proportion of Tutsi killed in sector i in 1994

g_i : birth rate (BIR_i) - net emigration rate ($neMIG_i$) - mortality rate (MOR_i) (besides the mortality rate of Tutsi during the genocide) in sector i between December 1990 and June 2002

11.5 years : time span between December 1990 and June 2002.

Taking logarithms and rearranging (1.1) we obtain:

$$\begin{aligned} G_i &= (\frac{1}{11.5}) \times \ln(1 - T_i\delta_i) + \ln(1 + g_i), \\ \text{with } G_i &= (\frac{1}{11.5}) \times \ln(\frac{P_{2002,i}}{P_{1990,i}}) : \text{ the annual population growth rate in sector } i. \end{aligned}$$

Since we do not know BIR_i, $neMIG_i$, and MOR_i, we cannot directly derive δ_i from equation (1.2). However, we can obtain an estimated value for the average proportion of Tutsi killed (δ_i) by estimating the following equation with nonlinear least squares (NLS):

$$G_i = (\frac{1}{11.5}) \times \ln(1 - T_i\delta) + \alpha + \varepsilon_i \qquad i = 1, \ ..., N = 117, \qquad (1.1)$$

with α a constant, equal to the average value of $ln(1 + g_i)$ over the 117 sectors. The NLS estimator for δ is consistent if the disturbances ε_i are independently and identically distributed with expected value zero and finite variance σ^2 (Malinvaud, 1970). This condition implies that the proportion of Tutsi in 1990 in sector i is uncorrelated with the net emigration rate, the birth rate and the non-genocide mortality rate. Formally:

$$Cov\{T, neMIG\} = 0 \qquad (A\ 1)$$

$$Cov\{T, BIR\} = 0 \qquad (A\ 2)$$

$$Cov\{T, MOR\} = 0. \qquad (A\ 3)$$

In what follows, I proceed in two steps. First, I discuss the plausibility of assumptions (A1), (A2) and (A3) and present variables that may proxy $neMIG_i$, BIR_i and MOR_i. If these variables are good proxies, the assumptions can be relaxed. Second, I estimate equation (1.3) to obtain the survival rate for Tutsi in Gikongoro.

Four different forms of migration can be distinguished: migration in search of cultivatable land, migration to urban areas, female exogamy and distress migration in response to insecurity. The latter form may cause correlation between T_i and $neMIG_i$. It is believed that two million people from all parts of Rwanda were displaced during the genocide. The vast majority of them were Hutu who fled in fear of the advancing RPF army. Most of them returned to their homes after spending some months or even years in refugee camps. But, some, especially Hutu men who took part in the genocide, did not return. If these men came from sectors with a high Tutsi population prior to 1994, $Cov\{T_i, neMIG_i\} > 0$. In addition, after the genocide, and upon the death of their husband, widows may have chosen to move back to their native sector. This choice might have been motivated by the desire to move away from their assailants or the place of terror, or by the search for land[23]. Also, upon the destruction of their houses, many Tutsi survivors were left without shelter. They might have moved to so-called *imidugudu*, houses provided under a government housing project. Again, the result would be that $Cov\{T_i, neMIG_i\} > 0$. On the other hand, the death toll of the genocide resulted in a decline in the labor-land ratio in sectors with a high ratio of Tutsi (T_i). This may have attracted farmers from other sectors, such that $Cov\{T_i, neMIG_i\} < 0$.

The birth rate is the ratio of live births to the population. According to the 1991 census report, Tutsi women gave birth to fewer children (TFR = 5.82) than Hutu women (TFR = 7.40) (SNR, 1994), such that $Cov\{T_i, BIR_i\} < 0$. Considering that both ethnic groups have shared a common history and lifestyle since centuries, this difference seems quite large. Rather than stemming from different social values and cultural norms, it may result from under-reporting of births by Tutsi parents (cf. discussion in table 1.A.2 in the appendix).

As to the mortality rates, ideally, one should control for the number of Hutu casualties in a sector. A relatively small number of Hutu were killed because they opposed the genocide. In addition, the RPF killed an unknown number of Hutu in the course of combat and in acts of revenge after the genocide. Moreover, acts of sexual violence were frequent during the genocide. Therefore, AIDS may have increased mortality rates after 1994, such that $Cov\{T_i, MOR_i\} > 0$.

If any one of three assumptions is violated, the estimate for δ (proportion of Tutsi killed during the genocide) will be inconsistent. Such omitted variable bias can be reduced by including proxies for $neMIG_i$, BIR_i and MOR_i. However, data at the sector level are limited. Besides T_i (the ratio of Tutsi in 1990), the available variables are: total

[23] Especially if a widow has no sons recognized by her family-in-law, her customary right to land might be challenged.

population in 1990 and 2002, the sex ratio in 1990 and 2002, and the area (km^2) of each sector[24]. To control for emigration trends in the sectors prior to the genocide, I will use three indicators: population density in sector in 1990, the square of this density and the sex ratio in 1990. Density represents pressure on land and may capture both migration in search for cultivatable land and rural-urban migration in the absence of war. The sex ratio in 1990 may also be informative about future migration: a high proportion of women may be linked to a continued tradition of male emigration which gives rise to female exogamy.

Based on the previous discussion, I estimated several models based on equation (1.3), including on the right hand side the population density in 1990, the squared population density in 1990 and the sex ratio in 1990. The results of model A are presented in the first column of Table 1.5[25]. The estimate for the coefficient δ is 0.745, suggesting that about three out of four Tutsi were killed in 1994. This point estimate lies within a fairly narrow 95% confidence interval of [0.649, 0.841].

The spatial pattern of killings in Gikongoro

For a more in-depth analysis of the geographical pattern of killings, I plotted the 117 data points in Figure 1.2. The horizontal axis measures the proportion of Tutsi in 1990 (T_i). The curve represents the estimated relationship between T_i and G_i : $(\frac{1}{11.5}) \times \ln(1 - T_i\delta)$. Its slope is $-\delta \times (\frac{1}{11.5}) \times (\frac{1}{1-T_i\delta})$ with $\delta = 0.75$.

The dots around the curve are the error terms of equation (1.3), i.e. the deviation from the predicted annual population growth. The curve can be used as a benchmark to identify in which sectors the extent of killings significantly deviated from the mean. Especially in the right segment of the figure, the curve is not a good fit of the data points. This indicates that the genocide was considerable more deadly in some places than in others.

How can the unequal impact of the genocide be explained? One answer may be that in some sectors with a large Tutsi population, the Tutsi succeeded in protecting

[24] In 2002, the country's surface was re-estimated with the help of the Information Management Unit of the United Nations Development Programme (IMU/UNDP). In December 2003, I received these data by e-mail from the SNR (Service National de Recensement de Rwanda).

[25] I experimented with the functional form of δ in model A, allowing for nonlinearities in the relationship between δ and T_i, but the alternative models were rejected in favour of model A. Finally, I performed a model-specification link test for single-equation models. The test result fails to reject the assumption that the model is correctly specified.

Table 1.5: Proportion of Tutsi killed during the genocide estimated from a NLS regression on the average annual growth rate (1990-2002) for 117 sectors of Gikongoro

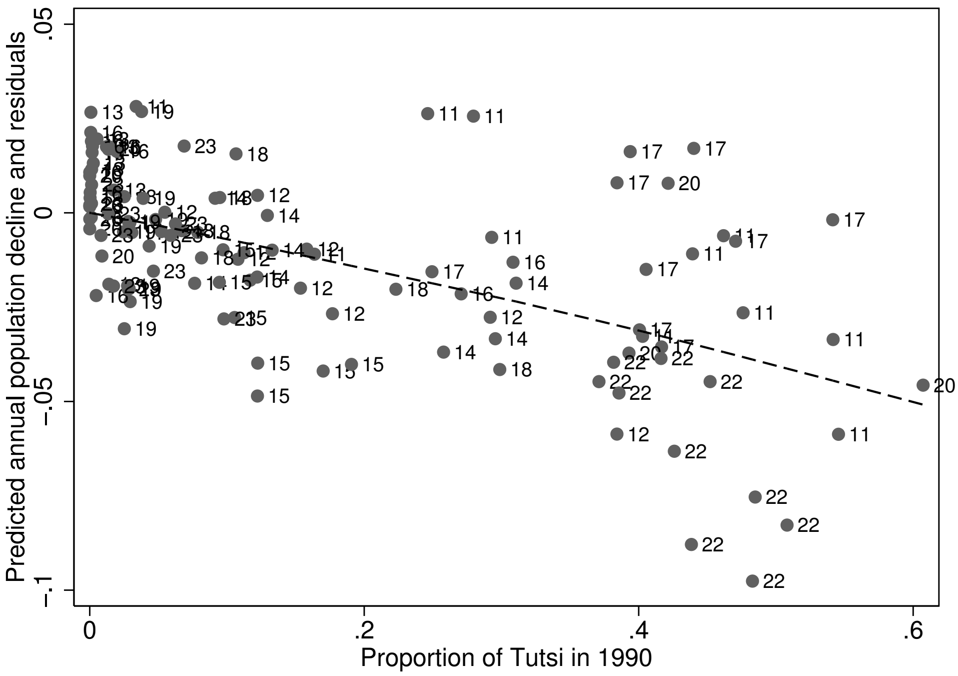
	Model A		Model B		Model C	
Prop. of Tutsi killed during genocide (δ)	0.745*	(0.096)	0.801*	(0.088)	0.340*	(0.107)
Sex ratio in 1990	0.074*	(0.009)	0.044*	(0.010)	0.060*	(0.010)
Pop. density in '90[a]	- 2.0e-04*	(5.3e-05)	- 7.7e-05‡	(4.9e-05)	- 1.3e-04†	(5.1e-05)
Squared pop. density in '90	1.3e-07	(8.2e-08)	1.5e-08	(6.4e-08)	2.7e-08	(6.8e-08)
Communes[b]						
Muko			0.030*	(0.007)		
Musange			0.002	(0.007)		
Nyamagabe			0.031*	(0.008)		
Musebeya			0.010	(0.007)		
Rukondo			-0.020*	(0.008)		
Mudasomwa			0.011	(0.007)		
Karama			-0.001	(0.008)		
Kinyamakara			-0.008	(0.008)		
Kivu			0.009	(0.007)		
Mubuga			-0.024*	(0.008)		
Nshili			1.4 x 10-4	(0.007)		
Mayor opposed					0.005	
Kaduha massacre					-0.024*	
Kibeho massacre					-0.043*	

Notes: standard errors between brackets; significant at the ‡10% level, †5% level, *1% level; the regression equation underlying model (A) was transformed to obtain homoskedastic error terms; inferences are based on Huber/White robust standard errors.[a] To calculate population density we used the local population of 1990 and recent data on surface by sector. In 2002, the country's surface was re-estimated with the help of IMU/UNDP. [b] The reference group in Model (B) is Karambo Commune.

themselves by grouping together to outnumber the attackers (as happened for example at the Catholic diocese of Kabgayi in Gitarama Prefecture). Where this strategy failed, the genocide had devastating consequences (e.g. Kibeho and Kaduha parish in Gikongoro). A second reasoning is that local authorities might have succeeded in some places in resisting the genocide, or at least in slowing it down or weakening its effectiveness. In other sectors and communes, local authorities were actively involved in organizing the killings. The 800-page report by Human Rights Watch (HRW 1999) details the events of the genocide. A comparison of their findings with our data sheds more light on the unequal impact of the genocide. For the purpose of comparison, I numbered the observation points in Figure 1.2, each number corresponding to a commune.

In Figure 1.2, the observations for Mubuga Commune (22) are practically all located well below the line of our benchmark, implying that the Tutsi in Mubuga Commune had a relatively low chance of surviving. The commune counted 43% Tutsi among its

Figure 1.2: Relationship between the proportion of Tutsi in 1990 and the annual population growth rate between 1990 and 2002, estimated for 117 sectors of Gikongoro



Note: The curve is based on the equation: $(1/11.5) * ln(1 - T_i\delta)$ with $\delta = 0.75$ (average proportion of Tutsi killed) and T_i=the proportion of Tutsi in a sector in 1990. The dots are the residuals of regression (A) (See Table 1.5). The numbers correspond to the sectors of the following communes: Muko(11), Musange (12), Musebeya (13), Karambo (14), Rukondo (15), Mudasomwa (16), Nyamagabe (17), Karama (18), Kinyamakara (19), Kivu (20), Rwamiko (21), Mubuga (22), Nshili (23).

population and recorded an annual population growth of -4.74%. The northern part of the commune was most severely hit[26]. This result is supported by the facts that assailants from Rwamiko carried the violence into Mubuga and that a massacre took place at Kibeho parish and college (HRW 1999, p.313). Another commune with a large proportion of Tutsi (43%) is the partly urban commune of Nyamagabe (17). Despite its high proportion of Tutsi, Nyamagabe had an average population growth of 1.0%. At first sight, one might think that urban growth in Nyamagabe would have flattened out the relationship between the genocide and population decline. But, even after controlling for rural-urban migration with the square of population density in model A, the sectors of Nyamagabe are characterized by higher growth figures than those estimated by the

[26]Kibeho, Nyarushishi, Nyarusovu, Nyarwumba and Kabirizi.

model[27]. Also in Muko Commune (11) a considerable number of Tutsi seem to have escaped the killings. It recorded 2.83% growth despite its large Tutsi population (35%). The three sectors that recorded the lowest population growth were those in the east, close to Musange[28]. This might have been because the Tutsi of these sectors tried to take refuge in the church of Kaduha and were slaughtered while on their way or later in the massacre at the church (HRW 1999, p.336). Although Rukondo (15) was largely Hutu (87%), its population declined on average by 1.16%. The sectors that recorded lower than expected population growth were those close to the border with Karambo and Musange[29]. A large number of Tutsi in these sectors may have been victims of the killings at Kaduha parish in Karambo.

The communes discussed till now, Mubuga, Nyamagabe, Muko and Rukondo, show a large difference with respect to the benchmark. For Mubuga and Rukondo this difference points to lower survival chances for Tutsi compared to the benchmark. The opposite is true for Nyamagabe and Muko. For the other communes, the difference is not pronounced or only noteworthy for one or two sectors of the commune[30]. A new model was estimated, including dummy variables for the communes (Model B, Table 1.5). The reference group was Karambo Commune. The estimated coefficients of Muko

[27] This result depends on the square of population density being a good proxy to capture migration. To verify this, I used the IHLCS (Integrated Household Living Conditions Survey) (MINECOFIN, 2002) to calculate immigration by commune for Gikongoro (The data cannot be used to calculate emigration at a communal level). The IHLCS has information on 2,461 individuals in Gikongoro. I calculated the proportion of immigrants among these individuals for each commune over the last ten years. It appears that Nyamagabe is indeed the commune with by far the largest proportion of immigrants; 9.4% of its population in 2002 were immigrants who settled in the commune between 1990 and 2002. But, even when introducing the proportion of immigrants into model A, the results for Nyamagabe remain unchanged (these results are not reported, but can be obtained from the author on request).

[28] Sovu, Gitondorero and Yonde

[29] Gikoni, Mbazi and Remera

[30] All sectors of Karambo closely follow the fitted line in Figure 2. This suggests that the genocide in Karambo was neither more nor less severe than the average of Gikongoro. The same applies to Karama. In Kinyamakara, the proportion of Tutsi was very small (3.2%), which makes it difficult to judge whether or not the genocide struck hard. The same is true for Musebeya (0.9%) and Nshili (3.7%). Tutsi were also a small minority in Mudasomwa, but they were almost all concentrated in two sectors bordering Nyamagabe (Nyamigina and Buhoro). Here, the killings appear to have been neither more nor less severe than the average of the prefecture. The eastern part of Kivu counted a sizeable Tutsi population, but the killings do not seem to have been as severe as in Mubuga. Mutovu in particular has much higher than expected population growth; maybe because it is somewhat more distant from Mubuga and Rwamiko, the communes that brought the violence into Kivu. The mayor of Kivu tried to oppose the genocide (HRW 1999, p.303) and he might have achieved some effective opposition in these communes. Finally, in Musange, the killings seem to have been in line with the average. One sector performing worse was Joma, at the crossing of Karambo and Rukondo. This ties in with the fact that attacks in Musange were being launched from Karambo (HRW 1999, p.313).

and Nyamagabe are positive and significant; those for Mubuga and Rukondo are negative and significant. This confirms the conclusions drawn from Figure 1.2.

While discussing Figure 1.2, I pointed to some explanations for the diversity of survival rates across communes and sectors. These explanations can be studied more explicitly. There were three communes where the mayor opposed the genocide (HRW, 1999): Kinyamakare, Kivu and Musebeya. However, the Kinyamakara mayor opposed the massacre only initially, and later even helped to organize the killings in his commune (HRW, 1999, p.340). In model C I added a dummy variable that equals one for the sectors of Kivu and Musebeya (where the mayors did not change their mind about opposing the genocide). The dummies "near Kaduha massacre" and "near Kibeho massacre" equal one when a sector is bordering or not further than one sector distant from one of the two sectors where these massacres took place. I included these two locations since they were the sites of the two worst massacres in Gikongoro Prefecture, each with several thousands of victims. The dummy for the opposition of a mayor has the expected sign, but is not significant. The estimated effect of the massacres is significant and highly negative. Moreover, when adding these dummies in model C, the estimated value for δ decreases considerably, indicating that the massacres at Kibeho and Kaduha accounted for much of the high estimated death toll in Gikongoro Prefecture. HRW (1999, p. 338) reports the killings in Kaduha as follows:

> "As the attacks expanded from one hill to the next and from one commune to another, Tutsi found it impossible to stay in their homes and increasingly difficult to hide with Hutu neighbors. Assailants in Muko, for example, were threatening to make Hutu protectors kill any Tutsi whom they had sheltered. First hundreds, then thousands of people from Musebeya, Muko, Karambo, and Musange Communes gathered at Kaduha parish center, in the church itself, in the adjoining schools, in the health center and in all the spaces in between. Tutsi from more distant regions, like parts of Muko, came first. Tutsi in the immediate vicinity of the church moved there only about April 14, when they were threatened with attacks by Hutu from the hills. Many Tutsi had come on their own, but some had come with the help of local officials, like those transported from Musebeya. In Muko, and perhaps elsewhere, the burgomaster had at first refused to help Tutsi flee to Kaduha, but later changed his position and began encouraging them to go there. Some survivors believe that authorities decided at a meeting at the sub-prefecture to attract Tutsi to Kaduha for one enormous massacre rather than to continue

killing them in smaller numbers throughout the area. Such a decision would have been consistent with the pattern of killings elsewhere in the country."

Conclusion

The genocide was severe in Gikongoro. Making assumptions about the fertitily rate, natural death rate and migration, I calculated that Tutsi in Gikongoro had on average 25% chance of surviving the genocide. Some communes significantly deviated from this benchmark. In several cases, the results for the sectors within a single commune varied considerably. I could explain part of the variation by their proximity to the location of massacres, such as those of Kaduha and Kibeho, or by the spreading of violence from one commune to another[31]. Very few mayors opposed the genocide in Gikongoro. Those who did were eliminated, constrained or started to fear for their own safety (HRW 1999, p.303-352). Although there is no doubt that their opposition saved a number of lives, it did not succeed in preventing the killings. By contrast, the strategy used by the assailants had a strong impact. The genocide was much worse in sectors where assailants convinced Tutsi to gather in Kibeho or Kaduha Parish after which thousands were massacred in these announced places of safety.

Finally, the finding of an extremely deadly genocide in Gikongoro corresponds to previous research. One of the rare studies that use household data to examine the effect of genocide found a survival percentage of only 10.7% in Gikongoro (Verwimp, 2003)[32]. Moreover, the HRW report (1999, p.303) based on testimonies and interviews, summarizes the genocide in Gikongoro as follows:

> "Some of the earliest attacks as well as some of the worst massacres of the genocide took place in Gikongoro. MRDN supporters launched the violence at three points and from there spread it into adjacent areas, much as they expanded disorder outward from Kigali and its vicinity into the prefecture of Gitarama. In some communes, like Musebeya, Kivu and Kinyamakara, administrators opposed the genocide and initially drew strength from the people in their communes who refused to kill. But as prefectural authorities failed to act against the violence and national authorities pressured for more and faster slaughter, they lost power

[31] From Rwamiko to Mubuga, from Mubuga to Kivu, and from Karambo to Musange (HRW, 1999, p. 313).

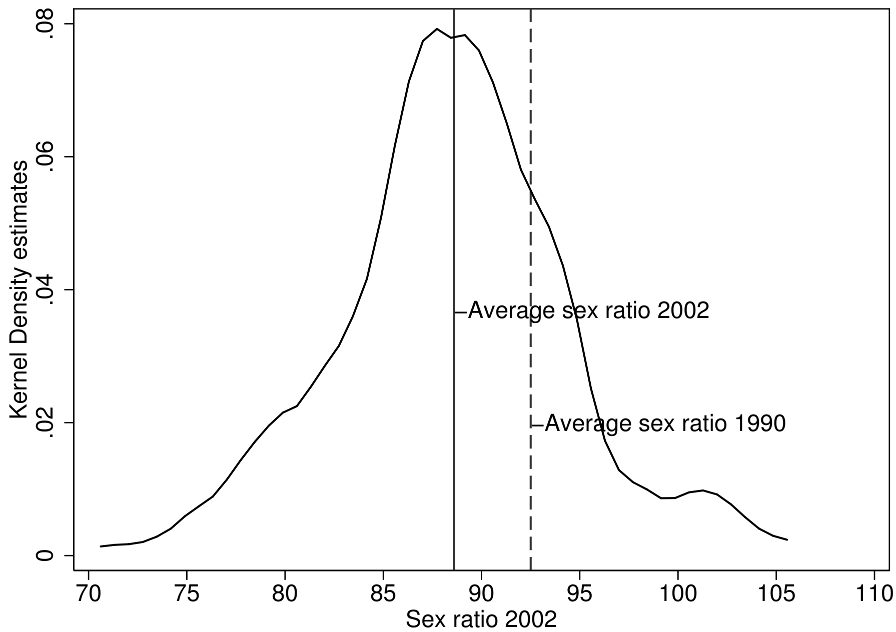
[32] This percentage is based on a very small sample of 28 Tutsi, located in five different sectors: Bitandana, Kibirizi, Gasaka, Kamegeri, Kigoma and Gorwe.

to local rivals who saw the killing campaign as an opportunity to establish or reestablish their power. The dissenters judged continuing opposition futile and dangerous and either withdrew into passivity or themselves took up the role of killers."

1.3.2 The relationship between the proportion of Tutsi and the sex ratio

Preliminary evidence

Figure 1.3: Kernel density of sex ratio in 2002, for 117 sectors in Gikongoro Prefecture



Source: Local population data for 117 sectors of Gikongoro; for 1990 and 2002.

In this subsection, the geographical pattern of sex ratios in Gikongoro are mapped and explained. Figure 1.3 presents the kernel density function of the sex ratio in 2002 for 117 sectors of Gikongoro. The vertical line at 92.5 represents the average sex ratio in 1990. We note from the density function that by 2002, the mean of the density function had shifted to the left, to 88.6. The density function is quite symmetrical, with a slightly higher frequency of below-average sex ratios. It spans a wide range, from below 75 to above 100. This wide range may stem from the existence of sectors with a high out-migration of men and others with a high in-migration of men, such as sectors with tea plantations. The low mean and relatively thick left tail may be the consequences of war and genocide or of a continued male emigration.

A comparison of Maps 1.A.1 and 1.A.3 in the appendix suggests that the effect of the genocide on the sex ratio is less clear than it was for population growth. We observe low sex ratios in Mubuga, Rwamiko and in some parts of Rukondo, Karambo and Muko. From Table 1.6 we note a rather weak negative relationship between the proportion of Tutsi in a sector and the sex ratio in 2002. For a more detailed analysis, I now proceed as in the previous section, with a regression analysis and a plot of the observations.

Table 1.6: Relationship between the proportion of Tutsi (1990) and the sex ratio (2002) for 117 sectors of Gikongoro

Proportion of Tutsi in the sector (1990)	Number of observations	Mean sex ratio 2002	95% confidence interval
<5%	46	89.9	[88.3 - 91.5]
5-10%	14	91.5	[88.2 - 94.8]
10-20%	17	86.4	[84.1 - 88.8]
20-40%	17	87.5	[85.7 - 89.4]
>40%	23	86.4	[83.8 - 88.9]
Total	117	88.6	[87.5 - 89.6]

Source: Local population data for 117 sectors of Gikongoro, for 1990 and 2002.

Estimation of the survival chance of Tutsi men and women in Gikongoro

The sex ratio in 2002 can be written as follows:

$$SR_{2002,i} = SR_{1990,i}\left[(1 - Tm_i\delta m_i)(1 + gm_i)^{11.5}/(1 - Tw_i\delta w_i)(1 + gw_i)^{11.5}\right] \qquad (1.2)$$

with

$SR_{2002,i}$: the sex ratio in June 2002 in sector i

$SR_{1990,i}$: the sex ratio in December 1990 in sector i

gm_i : male birth rate - net emigration rate - mortality rate (excluding the mortality rate of Tutsi men during the genocide) in sector i

gw_i : female birth rate - net emigration rate - mortality rate (excluding the mortality rate of Tutsi women during the genocide) in sector i

Tm_i : the ratio of Tutsi men to total men in sector i in 1990

Tw_i : the ratio of Tutsi women to total women in sector i in 1990

δm_i : the proportion of Tutsi men killed in sector i in 1994

δw_i : the proportion of Tutsi women killed in sector i in 1994

11.5 years : time span between December 1990 and June 2002.

Taking logarithms and rearranging (1.4), we obtain:

$$\begin{aligned} \ln(SR_{2002,i}) &= \ln(SR_{1990,i}) + \ln(1 - Tm_i\delta m_i) - \ln(1 - Tw_i\delta w_i) \\ &\quad +11.5 \times \ln(1 + gm_i) - 11.5 \times \ln(1 + gw_i). \end{aligned} \tag{1.3}$$

Again, we do not have sufficient information (about gm_i and gw_i) to directly derive δm_i and δw_i from (1.5). I therefore estimate the following equation[33] with NLS:

$$\begin{aligned} \ln(SR_{2002,i}) &= \ln(SR_{1990,i}) + \ln(1 - Tm_i\delta m) - \ln(1 - Tw_i\delta w) + \beta + \varepsilon_i \\ i &= 1,\ ..., N = 117, \end{aligned} \tag{1.4}$$

with β the average difference between $11.5 \times \ln(1 + gm_i)$ and $11.5 \times \ln(1 + gw_i)$ for the 117 sectors of Gikongoro. A necessary condition for consistency of the NLS estimate for δm and δw is that T_i does not correlate with $neMIG_{i,men/women}$ and $MOR_{i,men/women}$, i.e. the ratio of the net-emigration of men to the net-emigration of women, and the ratio of the mortality of men to the mortality of women. Formally:

$$Cov\left\{T_i, neMIG_{i,men/women}\right\} = 0 \tag{A 4}$$

$$Cov\left\{T_i, MOR_{i,men/women}\right\} = 0 \tag{A 5}$$

These assumptions might be violated. On the one hand, if T_i is strongly correlated with casualties of Hutu men, then $Cov\left\{T_i, MOR_{i,men/women}\right\} > 0$. On the other hand, if sexual violence during 1994 resulted in HIV/AIDS infections and other sexually transmitted diseases, then $Cov\left\{T_i, MOR_{i,men/women}\right\} < 0$. Furthermore, if many Tutsi widows moved out of their sector after the genocide, $Cov\left\{T_i, neMIG_{i,men/women}\right\} < 0$. However, if alleged (mostly male) perpetrators of the genocide took refuge abroad and

[33] The equation (II.3) is estimated under the constraint that $\delta w = [\delta - \delta m \times (Tutsi\ men\ /\ total\ Tutsi)]\ /\ (Tutsi\ women\ /\ total\ Tutsi)$

Table 1.7: Proportion of Tutsi men and women killed during the genocide estimated from a NLS regression on the (log) sex ratio in 2002 for 117 sectors of Gikongoro

	Model D		Model E		Model F	
Prop. of Tutsi men killed in genocide (δ_m)	0.791*	(0.016)	0.768*	(0.025)	0.763*	(0.018)
Prop. of Tutsi women killed in genocide (δ_w)	0.710*	(0.016)	0.732*	(0.025)	0.737*	(0.018)
Log sex ratio in 1990	0.047	(0.098)	0.161	(0.106)	0.041	(0.100)
Pop. density in 1990[a]	-5.8e-04*	(9.3e-05)	-3.4e-04‡	(1.7e-04)	-6.3e-04*	(9.7e-05)
Squared population density in '90	7.2e-07*	(1.8e-07)	5.4e-07†	(2.6e-07)	7.5e-07*	(1.8e-07)
Communes[b]						
Muko			-0.073‡	(0.039)		
Musange			-0.067‡	(0.040)		
Nyamagabe			-0.045	(0.047)		
Musebeya			-0.031	(0.043)		
Rukondo			-0.063	(0.045)		
Mudasomwa			-0.054	(0.039)		
Karama			-0.090‡	(0.047)		
Kinyamakara			-0.073	(0.046)		
Kivu			0.018	(0.043)		
Mubuga			-0.140*	(0.049)		
Nshili			-0.057	(0.039)		
Mayor opposed					0.036	(0.036)
Kaduha massacre					-0.001	(0.028)
Kibeho massacre					-0.073†	(0.036)

Notes: standard errors between brackets; significant at the ‡10% level, †5% level, *1% level.
[a]To calculate population density we used the local population of 1990 and recent data on surface by sector. In 2002, the country's surface was re-estimated with the help of IMU/UNDP.
[b]The reference group in Model (E) is Karambo Commune.

did not return, the reverse is true: $Cov\left\{T_i, neMIG_{i,men/women}\right\} > 0$.

To reduce omitted variable bias, I added the population density in 1990 and the squared population density in 1990 to equation (1.6). The latter variable may capture rural-urban migration of men. The sex ratio of 1990, which is included in (1.6) controls for inertia in the sex ratio, and may capture migration between 1990 and 2002. Table 1.7 shows the results. In model D the estimated values for the parameters δm and δw are respectively 0.791 and 0.710 and they are significant. The link-test fails to reject the null hypothesis that the model is correctly specified. We may conclude that whereas Tutsi men had a 21% chance on average of surviving the genocide, the survival rate for Tutsi women was not much higher, only 29%. This small difference is in line with the observation of Human Rights Watch (HRW 1999, p. 296) that in 1994 assailants did not often spare the lives of Tutsi women.

> "In many communities women and children who had survived the first weeks of the genocide were slain in mid-May. In the past Rwandans had not usually killed women in conflicts and at the beginning of the genocide assailants often spared them. When militia had wanted to kill women during an attack in Kigali in late April, for example, Renzaho (Colonel, and prefect of Kigali) had intervened to stop it. Killers in Gikongoro told a woman that she was safe because 'Sex has no ethnic group'. The number of attacks against women, all about at the same time, indicates that a decision to kill women had been made at the national level and was implemented in local communities. Women who had been living on their own as well as those who had been kept alive to serve the sexual demands of their captors were slaughtered."

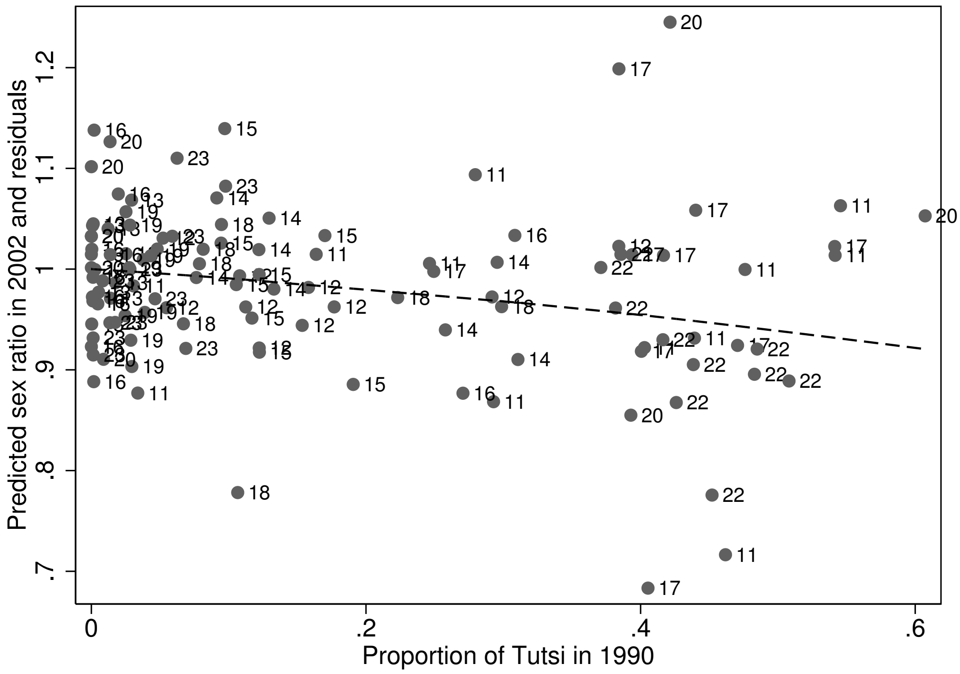
The spatial pattern of survival chances of Tutsi men and women in Gikongoro

In order to explain the geographical pattern of sex ratios. I plotted the observation points in Figure 1.4. The horizontal axis measures the proportion of Tutsi in a sector. The curve gives the estimated relationship between T_i and $SR_{2002,i}$: $\frac{(1-Tm_i\delta m)}{(1-Tw_i\delta w)}$, with $\delta m = 0.79$ and $\delta w = 0.71$, and respective 95% confidence intervals [0.775, 0.807] and [0.694, 0.726]. The dots are the error terms from equation (1.6), i.e. the deviation from the predicted sex ratio. Figure 1.4 shows considerable variation around the curve, with the sectors of Nyamagabe and Muko Commune lying both far below and far above the curve. Only the sectors of Mubuga Commune show a clear pattern below the benchmark. In regression E, Mubuga has a coefficient that is highly negative and significantly different from zero. This corresponds to our earlier discussion were we found that the genocide was particularly severe in Mubuga commune. In regression F, the coefficient for the dummy of the Kibeho massacre in Mubuga Commune is significantly negative.

1.4 Conclusion

This chapter provides evidence for the allegation that the number of Tutsi in the 1991 population census was under-reported. This allegation has often been made on the basis of two arguments. On the one hand, because of its ethnic quota policy, the Rwandan government had a motive for under-reporting the proportion of Tutsi in the population. On the other hand, Tutsi themselves, trying to avoid discrimination, had a motive to register

Figure 1.4: Relationship between the proportion of Tutsi in 1990 and the sex ratio in 2002, estimated for 117 sectors of Gikongoro



Note: The curve is based on the equation: $(1 - Tm_i\delta m)/(1 - Tw_i\delta w)$ with $\delta m = 0.79$ (average proportion of Tutsi men killed), $\delta w = 0.71$ (average proportion of Tutsi women killed),Tm_i=the proportion of Tutsi men in a sector in 1990 and Tw_i=the proportion of Tutsi women in a sector in 1990. The dots are the residuals of regression (D) (See Table 1.7). The numbers correspond to the sectors of the following communes: Muko(11), Musange (12), Musebeya (13), Karambo (14), Rukondo (15), Mudasomwa (16), Nyamagabe (17), Karama (18), Kinyamakara (19), Kivu (20), Rwamiko (21), Mubuga (22), Nshili (23).

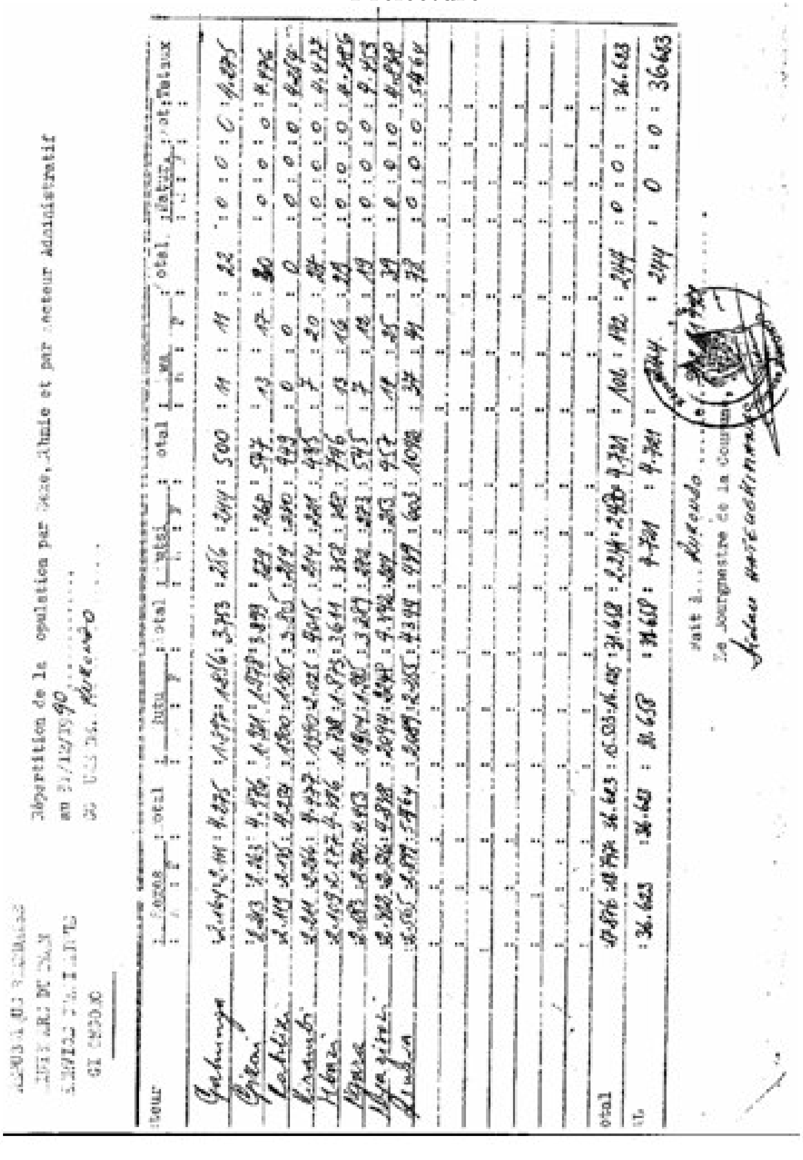
as Hutu. The evidence presented stems from a comparison between the 1991 census and 1990 population data from the local administration of Gikongoro Prefecture. The former reported 12.8% Tutsi in the population of Gikongoro, while the latter contained a much higher proportion of Tutsi, 17.5%. By contrast, other population characteristics, such as population size and the sex ratio hardly differed across these data sources. If the extent of under-reporting was similar in other prefectures, the number of Tutsi at the outbreak of the genocide would have been about 40% higher than the number extrapolated from the 1991 census.

After the genocide, the Rwandan government no longer reported ethnic identity in the population statistics. This complicates the estimate of Tutsi survivors of the genocide. Using the local population data of Gikongoro Prefecture and making assumptions about the ferility rate, natureal death rate and migration, I estimate that only 25% of Tutsi in Gikongoro survived. Some communes in Gikongoro clearly deviated from this benchmark. Especially in Mubuga and Rukondo the genocide was much more deadly. The opposite was true for Nyamagabe and Muko. The location of huge massacres and the way violence spread across communes were strong determinants of the survival chance of Tutsi in a sector. The opposition of local authorities in Gikongoro did not make a significant difference. The lives of Tutsi women in Gikongoro were not spared: it is estimated that Tutsi women had on average 29% chance of surviving, compared with a 21% chance for Tutsi men.

Gikongoro is only one of the eleven prefectures in Rwanda, accounting for less than 7% of the total population and about 10% of the Tutsi population. Extrapolating the evidence from Gikongoro to the whole of Rwanda cannot therefore provide a sound estimate of the overall death toll of the genocide. However, the case of Gikongoro brings the estimated death toll closer to its true value and narrows the interval around the estimate. Based on the presented evidence and a sensitivity analysis, I estimate that the number of Tutsi killed during the genocide lies between 600,000 and 800,000, and that only 25 to 30% of the Tutsi population survived the genocide of 1994.

1.A Appendix

Table 1.A.1: An example of the population data of the local administration of Gikongoro Prefecture



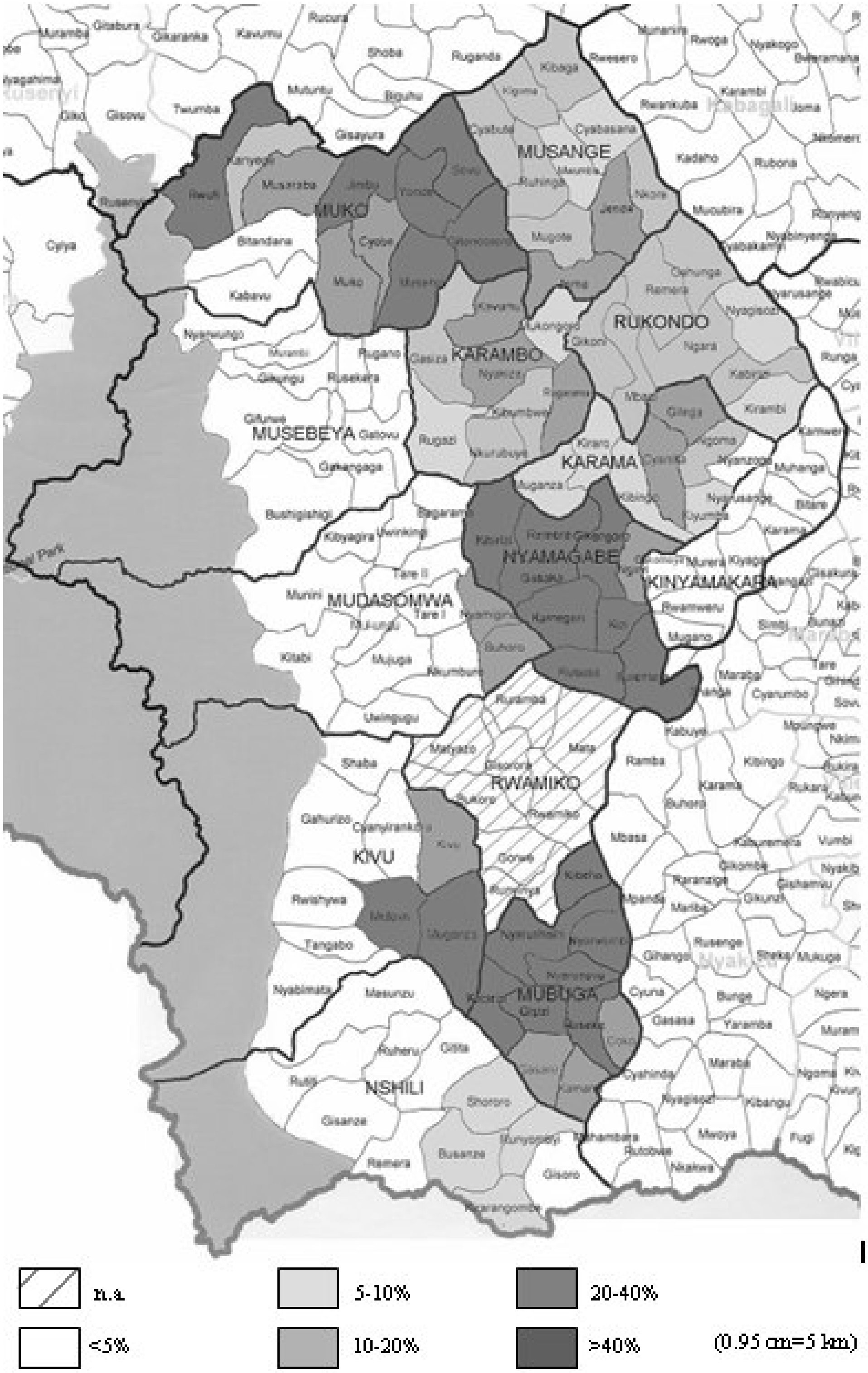
Répartition de la population par sexe, ethnie et par secteur administratif

au 31/12/1990

Fait à ... Rukondo

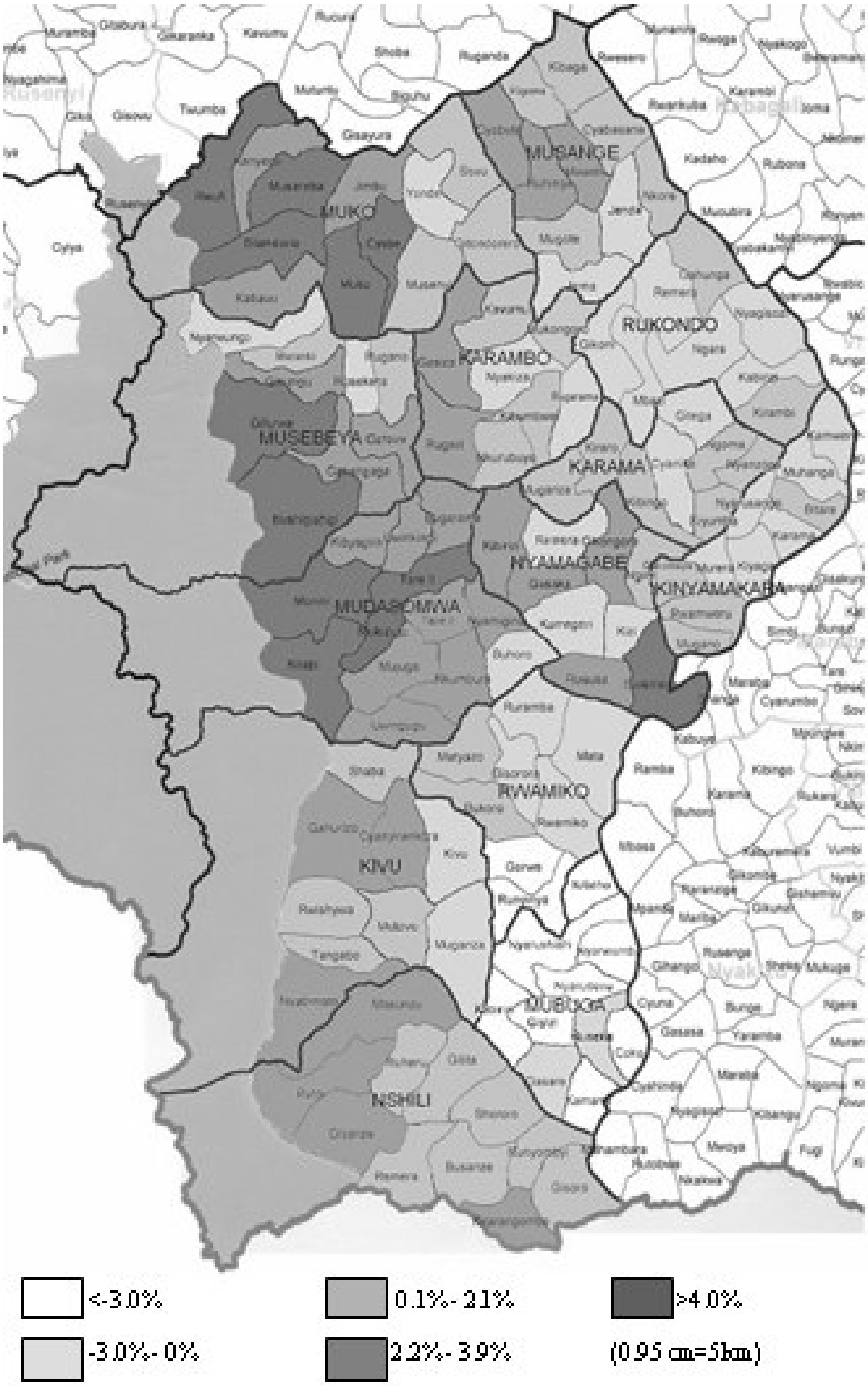
Le bourgmestre de la Commune

Map 1.A.1: The proportion of Tutsi at the sector level in Gikongoro Prefecture, 1990



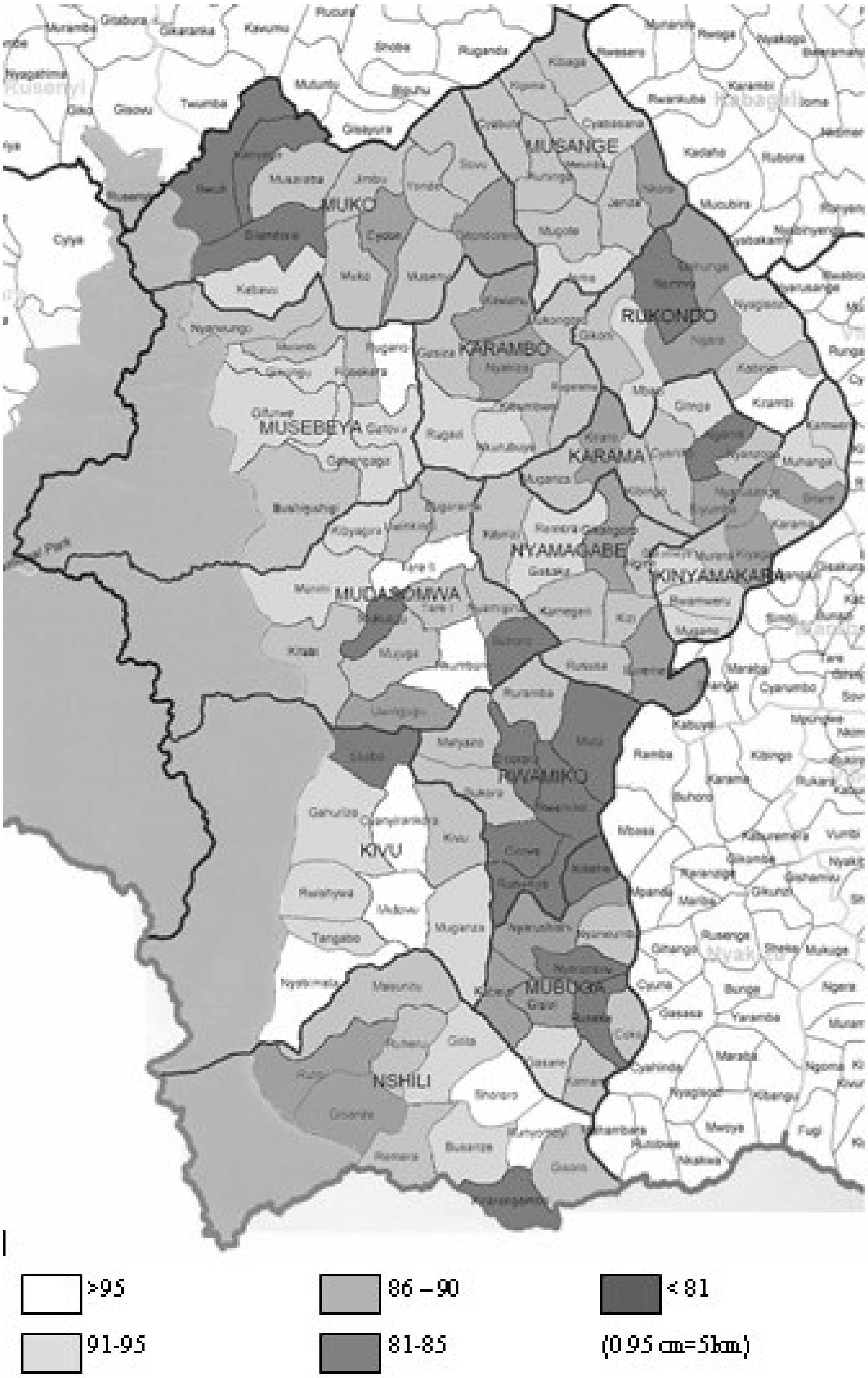
Source: local population data for 117 sectors of Gikongoro, 1990.

Map 1.A.2: Annual population growth over 1990-2002 at the sector level in Gikongoro Prefecture



Source: local population data for 117 sectors of Gikongoro, 1990 and 2002.

Map 1.A.3: Sex ratio in 2002 at the sector level in Gikongoro Prefecture



Source: local population data for the sectors of Gikongoro, 2002.

Table 1.A.2: Assumptions underlying the estimate for the genocide's death toll

Assumptions made for the annual population growth rate (for Tutsi) between 1991-1994:	Assumptions made for the number of Tutsi survivors
We estimate the number of Tutsi in July 1994 as follows: $P_{July\ 1994} = (1+0.03)^{time\ span}$ x $P_{August\ 1991}$; $time\ span = 2.96$ years; the annual population growth of 3% is a choice made on the basis of the following: - Between 1978 and 1991 the annual population growth was 3.1% on average. Between 1991 and 2002, it decreased to 1.2%, but this is largely due to high mortality rates during war and genocide. The number of children born per woman remained high, at 5.8 in 2000. It was 8.5 in 1983 and 6.2 in 1992 (ONAPO, 2001). - The high incidence of HIV infection may have increased mortality rates after 1991. However, this is likely to have played a significant role only after 1994, as a result of the displacement of the population during the war and genocide, and sexual violence committed on a large scale. - The 1991 census reports a lower fertility rate among Tutsi, and a lower population growth for Tutsi between 1978 and 1991 (1.9% versus 3.2% for Hutu). This difference might stem from the fact that more Tutsi live in urban areas than Hutu. However, it might also be a consequence of less underreporting of Tutsi in the 1978 census than in the 1991 census, which was carried out in a climate of civil war and great fear among Tutsi. This may not only have affected recorded growth rates for Tutsi, but also the recorded fertility. To increase the chances of enrolling their children in public high schools, Tutsi parents used to make arrangements with Hutu friends to adopt their children before they completed primary school. Officially belonging to their Hutu adoptive family, these children were recorded as Hutu in the census. - To study the sensitivity of the death toll among Tutsi to the assumed population growth rate, I repeated the calculations using an annual growth rate of 2 %.	We make three assumptions regarding the survival rate: - 150,000 Tutsi survived: these are the survivors counted by aid organizations at the end of July 1994. - 25% survived: section 3 of this paper estimated the survival rate in Gikongoro at 25 %. - 30% survived: together with Butare and Kibuye, Gikongoro is one of the prefectures believed to have suffered most from the genocide. Therefore, it is likely that the survival rate for the whole of Rwanda lies above 25%. HRW (1999) estimates that 25% of Tutsi in Butare survived. Verwimp (2003a) finds that less than 25% of Tutsi in Kibuye survived (based on a large data set from IBUKA), while more than 50 % in Gitarama (based on a small household data set).

Table 1.A.3: Sensitivity analysis assuming an annual population growth rate of 3 %

Scenarios for the reliability of the census report	Tutsi population in August 1991	Tutsi in July 1994, "no genocide scenario"	Number of survivors (and %) at the end of July 1994	Number of Tutsi killed	Tutsi killed as % of total Tutsi population in 1994
No under-reporting[a]	596,400 (8.40%)	650,900	150,000 (23.0%)	500,900	77.0
			162,700 (25.0%)	488,200	75.0
			195,300 (30.0%)	455,700	70.0
Under-reporting of 40 %, only in Gikongoro[b]	621,700 (8.76%)	678,500	150,000 (22.1%)	528,900	77.9
			169,600 (25.0%)	508,900	75.0
			203,600 (30.0%)	475,000	70.0
Under-reporting of 50 %, only in Gikongoro[c]	627,700 (8.84%)	685,100	150,000 (21.9%)	535,100	78.1
			171,300 (25.0%)	513,800	75.0
			205,500 (30.0%)	479,600	70.0
Under-reporting of 40 % in Butare, Gikongoro, Kibuye and Kigali City[d]	717,300 (10.10%)	782,900	150,000 (19.2%)	632,900	80.8
			195,700 (25.0%)	587,200	75.0
			234,900 (30.0%)	548,000	70.0
Under-reporting of 50 % in Butare, Gikongoro, Kibuye and Kigali City[d]	747,100 (10.52%)	815,400	150,000 (18.4%)	665,400	81.6
			203,900 (25.0%)	611,600	75.0
			244,600 (30.0%)	570,800	70.0
Under-reporting of 40 %, only in Gikongoro[e]	837,100 (11.79%)	913,600	150,000 (16.4%)	763,600	83.6
			228,400 (25.0%)	685,200	75.0
			274,100 (30.0%)	639,500	70.0
Under-reporting of 50 %, only in Gikongoro[e]	896,900 (12.63%)	978,900	150,000 (15.3%)	828,900	84.7
			244,700 (25.0%)	734,200	75.0
			293,700 (30.0%)	685,200	70.0

[a]Given the evidence presented in the second section of this chapter, this scenario is highly unlikely. [b]It is hard to believe under-reporting would be limited to one prefecture. This scenario implies a proportion of 28% of Tutsi in Rwamiko (the commune with the missing data), and on average 18% in Gikongoro. [c]There are several reasons to assume that the proportion of Tutsi in Rwamiko was high. This scenario implies a proportion of 45% Tutsi in Rwamiko, and on average 19% in Gikongoro. [d]This type of under-reporting would leave the ranking of prefectures by ethnicity intact. [e]This scenario is plausible. The relative proportions of Tutsi in the different prefectures would be maintained.

Table 1.A.4: Sensitivity analysis assuming an annual population growth rate of 2 %

Scenarios for the reliability of the census report	Tutsi population in August 1991	Tutsi in July 1994, "no genocide scenario"	Number of survivors (and %) at the end of July 1994	Number of Tutsi killed	Tutsi killed as % of total Tutsi population in 1994
No under-reporting[a]	596,400 (8.40%)	632,400	150,000 (23.7%)	482,400	76.3
			158,100 (25.0%)	474,300	75.0
			189,700 (30.0%)	442,700	70.0
Under-reporting of 40 %, only in Gikongoro[b]	621,700 (8.76%)	659,200	150,000 (22.8%)	509,200	77.2
			164,800 (25.0%)	494,400	75.0
			197,800 (30.0%)	461,500	70.0
Under-reporting of 50 %, only in Gikongoro[c]	627,700 (8.84%)	665,600	150,000 (22.5%)	515,600	77.5
			166,400 (25.0%)	499,200	75.0
			199,700 (30.0%)	465,900	70.0
Under-reporting of 40 % in Butare, Gikongoro, Kibuye and Kigali City[d]	717,300 (10.10%)	760,600	150,000 (19.7%)	610,600	80.3
			190,200 (25.0%)	570,500	75.0
			228,200 (30.0%)	532,400	70.0
Under-reporting of 50 % in Butare, Gikongoro, Kibuye and Kigali City[d]	747,100 (10.52%)	792,200	150,000 (18.9%)	642,200	81.1
			198,100 (25.0%)	594,200	75.0
			237,700 (30.0%)	554,500	70.0
Under-reporting of 40 %, only in Gikongoro[e]	837,100 (11.79%)	887,600	150,000 (16.9%)	737,600	83.1
			221,900 (25.0%)	665,700	75.0
			266,300 (30.0%)	621,300	70.0
Under-reporting of 50 %, only in Gikongoro[e]	896,900 (12.63%)	951,000	150,000 (15.8%)	801,000	84.2
			237,800 (25.0%)	713,300	75.0
			285,300 (30.0%)	665,700	70.0

[a]Given the evidence presented in the second section of this chapter, this scenario is highly unlikely. [b]It is hard to believe under-reporting would be limited to one prefecture. This scenario implies a proportion of 28% of Tutsi in Rwamiko (the commune with the missing data), and on average 18% in Gikongoro. [c]There are several reasons to assume that the proportion of Tutsi in Rwamiko was high. This scenario implies a proportion of 45% Tutsi in Rwamiko, and on average 19% in Gikongoro. [d]This type of under-reporting would leave the ranking of prefectures by ethnicity intact. [e]This scenario is plausible. The relative proportions of Tutsi in the different prefectures would be maintained.

Chapter 2

Cattle sales in war- and peacetime: a study of household coping in Rwanda, 1991-2001

2.1 Introduction

In times of natural disaster, a large part of the population may face life-threatening food shortages. In some cases, the international community reacts with food aid. The case of the Asian Tsunami (December 2004) is a recent example. In times of violent conflict, the threat of food insecurity may be comparable, and food aid may be as needed, but the response of international donors is likely to be much less generous, as illustrated by the ongoing crisis in Darfur. As a result households affected by violent conflict need to rely mainly on their own coping strategies to deal with an income shortfall.

To what extent can households keep up with food consumption during wartimes? Which coping strategies fail and which ones are effective? Answering these questions not only sheds light on the ability of households to cope with crises when aid is absent, but also leads to a better understanding of the kind of aid and targeting that are required to allow households to use their own coping strategies, both during and after times of violent conflict.

Despite the prevalence of civil war in many parts of the developing world, little is known about household responses to adverse income shocks stemming from violent conflict. In contrast, household responses to other sources of income shortfall, such as rainfall irregularities and illness, have been extensively examined in the literature[1]. According to this literature, rural households use several coping strategies, such as informal insurance through social networks, the reorganization of household units, temporary migration, and the depletion of assets to purchase food.

To a large extent, the existing literature on coping strategies in peacetime can be applied to the analysis of household responses in wartime. Indeed, much like a widespread harvest failure, political unrest may lead to increased food insecurity urging households to use one or several of their coping strategies. On the other hand, household strategies in wartime may differ from those in peacetime depending e.g. on the length of the war and the lack of safety created by killing and looting soldiers or rebel groups. This lack of safety restricts the movement of people and the distribution of food aid, making households dependent on a restricted set of their own coping strategies.

In order to gain insight in the ability of households to cope with adverse income shocks all household coping strategies should be studied simultaneously. However, because of data limitations, I focus on one single strategy, i.e. the depletion of cattle in rural Rwanda during the period 1991-2001. I study whether peasant households used cattle sales to compensate for an income shortfall following political unrest and other adverse income shocks. The use of cattle to buffer consumption against income shocks has been studied in peacetime, but not in wartime. Therefore, the main contribution of this study lies in the comparison of cattle sale behavior in wartime and in peacetime.

There is ample evidence that rural households in developing countries react to adverse income shocks by dissaving (Paxson, 1993; Udry, 1995; Alderman, 1996; Lim and Townsend, 1998). Such behavior is consistent with the permanent income hypothesis and other simple models of consumption smoothing according to which people smooth out fluctuations in income so that they save during periods of unusually high income and dissave during periods of unusually low income (Friedman, 1957; Hall and Mishkin, 1982). It has also long been hypothesized that credit-constrained households which face substantial risk accumulate assets especially for the purpose of consumption smoothing (Zeldes, 1989, Deaton, 1991). Establishing reserves for this purpose is referred to as self-insurance or precautionary savings.

However, it is not clear in which form these savings occur. The portfolio of assets

[1] See for example Alderman, 1996, Asfaw and Von Braun, 2004, Corbett, 1988, Deaton, 1990, Dercon, 1996, Fafchamps, 1998, 2003, Kinsey et al. 1998, Lim and Townsend, 1998, Paxson, 1993, Ravallion, 1997, Morduch, 1990, McPeak, 2004, Rozensweig, 1988, Rozensweig and Wolpin, 1993, Townsend, 1994 and Udry, 1995.

available to rural households in developing countries is far from ideal. Financial savings are often an unattractive option because banks are scarce in rural areas and inflation may be high. Grain stocks may be very useful for smoothing consumption over a short time horizon, but the longer the horizon, the higher the storage losses. In contrast, livestock has a positive return in the form of animal traction, manure, off-spring and milk.

Whether or not Rwandan peasant households keep cattle for self-insurance, i.e. for the purpose of consumption smoothing is not the main concern of this chapter. If they do, there is a high likelihood that households respond to adverse income shocks with cattle sales. But if they do not, this likelihood is not zero, because, even if cattle is not kept as part of a precautionary or insurance strategy to deal with the exposure to recurrent income shocks, cattle sales may be part of a crisis strategy to cope with an unusually severe or unexpected threat to food security, such as the disruption of production by war.

So far, several empirical studies have found evidence for the use of livestock as a buffer in developing countries, either as part of a common strategy or in response to unusual stress (Corbett, 1988; Kinsey et al. 1998, McPeak, 2004, Rozensweig and Wolpin, 1993). However, an equally large number of studies report contradicting results (Fafchamps, 1998, Lim and Townsend, 1998, Udry, 1995). These latter studies point to the difficulties in using livestock as a buffer, such as its lumpiness, its risky return, its terms of trade risk, and the importance of livestock for agricultural production.

In wartime, there may also be difficulties in the use of livestock for consumption smoothing. First, since a violent conflict often affects whole regions or countries, many households may simultaneously want to sell livestock in exchange for food, driving down the prices of livestock compared to food prices (terms of trade risk). In addition, soldiers, rebel groups and road blocks may restrict the movement of people and livestock, and thus livestock sales. On the other hand, if the movement of people is still possible, households may decide to quickly deplete their livestock, in anticipation of an increased risk of livestock raiding or the need to take refuge.

In the theoretical part of this chapter, I present a consumption-smoothing model to illustrate these difficulties and trade-offs associated with the use of cattle for coping with adverse income shocks in wartime. The empirical analysis uses a unique dataset of 258 Rwandan peasant households, collected eight years after the genocide, and including recall information on adverse income shocks, cattle stock and transactions, and household composition. To test whether households sold cattle in response to war-related adverse income shocks and other shocks, I use a direct measure of self-reported shocks for all eleven years within the period 1991-2001.

I find that cattle sales were responsive to adverse income shocks both in peacetime and in wartime. This result should be interpreted with care. The data at hand do not permit a test of the optimal saving behavior as predicted by the permanent income hypothesis, the buffer stock model for precautionary savings or any other model of consumption smoothing. In order to do so, one would need complete data on household consumption, income and savings over time (cf. discussion in Udry, 1995). The relationship between self-reported adverse income shocks and cattle-stock transactions over time can at best provide suggestive evidence of the use of cattle for consumption smoothing. Indeed, this relationship could also be the outcome of a shift in the household asset portfolio composition triggered of by changes in relative asset returns following the shocks.

Therefore, to take the empirical analysis one step further, I distinguish between the different reasons reported for cattle sales, whether motivated by the need to purchase food or by portfolio changes. I repeat the econometric test with cattle sold for the purpose of purchasing food as the explanatory variable. Doing so, the relationship between cattle sales and adverse income shocks becomes weaker in peacetime, but much stronger in wartime. However, although used for this purpose, it is unlikely that cattle sales were effective to buffer consumption against the wartime shocks. First, during the genocide cattle prices fell to less than half of the 1993 cattle price, while food prices soared concurrently. In addition, the risk of cattle raiding was very high during the period of political unrest such that many households that tried to exchange cattle for food may have returned empty-handed. Moreover, I find evidence that the households most targeted in the violence did not sell their cattle in 1994, arguably because of the lack of safety on the roads.

The organization of the chapter is as follows. The next section provides insight in the Rwandan farm and livestock system and the effects of the genocide on food insecurity at the household level. In section three, I discuss the theory and evidence for the role of livestock in coping with adverse income shocks in peacetime. Subsequently, I develop a theoretical framework that illustrates the difficulties associated with the use of livestock for consumption smoothing in wartime. Section four presents summary statistics on shocks and cattle transactions for our sample of 258 households in Gikongoro and Gitarama Province. In section five, I test for the use of cattle sales for coping with adverse income shocks in both war- and peacetime. Section six focusses on cattle purchase behavior and evaluates whether the households in our sample purchased cattle especially for the purpose of consumption smoothing. In section seven, I present some data and results for small livestock, for which the available recall data was much less extended than for cattle. Section eight concludes.

2.2 Rural livelihood, shocks and coping strategies in Rwanda

2.2.1 Farm system and food (in)security

Rwanda is the most densely populated country in Africa. But notwithstanding heavy population pressure, the Rwandan population has remained overwhelmingly rural and dependent on (mainly subsistence) agriculture. The extension of cultivation to unused land has reached its limit. Consequently the average farm size has decreased over time (Clay, 1996; Clay et al, 2002; Government of Rwanda, 2003; Mpyisi et al. 2003). Moreover, land productivity has declined as less fertile land has been taken up for cultivation. Technological progress and agricultural intensification have not yet been able to turn the tide (Clay, 1996; Clay et al., 2002; André and Platteau, 1998; Mpyisi et al. 2003)[2]. The result is a growing number of food insecure households with small and infertile land holdings (McKay and Loveridge, 2005).

Besides structural food insecurity, the Rwandan rural population also regularly faces sharp income fluctuations. Farmers are chronically confronted with livestock, root and crop diseases, but rainfall conditions remain the most important factor in determining the outcome of the season. Insufficient rainfall may result in harvest failure, while heavy rainfall is often associated with a high agricultural output in Rwanda. The downside is that excessive rains aggravate erosion and may cause flooding; washing away young crops (FEWS NET, 2000).

The hardship of rainfall shocks is aggravated by food price increases following widespread harvest failure. Higher prices mean more difficult access to food, especially for the poor who depend on the market for their subsistence. Price increases may be moderated by imports from other areas or from neighboring countries. In Rwanda, the main

[2] The use of improved seeds and fertilizer is very limited in Rwanda, even compared to African standards (World Bank, 2004). Other forms of intensification, such as increased labor input, mixed cropping, and the use of manure are widely applied but cannot sufficiently boost land productivity.

markets for non-perishable commodities, such as cereals and pulses, are well integrated, but those for bulky, perishable commodities such as sweet potatoes, cassava and cooking bananas are poorly integrated. Price hikes, especially for beans, are partly checked by imports from the Democratic Republic of Congo and Uganda. However, despite the market mechanisms, prices of food crops in Rwanda are highly sensitive to weather conditions. They rise as a result of drought-induced production shortfalls, and fall markedly in the face of an optimistic production outlook (FEWS NET, 2000; ADDS rainfall data 1998-2001; PASAR market prices, 1986-2002).

2.2.2 Livestock system

Cattle play an important role in the rural society of Rwanda. They provide their owner with status and prestige, and are exchanged as a sign of a close and enduring bond, for example as part of a bride price (De Lame, 1996; Migeotte, 1997). In economic terms, cattle are valuable for rural Rwandan households, mainly because their manure is widely used as fertilizer[3]. Despite these two distinct roles of cattle, only 30 percent of Rwandan farmers owned cattle in 2000 (Government of Rwanda, 2002b). Cattle ownership drops to 15 percent for the households in the lowest expenditure quintile. The lumpiness of cattle combined with the households' low purchasing power, even in good crop years, may prevent many poor households from accumulating cattle.

It has been estimated that during the genocide of 1994, 80 percent of the cattle stock was lost (FAO, 1997). Looting soldiers, militia and ordinary civilians killed cattle for immediate consumption or to spread terror. Cattle were also lost because of indirect effects of warfare, namely, the lack of pasture, fodder and veterinary attention during the war. Restocking of cattle in the immediate post-war years was slow because of severe rural poverty. But a comparison of two nationwide surveys, of 1990 and 2000, suggests that by 2000 the average number of cattle per farm household almost reached its pre-crisis level of about 0.60 heads (FSRP et al., 1984-1992, Gov. of Rwanda, 2002b)[4].

[3]Cattle are hardly ever slaughtered for meat consumption. If so, the meat mostly goes to urban centers. Animal traction is very rare on the hilly highlands of Rwanda.

[4]A Rwandan farmer household owned on average 0.65 heads of cattle in 1990, compared to 0.60 in 2000. These figures are calculated from respectively the FSRP data and the EICV data (Government of Rwanda, 2002b). The FSRP survey was concerned with agricultural production and did not include pastoral households. The EICV was a nationally representative sample of all types of households. In order to compare cattle ownership across both datasets, I excluded urban households and the households of Umutara province from the EICV data. Many households of Umutare province entered Rwanda after

In a longer time perspective, there is evidence that the average number of cattle per farm household has decreased. According to a nationwide survey of 1984, farm households owned on average 0.75 heads of cattle (FSRP et al., 1984-1992). One explanation of the decrease might be that land scarcity profoundly changed the livestock system. As farmers started to cultivate land previously held in pasture, pasture land became extremely scarce and its access privatized (Clay, 1996; Clay et al., 2002: Mpyisi et al., 2003). A growing number of cattle owners needed to rent in pasture land, or keep their cattle stabled. This latter option is costly in terms of the investment in the stable and the labor time needed for feeding and watering the stabled cattle[5].

Besides cattle, Rwandan rural households also keep small livestock. In 2000, farmer households owned on average 1.33 goats, 0.43 sheep and 0.33 pigs. About 80 percent of farmer households owned some livestock. Even in the lowest expenditure quintile, the proportion of livestock owners was quite high (71 percent) (Government of Rwanda, 2002b). Although most farm households still prefer to own cattle, because of its high value and large quantities of manure, they recognize that small livestock has some advantages. Households in Gikongoro mentioned that goats do not need a stable, are easy to feed and can be sold nearby since goat meat is consumed in small local rural centers. Sheep are less popular in Rwanda. Their meat is almost exclusively consumed by the Twa, a small ethnic minority. The popularity of pigs has increased over time. The average number of pigs kept in 2002 was markedly higher than the numbers found in the surveys of 1984 and 1990 (0.33 per rural household compared to respectively 0.21 in 1990 and 0.18 in 1984). Pigs can be fed with sweet potatoes and have a large off-spring with a litter of 10 to 12 newborns. Rwandan peasants do not eat pork, but besides export opportunities to neighboring countries (mostly Congo), there is a growing urban market for pork meat within Rwanda (Interviews in Gikongoro, 2003).

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the genocide and are pastoral households. The households living in Umutara Province owned on average 10.18 heads of cattle in 2000. Including these would increase the average number of cattle owned in 2000 from 0.60 to 1.47 heads per household.

[5]Grass strips, planted on the edges of the land parcels are used for feeding stabled cattle. Feeding cattle becomes especially time consuming in the dry season, as both pasture land and grass strips become scarcer. During fieldwork in Gikongoro Province farmers told me about a dispute between cattle owners and owners of wood land, as the former burned the wood land in the dry season to let their cattle graze. Local authorities solved the dispute by prohibiting cattle grazing on burned wood land. The cattle tenure system that has existed since a long time back, offers only a partial solution for the increased cost associated with cattle ownership. The care for animals is difficult to monitor and a rural sector can only have as many cattle as its grass strips and pasture land can bear. Moreover, the tenure system itself has changed over time. Households in Gikongoro reported that the cattle owner now has to pay the tenant money for renting in pasture land or for building a stable.

2.2.3 Risk management and coping strategies

Rwandan farmers have several ex-ante strategies to manage risk. Confronted with small landholdings, one emerging strategy is the diversification of activities by rural-urban migration, off-farm employment and petty trade (Interviews in Gikongoro, 2003). However, the most common strategy is still crop diversification. Rwandan farmers cultivate different crops on multiple parcels (Clay and Kampayana, 1997; Government of Rwanda, 2002a). The large numbers of crops and parcels allow a continuity of harvests over the year, while reducing crop damage risk (Blarel et al., 1992)[6]. Researchers have noticed an expansion of the production of taro (colocasia) and cassava over time. These are tubers of limited nutritional value, but they are drought and flood resistant (Donovan et al., 2002; Mpyisi et al., 2003; McKay and Loveridge, 2005). It can be argued that this expansion reflects the farmers' strategy of maximizing food crop volume and hedging against the risk of food insecurity.

In spite of the use of bio-diversity to reduce income risk, irregularities in rainfall may easily push Rwandan rural households who live on the edge of food insecurity, below subsistence. Households then have to rely on food aid or on their own ex-post coping strategies. As part of such coping strategies, rural households may temporarily reduce the number of meals eaten, change their diet, cut back on other household expenditures, such as petrol or drugs, collect wood or produce charcoal for sale, sell manure or milk, engage in petty trade or work off-farm. In case of unusual stress households may move to other regions in search of work or stay with better-to-do relatives. The Famine Early Warning System (FEWS NET) also reports that in times of unusual stress households in rural Rwanda start liquidating productive assets by eating seed grains or selling breeding animals. According to the FEWS NET monthly reports, the animals sold are mostly small ruminants, except in Umutara, a province in the Eastern lowland, where households have relatively large cattle stocks (FEWS NET, 1997-2005).

[6]The main food crops produced are beans, sorghum, corn, manioc, Irish potatoes, sweet potatoes, soybeans and bananas. Primary exports are coffee and tea. Perennial crops such as bananas, sweet potatoes, cassava and vegetables are harvested according to crop maturity and household consumption needs, providing a degree of food supply stability throughout the year. Other food crops are cultivated in two main seasons: In season "A" - generally planted in September/October and harvested in January/February - the main crops are beans and maize. The principal crop in season "B" is sorghum, but beans are also grown; planting takes place in February/March and harvesting in June/July. In marshland areas, there is a small third season ("C") in July/August, with sweet potatoes and vegetables as main crops. Season C helps to alleviate the severity of the hunger period of October-November and normally contributes about 15 percent of annual food production.

2.2.4 Food insecurity during the genocide

Violent conflicts differ by intensity, spread and duration. The longer the period of violence, the more likely it becomes that households liquidate their productive assets, or abandon them to take refuge. However, a short war can also have long lasting impacts on household welfare, especially if the violence is intense, widespread and if households were already vulnerable at the outset of the conflict (Grunewald, 1998; Stewart and Fitzgerald, 2001).

These latter three elements were present in Rwanda during the genocide. Although the Rwandan genocide was concentrated in a relatively short time period, all regions were affected, and a large fraction of the population left their fields unattended, fearing for their lives or participating in the killings. Furthermore, at the outbreak of the genocide, the Rwandan population was already weak. Not only was Rwanda fighting an uphill battle against land scarcity and land degradation, but the civil war at the border with Uganda had disrupted life in the North of the country since 1990. In addition, the month in which the violence broke out fell in between planting (February/March) and harvesting (June/July). During the genocide, households thus needed to rely on the stocks of the previous harvest (January/February).

Food aid was very limited during the months of April to June 1994. Insecurity was so severe that only a handful of relief agencies delivered assistance during these months. They operated from Bujumbura (Burundi) or Bukavu (the Congo) and undertook extremely hazardous missions to provide food and medical care to displaced persons within Rwanda. In general, persons in need were difficult to reach and the amount of food aid distributed was very limited (Borton et al., 1996). Even when relative peace was established late in June, food insecurity remained high and many people were still dependent on food aid, among them the two million people who were internally displaced or sought refuge in neighboring countries.

2.3 Theoretical framework

Several economic models of household behavior may yield the prediction that household sell cattle upon adverse income shocks. A household portfolio model may be informative because, upon the realization of a shock, households may have incentives to shift their wealth into other types of assets. For example, upon the illness of a household member holding household wealth in the form of cattle may become too labor intensive. Or, in anticipation of the need to take refuge, a household may want to store its wealth in cash holdings that can easily be taken along.

The aim of the theoretical framework is to derive predictions for the use of livestock as a buffer stock by Rwandan households. Therefore, I focus on household consumption models, although, in the empirical analysis, I will control for the possibility of cattle sales as part of a portfolio choice. Consumption-smoothing through saving and dissaving is consistent with common models of intertemporal consumption choice, such as the permanent income model.

As indicated in the introduction of this chapter, the data at hand do not allow testing a particular model of consumption smoothing. However, based on previous studies, it is clear that some models are more appropriate than others for explaining household consumption and savings in rural areas of Sub Saharan Africa. Several features of the Rwandan context are indeed relevant for the set-up of the theoretical framework. First, households in rural Rwanda live on the edge of food insecurity and face multiple risks. In addition, credit and insurance markets are poorly developed (Dabalan et al., 2004). As a result, adverse income shocks pose a real threat to consumption levels, providing households with a motive for self-insurance through buffer stocks. Therefore, a good starting point is the buffer-stock model of precautionary savings prioneerd by Deaton (1991).

This model is presented in the next subsection. Subsection 2.3.2 gives an overview of arguments of the literature and empirical evidence for the role of livestock as a buffer stock. In subsection 2.3.3, I apply these arguments to the Rwandan context. Finally, in subsection 2.3.4, I develop an extension of the basic buffer-stock model to illustrate the difficulties and trade-offs associated with the use of cattle as a buffer in wartime.

2.3.1 The basic buffer-stock model

Deaton (1991) models the household's intertemporal consumption decision under uncertainty. Households face risky labor income y_t in each period t. Income is risky in the sense that random shocks may occur. It is assumed that there is no significant technological progress over time and that labor is inelastically supplied such that y_t is a stationary random variable. In addition, households own a single asset A_t at the beginning of period t and this asset earns a fixed interest rate r. The optimization problem of the household is to decide in each period t how to allocate total liquid wealth, i.e. $y_t + A_t$, between consumption and savings.

A crucial assumption of the model is that households have decreasing absolute risk aversion. This provides households with a motive for precautionary savings. As a result, households save more when future income becomes increasingly uncertain (Kimball, 1988; Zeldes, 1989). Deaton (1991) introduces three additional assumptions: households cannot borrow, are impatient to consume and have an infinite time horizon[7]. Under these assumptions, it can be shown that economic agents who maximize their expected intertemporal utility, build up the asset A_t when income is "good" and draw it down when income is "bad".

If time is discrete, the household's intertemporal utility maximization problem can be written as follows:

$$\underset{c_t}{Max}\left[E\left(\sum_{t=0}^{\infty}(1+\delta)^{-t}v\left(c_t\right)\right)\right] \qquad \forall t=0...\infty \tag{2.1}$$

s.t.

$$s.t. \quad A_{t+1}=\left(A_t+y_t-c_t\right)(1+r) \qquad \forall t=0...\infty \tag{2.2}$$

$$A_t \geq 0, \quad A_0=\bar{A}, \qquad \forall t=0...\infty, \tag{2.3}$$

where δ, $(0<\delta<1)$, is the rate of time preference. Impatience implies that $\delta>r$, such that households will not accumulate assets in the long run. The function $v(c_t)$ is the instantaneous utility associated with consumption c_t. The assumption of decreasing absolute risk aversion implies that $v(c_t)$ is increasing, strictly concave and that marginal utility is convex ($v\prime>0$, $v''<0$ and $v'''>0$). Equations (2.2) and (2.3) give respectively the budget and the borrowing constraints, where both labor income, y_t, and assets, A_t, are expressed in consumption units. The borrowing constraint implies that a household cannot dissave beyond the value of its current assets.

Solving for this maximization problem yields the following optimality condition

$$v\prime(c_t)=\left(\frac{1+r}{1+\delta}\right)E_t v\prime(c_{t+1})+\lambda_t \qquad \forall t=0...\infty, \tag{2.4}$$

where λ_t is the Lagrange multiplier associated with the borrowing constraint in year t. If the borrowing constraint does not bind ($\lambda_t=0$), the household chooses period t consumption such that its marginal utility of consumption in period t equals the discounted

[7]Assuming a finite time horizon, but no bequest motive, would yield a similar solution (Deaton, 1991).

expected marginal utility of future consumption, i.e.

$$v\prime(c_t) = \left(\frac{1+r}{1+\delta}\right) E_t v\prime(c_{t+1}) \qquad \forall t = 0...\infty. \tag{2.5}$$

If the constraint is binding ($\lambda_t > 0$), equality (2.5) does not hold. Instead, with all its assets A_t and income y_t consumed in period t, the household wants to borrow but cannot. Therefore:

$$v\prime(c_t) = v\prime\left(A_t + y_t\right) > \left(\frac{1+r}{1+\delta}\right) E_t v\prime(c_{t+1}) \qquad \forall t = 0...\infty. \tag{2.6}$$

The basic buffer-stock model provides us with two important predictions with respect to self-insurance. First, households save and dissave assets to smooth consumption over time. Second, households engage in precautionary savings: the more uncertain future income becomes, the more the household will be willing to save out of current income. Using simulations, Deaton (1990) shows that, despite active self-insurance by households, the model predicts fairly large fluctuations in consumption. Indeed, due to impatience for consumption, households do not build up very large asset stocks. Consequently, when confronted with an unanticipated severe negative shock, the depletion of all liquid assets may not be sufficient to keep the household on its optimal path, or even above subsistence.

2.3.2 Livestock as a buffer

In the context of rural areas in developing economies, livestock seems an obvious asset to use as a buffer, because, in contrast with food stocks, livestock has a positive return in the form of off-spring, milk, animal traction and manure. However, there are some important constraints on its effectiveness as a buffer stock, such as the terms of trade risk and the risky return on cattle. Moreover, accumulating cattle for the purpose of consumption smoothing may be hampered by the lumpiness of cattle and the cost of livestock maintenance, especially when livestock ownership is subject to diminishing returns. The latter may not be true for pastoralist households which do not depend on fixed landholdings. However, depending on cattle for their livelihood, pastoralists may be especially reluctant to sell their key productive asset.

The mix of advantages and disadvantages of the use of livestock as a buffer stock is reflected in the mixed empirical evidence. For example Rozensweig and Wolpin (1993) and McPeak (2004) find evidence to support the buffer stock hypothesis for livestock, while Udry (1995), Lim and Townsend (1998) and Fafchamps et al. (1998) find that livestock transactions are hardly responsive to income shocks.

Many of these studies implicitly assume that if households sell livestock upon an adverse income shock it must be that they keep livestock for the purpose of consumption smoothing. Only Udry (1995) explicitly addresses the question whether households save in anticipation of shocks[8]. For a sample of Nigerian farmer households, he finds some suggestive evidence for precautionary savings in grain, but not in livestock.

A test for precautionary savings cannot straightforwardly be implemented or interpreted for our sample of Rwandan farmer households. Nevertheless I will present the test results found, both to remain in the spirit of the Deaton model and because such a test can provide at least some insights into the question whether households use cattle as a "specialized" buffer stock or merely as an "occasional" buffer stock.

2.3.3 Livestock as a buffer in Rwanda

Whether or not livestock is among the assets used for buffering by Rwandan rural households is not a priori clear. The high population density might positively affect livestock and food market integration and therefore reduce the terms of trade risk associated with the use of livestock as a buffer against covariant income shocks. On the other hand, due to land scarcity in Rwanda, the cost of feeding and watering cattle may rapidly increase with herd size reducing the scope of cattle accumulation for the purpose of buffering (cf. footnote five on cattle feeding in Rwanda).

It is neither a priori clear whether Rwandan rural households used livestock for buffering in wartime. There are reasons to believe that they had few other options in 1994: alternative strategies such as informal insurance and off-farm work are unlikely to have been available, because the genocide affected all parts of the country simultaneously and put a halt to most production activities. On the other hand, transactions of cattle were most likely severely hampered by the lack of safety on the roads and the bad terms of trade. The question I want to address is whether, under these circumstances, Rwandan rural households used cattle sales to smooth consumption. In order to do this, I add three elements to the basic buffer-stock model: risky prices, risky cattle returns, and the risk of cattle raiding[9].

[8] I thank Stefan Dercon for bringing this to my attention.

[9] This extension is similar to the one of Stefan Dercon (2004b) who extends the basic Deaton model

2.3.4 The buffer-stock model in a setting of violent conflict

The model can be applied to both small livestock and cattle. However, since the empirical application focuses on cattle, in the remainder of the presentation I take cattle as the single asset A_t in the model. The objective function and the borrowing restriction remain the same as in equations (2.1) and (2.3), but the budget constraint becomes:

$$p_{t+1}(1-\kappa_{t+1}^{R})A_{t+1} = \frac{p_{t+1}}{p_t}\frac{(1-\kappa_{t+1}^{R})}{(1-\kappa_t^{R})}\left[p_t(1-\kappa_t^{R})A_t + y_t - c_t\right](1+r_{t+1})(1-\kappa_{t+1}^{H}), \quad (2.7)$$

with p_t and p_{t+1} the prices of cattle measured in consumption units in period t and $t+1$ respectively; r_{t+1} the risky return on cattle held over from period t into period $t+1$; κ_t^R and κ_{t+1}^R the risk of cattle raiding on the road (on the way to a possible buyer) in period t and $t+1$ respectively; and κ_{t+1}^H the risk of cattle raiding at home between period t and $t+1$.

Alternatively, the risk of cattle raiding on the road may be captured by the market prices, while the risk of cattle raiding at home may be captured by the risky return. However, because the interest of this chapter lies in the effect of political unrest, I chose to model cattle raiding explicitly. The values of κ_t^R, κ_{t+1}^R, and κ_{t+1}^H lie in the interval $[0,1]$. The ratio $p_{t+1}(1-\kappa_{t+1}^R)/\ p_t(1-\kappa_t^R)$ on the right hand side of equation (2.7) serves to convert the asset stock at time $t+1$ into consumption units valued at prices of period $t+1$.

As in the basic model, there are two possible outcomes. On the one hand, when the borrowing constraint does not bind, the following equality holds:

$$v\prime(c_t) = \frac{E_t\left[p_{t+1}(1-\kappa_{t+1}^{R})(1+r_{t+1})(1-\kappa_{t+1}^{H})v\prime(c_{t+1})\right]}{p_t(1-\kappa_t^{R})(1+\delta)} \qquad \forall t = 0...\infty. \quad (2.8)$$

On the other hand, when the borrowing constraint binds, the household consumes all its labor income and depletes its entire cattle herd in period t, such that:

$$v\prime(c_t) = v\prime\left(p_t(1-\kappa_t^{R})A_t + y_t\right) \qquad \forall t = 0...\infty. \quad (2.9)$$

According to equation (2.8), households have an incentive to save more and consume less if the price of assets in period t is low compared to the expected price in period $t+1$.

to incorporate risky prices and risky asset returns.

Formally, if p_t decreases, the right-hand side of equation (2.8) increases and, everything else held constant, the equality is maintained by decreasing current consumption, c_t, i.e. increasing savings in period t. A similar effect is obtained when assuming a marginal increase in the probability of cattle raiding in period t, κ_t^R.

The optimality condition (2.8) also implies that, ceteris paribus, the lower the expectations about r_{t+1}, the lower the propensity to carry over assets A_t from period t to $t+1$, and the higher consumption in period t. A similar effect is obtained when the expected risk of cattle raiding at home, κ_{t+1}^H, increases.

Changes in expectations of the cattle price, cattle raiding, and the rate of return are likely to have occurred simultaneously during the Rwandan genocide. To start with, the realization of the terms of trade risk was highly plausible[10]. Many households at once faced a production shortfall and therefore may have wanted to sell cattle in exchange for food, while very few may have been interested in buying cattle. As a result, asset prices may have collapsed (increasing expectations of a rise in p_{t+1}/p_t), the more so because political unrest hindered market integration, making the trade of livestock and food between war-affected and non-affected regions virtually impossible.

Second, the risk of cattle raiding was very high. The army, militias and ordinary people killed cattle for immediate consumption or merely to spread terror, because cattle were not only a valuable asset, but also a symbol of (Tutsi) power. The households targeted in the violence may have preferred to cut consumption to very low levels rather than risk their cattle (and their own lives) on the road.

Third, due to the lack of adequate feeding and watering during the war, it is likely that the expected return[11] for holding cattle was low, all the more so because households may have feared that unrest would drag on for some time and may have anticipated the need to take refuge abroad. Therefore households may have been inclined to immediately sell their cattle in 1994 [12].

[10] A sharp decrease of y_t is likely to result in a drop of p_t. Among others Toulmin (1995), Fafchamps and Gavian (1997), Kinsey et al. (1998), Sandford and Habtu, (2000), and Barret et al. (2003) document a collapse of terms of trade between livestock and food during famines.

[11] The distribution of this return is a complex function of the expected milk production and off-spring of the herd, and the expected contribution of manure to the agricultural production between t and $t+1$. In turn, these factors depend on the health condition of cattle at t, the risk on cattle diseases, the expected availability of labor, (pasture) land, fodder, water and veterinary services between t and $t+1$.

[12] In contrast to farmers, pastoralists may be inclined to hold on to their livestock, even if livestock losses are expected to be high. First, selling livestock may jeopardize future herd productivity and therefore the pastoralists' income. Second, the post-crisis return on cattle may be high due to more available pasture land per animal (especially if the livestock system is based on common grazing land).

Since these effects occurred simultaneously, the impact of the violent conflict in Rwanda on cattle sale behavior is ambiguous. In the empirical part of this chapter, I disentangle the war-related shocks into several components in order to study the effect of the different parameters of the extended buffer stock model. Before doing so, I discuss possible extensions of the model presented.

2.3.5 Possible extensions of the model

The model would be more complete if it would allow for household portfolio decisions. However, incorporating this would complicate the model substantially (see Fafchamps et al., 1998). Besides, data on other assets to test such a model is lacking. Instead, to distinguish between the use of cattle sales for consumption smoothing and portfolio choice, I analyze both cattle sales in general and cattle sales for the purpose of purchasing food.

A second issue of possible interest that is left out of the model is a person's risk of being killed. A person may put his/her life in danger by leaving his or her home to sell its cattle. Alternatively, keeping cattle at home may attract militia eager to steal and prepared to kill. Although not explicitly modeled, these risks can be captured by allowing the risk of cattle raiding at the road or at home go to the upper limit of the interval $[0, 1]$.

Thirdly, due to pasture land scarcity in Rwanda it would be plausible to assume that r_{t+1} declines with herd size. This can be introduced explicitly in the theoretical framework, by including the cost of livestock maintenance as a function of herd size (see for example Fafchamps et al., 1998; McIntire et al., 1992). However, to keep the model simple, I do not explicitly include the cost of livestock caring.

Finally, I note that the assumption of y_t as a stationary random variable may be unrealistic when income shocks stem from violent conflict. Households may expect political unrest to drag on for a while, resulting in positive correlation between y_t and y_{t+1}. Households may then be reluctant to dissave much in period t, at the outbreak of the conflict, because they suspect unrest to continue in period $t + 1$. Therefore, allowing for serially dependent shocks in the model would make households more inclined to hold on to their cattle during civil unrest. For an extensive discussion of the buffer-stock model with serially dependent shocks, I refer to Deaton (1991).

In addition, cattle prices may increase markedly in the post-war years because of the high demand for re-stocking cattle (Cutler, 1986; Fafchamps, 1998; McPeak; 2004).

2.3.6 Summary

To sum up, both in peace- and in wartime, the decision to use livestock as a buffer-stock is characterized by a series of trade-offs. The trade-offs in peacetime are well-documented and have been modeled by several scholars. The model presented in this section illustrates some of the trade-offs in wartime. Very concretely, Rwandan households faced a huge covariant (income) shock in 1994. They had to find ways to make ends meet, but many coping strategies such as informal insurance were undoubtedly under stress. Since cattle were at high risk of being lost or looted, it is not unthinkable that households tried to quickly deplete their cattle stock in exchange for food. However, the more households decided doing so, the lower the price of cattle compared to food, and the less effective this strategy. Even if at the time, there were economic agents in Rwanda or neighboring countries interested in buying cattle, the lack of safety on the roads may have prevented sellers and buyers to meet. The outcome of these trade-offs in wartime is an empirical question that will be treated in the next two sections.

2.4 Adverse income shocks and livestock transactions in Gitarama and Gikongoro, 1991-2001.

2.4.1 The data used

I use information of a sample of farmer households in Central and South-west Rwanda. The dataset was collected in 2002 and includes recall information on shocks, assets, and household composition for all 11 years within the time span 1991-2001; 258 households were interviewed, clustered in 16 communes, ten of which are located in Gitarama province and six in Gikongoro province (see Figure 1 and the introduction of this dissertation).

Both in Gitarama and Gikongoro, unrest was very high in 1994. These provinces had a relatively high proportion of Tutsi among their population, respectively 9.2 and 12.5 percent compared to a national average of 8.3 percent[13]. It is estimated that only 25

[13]These percentages stem from the 1991 population census. However, the Habyarimana regime is said to have deliberately underreported the number of Tutsi to keep their school and public employment quotas low. Using data from the local administration of Gikongoro, chapter 1 provides evidence that the proportion of Tutsi in Gikongoro was close to 18 percent, much higher than the 12.5 percent reported in the census.

percent of Tutsi in Gikongoro survived the genocide, while the survival rate in Gitarama is estimated to have been much higher (Des Forges, 1999; Verwimp, 2003; first chapter of this dissertation). The sample of 258 households is not a random sample. Since Tutsi represented only a small minority of the population, especially after 1994, it was decided to over-sample Tutsi-headed households, lifting their share from below 10 percent (12/188) to 22.5 percent (58/258).

2.4.2 Typology of shocks

Households were asked to indicate adverse income shocks on a timeline. Among the reported income shocks, we distinguish two types: war-related shocks and other shocks[14]. The results are summarized in table 2.1.

The first two columns of this table give the proportion of households that were affected by a particular shock during the period 1991-2001. About forty percent of the households reported crop damage due to political insecurity. Many households were severely hit by the direct shocks of war and genocide: 31 percent of the households lost a household member due to violence, 15 percent of the households took refuge, while 10 percent of the households were confronted with the imprisonment of a household member. There are clear differences between Tutsi-headed and Hutu-headed households. For example, as many as 85 percent of Tutsi-headed households lost a member due to violence. The results of other shocks indicate that, in this period, almost all households (95%) suffered from rainfall irregularities in one or more years.

The previous section suggested that households respond differently to adverse income shocks, depending on whether the shocks are idiosyncratic or covariant (e.g. terms of trade risk), and on whether or not they are serially correlated over time.

Column three provides a measure for the degree of covariance of the different shocks. It gives the fit (R^2) of a regression of each type of shock on the complete set of time-varying commune dummies. The fit of this regression is high for the occurrence of rainfall irregularities, other weather related problems and crop diseases. In addition, adverse crop shocks due to political insecurity were also highly covariant across households of the same commune.

Column four gives the transition probability of a shock, i.e. the probability that a shock that occurred in period t repeats itself, or persists in period $t+1$. Several of the

[14] Households could mention up to three different crop shocks.

Table 2.1: Typology of shocks reported

	Households affected 1991-2001 (%) All hhs	Households affected 1991-2001 (%) Tutsi-hhs	Commune level variance as % of total variance[a]	Persistence of shock (transition probability[b])	Odds ratio of shock leading to food shortage[c]	Odds ratio of shock leading to future food shortage
War-related shocks						
Crop damage due to insecurity	40.3	49.2	43.9	39.9	4.29*	2.00*
Violent death of member	31.0	84.7	27.2	4.8	2.24*	1.51
House violently destroyed	14.7	44.1	22.5	0.0	1.18	0.99
Household seeking refuge	15.1	3.4	16.9	72.5	2.49*	2.22*
Member in prison	10.9	3.4	9.3	94.4	1.63*	1.47†
Other shocks						
Rainfall	95.0	98.3	60.5	52.7	3.66*	1.32*
Insects or diseases on crop	46.9	47.5	47.0	78.2	0.86	0.90
High temperature, frost	41.9	47.5	40.5	31.4	1.46†	1.01
Animal trampling/crop theft	12.4	13.6	9.6	46.3	1.53	1.00
Lack of fertilizer or land	32.9	28.8	36.4	84.6	1.50*	1.67*
Labor shortage due to illness	23.3	22	18.4	47.9	2.60*	1.13
Other labor problem	46.9	49.2	24.7	89.3	1.94*	1.27†
Natural death of member	42.6	27.1	7.3	8.1	1.28	0.83
House destroyed due to rainfall	12.8	13.6	6.9	0.0	0.67	1.14

Notes: † Significant at 5% level;* Significant at 1% level; [a] The degree of covariance is measured as the fit (R^2) of a regression of each type of shock on the time-varying commune dummies. [b] The transition probability gives the probability that after the occurrence of a shock in year t, the shocks repeats itself or persists in year t+1. [c] The odds ratio stems from a logistic regression. In this regression, the dependent variable is binary, taking value 1 in year t when the household reported a lack of food in year t, and 0 otherwise. The explanatory variables for column 5 and 6 are respectively the shocks in t and t-1.

shocks listed in table 2.1, such as seeking refuge or having a member in prison, have a high transition probability. The shock's transition probability gives a first idea about the correlation between y_t and y_{t+1}, but this measure is far from perfect. A shock that hits a household in period t may have a persistent effect on labor income, even though the shock itself is not repeated or persistent. The case of a violent death of a household member is illustrative. This shock is unlikely to repeat itself, but its adverse income effect may persist.

Ideally, we need to look at the effect of each shock on current and future income. However, household income for the years 1991-2001 is not available. Instead, each household was asked to indicate on a timeline in which year its members did not have sufficient food to eat. This is a subjective measure of a consumption shortfall, since it depends on the household's understanding of "sufficient food", and therefore on the preferences and past experience of the household. In addition, whether or not an income shock results in a consumption shortfall depends on the ability of the household to smooth consumption. Nevertheless the link between shocks and reported food shortage may give an idea about the immediate and persistent effect of shocks on the household's income.

The last two columns of table 2.1 assess this link. For each type of shock, these columns show the odds ratio that the shock in year t leads to a food shortage for the household in year t and $t+1$ respectively[15]. Most of the reported shocks listed in table 2.1 significantly increased the probability of an immediate consumption shortfall for the household. For about two thirds of the shocks resulting in a consumption shortfall in period t, the effect persisted in the year following the shock, although the estimated odds ratios become smaller.

This finding of a positive relationship between the shocks and times of food shortages is suggestive for the quality of the self-reported recall information. In this respect, it is noteworthy that the positive relationship between reported shocks and food shortages also holds for the years prior to 1994 (the results for separate years and periods are not reported).

I now turn to an examination of the distribution of the reported shocks over the time span 1991-2001. In the first column of table 2.2, the different shocks are aggregated into a shock index, and set out against time. The shock index was calculated as the number of shocks that occurred in year t divided by 5, which is the maximum number of household shocks reported in a single year. Consequently, the shock index takes values between 0 and 1. Table 2.2 shows an increasing trend of the shock index over time. This may be explained by the retrospective nature of the data, because for more recent years, the recall of events may considerably improve.

Despite this recall bias, some clear patterns emerge. First, in 1994, the shock index is high (especially for Tutsi-headed households), certainly compared to the previous years, but also compared to the immediate post-genocide years. Second, the division of the shocks into four categories clearly shows the importance of political insecurity in 1994.

[15] The odds ratio is calculated from a logistic regression of a binary variable -taking 1 when the household indicated a consumption shortfall (and 0 otherwise)- on each shock of interest, while controlling for all other shocks.

Table 2.2: Adverse income shock index and consumption shortfall over time

	Shock index		Division of shocks into categories[a]				Food shortage (%)	
	All households	Tutsi headed	Political insecurity	Rainfall	Lack of inputs	Other problems	All hhs	Tutsi headed
1991	0.06	0.05	1.3%	4.0%	85.3%	9.3%	7.0	5.1
1992	0.07	0.06	2.2%	4.3%	72.0%	21.5%	8.5	10.2
1993	0.10	0.11	2.3%	23.3%	55.0%	19.4%	12.4	11.9
1994	0.33	0.49	55.4%	7.8%	28.8%	8.0%	52.3	62.7
1995	0.20	0.18	32.8%	2.7%	53.3%	11.2%	37.6	50.8
1996	0.19	0.18	24.5%	7.6%	50.2%	17.7%	15.5	13.6
1997	0.28	0.26	16.9%	25.9%	33.8%	23.4%	33.3	25.4
1998	0.29	0.27	14.2%	22.1%	34.7%	28.9%	32.6	22.0
1999	0.33	0.32	10.5%	26.8%	29.5%	33.3%	27.9	23.7
2000	0.37	0.35	9.4%	34.0%	28.1%	28.5%	43.0	42.4
2001	0.35	0.33	7.3%	32.7%	34.1%	25.8%	24.8	20.3

[a] These categories are based on the shocks listed in table 2.1. Horizontally, they sum up to 100. The category of political insecurity is based on the shocks listed in the rows 8-9 and 11-13 of table 2.1

The war-related shocks continue into 1995 and 1996, mainly because of the high number of refugees and prisoners. In these post-war years households also frequently reported a shortage of labor or manure. This may be due to the high number of casualties, prisoners, unreturned refugees and the erosion of livestock. From 1997 onwards, the lack of inputs and rainfall irregularities become equally important causes for low incomes. Prior to 1994, the lack of inputs is reported as the main cause for an income shortfall, probably because for this period households found it difficult to recall the exact year of rainfall irregularities. Finally, the two last columns reveal that the number of (both Hutu- and Tutsi-headed) households suffering from food shortage reached a peak in 1994[16].

2.4.3 Cattle ownership, prices and transactions

Table 2.3 shows information on cattle ownership and cattle transactions over time. The first column gives the proportion of households owning cattle. The mean proportion over the period 1991-2001 is 32.4 percent, with a peak of 38.0 percent in 1993 and a low of 27.5 percent in 1995[17]. I note that two thirds of these cattle owners own one or two

[16]The number of years of food shortage varies considerably across households. For example 15 percent of households did not report any year of food insecurity, while 12.4 percent reported more than five years of food insecurity. Households in this latter category mostly mentioned the lack of inputs, such as labor, land and fertilizer, as the main cause for their (persistent) consumption shortfall.

[17]These figures may give the impression that only 30 to 35 percent of households owned cattle in the period 1991-2001. However, the households that own cattle change over time. Actually, more than half

heads of cattle, while only a handful own relatively large herds with five to fifteen heads of cattle. None of the households depend primarily on livestock for their livelihoods.

Column two provides information on the total number of heads of cattle in the sample over time. The following columns show the total number of heads of cattle lost, sold, purchased, born, received, and given in each year. According to the data, the heads of cattle lost in 1994 amounted to about half of the sample cattle stock at the start of 1994. In addition, in 1994, the number of cattle sold was rather high compared to other years. The data show some evidence of re-stocking of cattle in the first couple of years after the genocide. Both in 1996 and 1997 a relatively large number of animals was bought. In addition, the number of cattle received as a gift or transfer was quite high in the post-war years. This stems from the fact that, in the sample, several Tutsi widows received cattle from IBUKA, a Rwandan association for the survivors of the genocide.

Table 2.3: Cattle ownership and cattle transactions over time

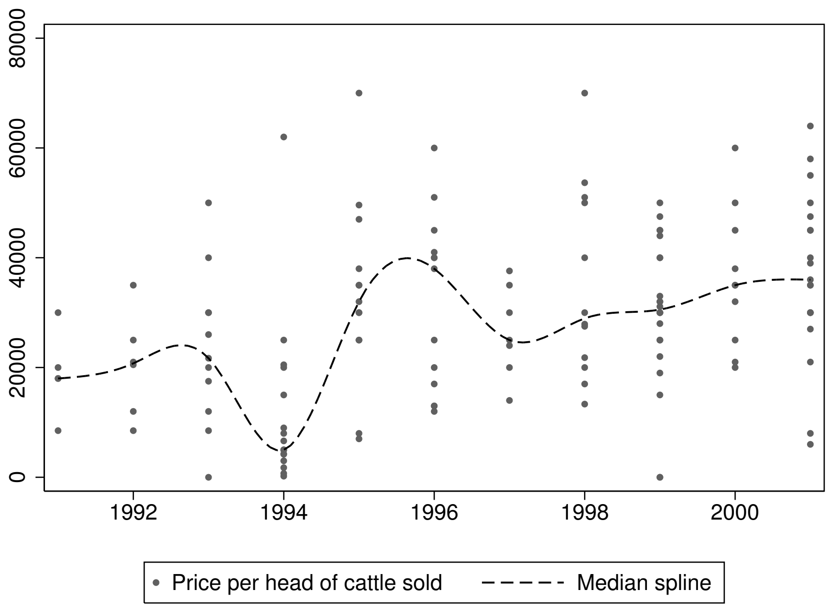
	Proportion of Households with cattle	Total number of heads of cattle:						
		owned	lost	sold	bought	born	received	given
1991	36.4%	267	0	5	8	1	2	3
1992	36.0%	262	17	7	13	11	3	1
1993	38.0%	296	8	15	13	20	2	1
1994	33.3%	257	135	27	8	9	5	2
1995	27.5%	163	22	14	12	6	10	2
1996	27.9%	175	4	15	20	11	6	3
1997	29.1%	184	8	8	16	9	5	3
1998	30.6%	194	8	18	7	9	10	6
1999	31.4%	180	10	27	9	11	5	6
2000	30.6%	181	16	10	18	13	8	8
2001	35.7%	197	10	21	22	19	5	9

In general, few cattle were sold in the sample, with an average of 15.2 heads per year (on average 7.5 percent of the cattle stock). In 1994, 27 heads of cattle were sold, about twice as much as the average number sold in other years. The average price received for a head of cattle during 1991-2001 was almost 30,000 RWF, more than half of the annual expenditure per rural inhabitant for this period[18]. In 1994, the cattle price was on average only 11,500 RWF per animal sold. The price observations are set out in figure

of the households (57.8 %) were cattle owners in one or more years of the period studied. The third chapter of this dissertation provides a study on economic mobility in Rwanda.

[18]In 2000, the annual expenditure per rural inhabitant (adult equivalent) amounted to 61,433 RWF, while it was at 8,125 RWF in 1990. The inflation for this period was 328% (Government of Rwanda, 2002a; McKay and Loveridge, 2005)

Figure 2.1: Evolution of nominal cattle prices during 1991-2001



2.1. A cubic spline is fit to (the medians of) the observation points. The line plot clearly shows a low in cattle prices in 1994 and a peak shortly after.

Besides the number of cattle sold and the price received, also the reasons for selling cattle differ between war and peacetime. For each animal sold, households were asked to give the main reason for selling. Table 2.4 shows the results. For the period 1991-2001, the need to purchase food was the main reason for selling cattle in only 17 percent of cases. In most cases the household sold cattle in order to make another investment, be it in physical or human capital. In a handful of cases, cattle were sold to pay a bribe or fine. For example, one farmer said he sold his cattle to get his son out of prison. A significant fraction of sales (14.7%) were made because the animals were considered useless or were difficult to care for.

For 1994, the picture looks very different: more than eight out of ten animals were sold either because of the need to buy food or because of insecurity. "Insecurity" points here to the fear for cattle raiding or the need to seek refuge. For example, one peasant answered that there was no pasture land in the refugee camps and he was therefore

Table 2.4: Reported reasons for cattle sales

	Nr of sales		% of total sales	
	All years	1994	All years	1994
Purchase of food	27	12	17.3	44.4
Insecurity	12	11	7.7	40.7
Investment in physical capital and farm expenditures			23.1	3.7
Construction of house or purchase of bike	20	0		
Purchase of agricultural inputs	16	1		
Investment in human capital and wedding expenses			32.7	7.4
Health care fee	26	2		
School fee	17	0		
Wedding expenses	8	0		
Need for cash to pay others			4.5	0
Pay wife upon divorce	3	0		
Divide inheritance upon father's dead	1	0		
Pay bribe or fine	3	0		
Cattle stock adjustment			14.7	3.7
Animal is ill, wild, old or useless	19	1		
Cannot take care of (more than 1) animal	4	0		

obliged to sell his cattle at a very low price. Both the precarious food situation in 1994 and the lack of other effective coping strategies may explain why, contrary to other years, households so often cited food consumption as the main reason for selling cattle in 1994.

2.5 Testing for the use of cattle for coping with adverse income shocks: a comparison between peace- and wartime

In this section, I test whether households sold cattle in a year in which one or more adverse income shocks occurred. To ascertain that these cattle sales were not just reflecting shifts in the household asset portfolio, I repeat this test with cattle sold for the purpose of purchasing food as explanatory variable.

The dependent variable, z_{it}, is a binary variable taking the value 1 when household i sold cattle in year t, and 0 otherwise[19]. The explanatory variable of interest is the shock index, s_{it}, a measure of the shocks faced by household i in year t. This measure

[19] No distinction is made between one or more heads of cattle sold, because the number sold rarely exceeds one. I do not use the data on cattle bought since information on positive income shocks is missing.

was defined in section 2.4.2[20]. The model can be formulated in terms of the following underlying latent model

$$z_{it}^{*} = s_{it}\gamma + x_{it}\beta + \alpha_i + \varepsilon_{it} \tag{2.10}$$

$$z_{it} = 1 \text{ if } z_{it}^{*} > 0$$

$$z_{it} = 0 \text{ if } z_{it}^{*} \leq 0,$$

where z_{it} is the underlying latent dependent variable; x_{it} are a series of control variables; α_i are N household specific unknown parameters; and ε_{it} is the error term.

Besides buffering motives, cattle stock adjustment (to reach the optimum herd size) may play an important role in livestock sale behavior (McIntire et al., 1992). Therefore, I include the cattle stock in year $t-1$, its square and changes in the cattle stock in year $t-1$ as control variables. For the same reason, I included the heads of cattle born, received and given in year t. In addition, the number of cattle stolen or killed and the heads of cattle that died from a disease in year t are included. Finally, I control for household land and labor, which determine the costs of cattle herding, but may also capture household preferences and the availability of other coping strategies. For example, as an alternative to selling assets in periods of distress, active adults may look for temporary off-farm employment. Or, the presence of small children may induce households to hold on to cattle for their milk. Table 2.5 gives a description of all variables used in the regression analysis.

The parameters α_i in equation (2.10) can be treated as random unknown parameters or as fixed unknown parameters. In the first case, the model can be estimated using the random effects probit approach. The crucial assumption underlying this approach is that the household-specific effects α_i are independent of s_{it} and x_{it} (Maddala, 1987). If this assumption is violated, a fixed effects treatment is more appropriate. Since both the Hausman and the Mundlak test reject that α_i and s_{it} are orthogonal, I use the fixed effects approach and fit a conditional fixed-effects logit model to the dataset (Hausman and Taylor, 1981; Mundlak 1978). It can be shown that, under weak regularity conditions, the conditional maximum likelihood estimator is consistent and asymptotically normal (Maddala, 1987). The conditional fixed-effects logit model has the disadvantage that

[20] The shock index accords an equal weight to all shocks listed in table 1. An alternative way is to use a logistic regression to calculate the probability of a food shortage for household i given the shocks that hit the household in year t. This second measure gives a high (low) weight to a shock that considerably (only slightly) increases the probability of a consumption shortfall. Qualitatively, the results of the regression analysis are comparable across both measures (see table 2.A.2 in the appendix).

Table 2.5: Explanatory variables used in regression analysis, definition and descriptive statistics for 1991-2001

	Description[a]	N=830	
		Mean	Variance
Shock index (t)	Sum of shocks listed in table 2.1	0.23	0.21
Common component of shock index (t)	Part of shock index explained by time-varying commune dummies	0.35	0.21
Idiosyncratic component of shock index (t)	Remaining part	0.40	0.12
Persistent component of shock index (t)	Part of shock index that persists over time[b]	0.20	0.20
Temporary component of shock index (t)	Remaining part	0.12	0.14
Shock index for 1994 (t)	Index of shocks occurring in 1994	0.33[c]	0.24[c]
Shock index for other years (t)	Remaining part	0.18d	0.20d
Highly violent component of shock index in 1994 (t)	Shock index due to violent death and the destruction of the hh's house	0.17[c]	0.31[c]
Other components of shock index in 1994 (t)	Remaining part	0.47[c]	0.17[c]
Common component of cattle lost due to violence (t)	Covariant part of cattle lost due to violence	0.06	0.19
Idiosyncratic component of cattle lost due to violence (t)	Remaining part	0.05	0.36
Common component of cattle lost due to other cause (t)	Covariant part of cattle lost due to other cause	0.03	0.06
Idiosyncratic component of cattle lost due to other cause (t)	Remaining part	0.05	0.26
Cattle lost due to violence (t)	Number of heads lost due to war/theft	0.06	0.43
Cattle lost due to other cause (t)	Number of heads lost due to disease or natural death cause	0.05	0.28
Cattle born (t)	Number of heads born	0.09	0.33
Cattle received (t)	Number of heads received as a gift	0.04	0.21
Cattle given (t)	Number of heads given as a gift	0.04	0.19
Cattle stock (t-1)	Number of heads owned	1.83	2.23
Squared cattle stock (t-1)		8.35	24.86
Cattle lost (t-1)	Number of heads lost	0.11	0.51
Cattle born (t-1)	Number of heads born	0.08	0.30
Cattle received (t-1)	Number of heads received as a gift	0.04	0.20
Cattle given (t-1)	Number of heads given as a gift	0.03	0.18
Land size (t-1)	Hectare of land owned	1.11	1.11
Children (t-1)	Number of individuals, < 15 years	2.83	1.81
Women (t-1)	Number of women, 15-65 years	1.57	1.04
Men (t-1)	Number of men, 15-65 years	1.29	1.08
Elders (t-1)	Number of individuals, > 65 years	0.18	0.40

[a] All the shock indexes are normalized to fit the interval [0,1]. [b] As a measure of persistence, I use the transition probabilities listed in table 2.1. [c] Mean and variance for 1994. [d] Mean and variance for 1991-2002, besides 1994.

the observations of households that do not change status over time, drop out. As a result, the hypothesis test is limited to households that sold cattle at least once during the period 1991-2001. This considerably reduces our observations from 2580 to 830, or alternatively from 258 households to 83 households[21].

Table 2.6 and 2.7 show the fixed-effects logit estimates, respectively for all cattle sales and cattle sales in exchange for food. I first test the basic hypothesis, i.e. whether households sold cattle in a year in which one or more adverse income shocks occurred (column 1). The estimate for γ is clearly positive and significantly different from zero. Its value in table 2.6 (1.48) implies that an increase of the shock index from 0 to 1, results in a 1.48 unit increase in the log of the odds of selling cattle. Put in another way, this means that the odds of selling cattle when the shock index equals 1 is 4.39 (exp(1.48)) greater than when the shock index equals zero. Alternatively, one can compute the marginal effect of a change in the shock index, evaluated at the sample median for the other explanatory variables. Doing so, I find that the probability of a household selling cattle increases with 0.35 percentage points for a marginal increase in the shock index. The results in table 2.7 are qualitatively similar, indicating that we are not merely picking up the effect of shifts in the household's asset combination upon an adverse income shock.

As mentioned before, the type of shock matters for the (relative) effectiveness of cattle sales for smoothing consumption. If the shock is covariant, the terms of trade risk may set in (pleading against cattle sale), but at the same time other coping strategies, such as informal insurance and wage work may perform poorly (favoring cattle sale). The picture is reversed for idiosyncratic shocks.

To find out which type of shocks cattle sales are most responsive to, I disaggregate the shock index s_{it} in two parts, a common and idiosyncratic component. The common component was obtained from a regression of the shock index on the full set of time-varying commune dummies. The part of the shock index not explained by this regression was treated as the idiosyncratic component of the shock index. Both parts were normalized to fit the interval [0,1]. Column 2 of table 2.6 shows that cattle sales were more responsive to covariant shocks than to idiosyncratic shocks. This is in line with the findings of Fafchamps et al. (1998) in Burkina Faso, who conclude that households

[21] The observations for 1991 are dropped due to the inclusion of lagged variables. Therefore, the maximum possible number of observations is 2580 (258*10). Comparing the characteristics of the included (83) with the excluded households (175), I find that the latter households own fewer cattle, and have on average smaller land and household sizes. The shocks are comparable across both groups of households (see table 2.A.1 in the appendix).

Table 2.6: Fixed effects logit estimates of the determinants of cattle sales

	1	2	3	4	5	6
Shock index (t)	1.48					1.21
	(0.015)					(0.057)
Idiosyncratic component		0.59				
of shock index (t)		(0.479)				
Common component		2.57				
of shock index (t)		(0.005)				
Temporary component			-0.66			
of shock index (t)			(0.528)			
Persistent component			2.77			
of shock index (t)			(0.004)			
Shock index for 1994 (t)				0.82		
				(0.390)		
Shock index for other years (t)				1.78	2.02	
				(0.009)	(0.004)	
Highly violent component					-0.99	
shock index in 1994 (t)					(0.435)	
Other components of					1.39	
shock index in 1994 (t)					(0.046)	
Common component of cattle						0.04
lost due to violence (t)						(0.951)
Idiosyncratic component of cattle						-0.63
lost due to violence (t)						(0.034)
Common component of cattle						3.80
lost due to other cause (t)						(0.051)
Idiosyncratic component of cattle						-1.47
lost due to other cause (t)						(0.025)
Cattle lost due to violence (t)	-0.50	-0.54	-0.47	-0.45	-0.44	
	(0.037)	(0.023)	(0.055)	(0.066)	(0.095)	
Cattle lost due to other cause (t)	-1.14	-1.17	-1.12	-1.12	-1.14	
	(0.048)	(0.045)	(0.053)	(0.048)	(0.047)	
Cattle stock (t-1)	1.53	1.54	1.56	1.54	1.53	1.52
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Squared cattle stock (t-1)	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Chi-squared statistic	131.16	133.72	135.39	132.07	135.48	135.56
Level of significance	0.000	0.000	0.000	0.000	0.000	0.000
Number of observations	830	830	830	830	830	830

Notes: p-value between brackets; control variables included though not reported are: cattle born (t and t-1), cattle received (t and t-1), cattle given (t and t-1), land size (t-1), number of children (t-1), number of women (t-1), number of men (t-1) and number of elders (t-1)

Table 2.7: Fixed effects logit estimates of the determinants of cattle sales in exchange for food

	1	2	3	4	5	6
Shock index (t)	2.98					2.70
	(0.077)					(0.128)
Idiosyncratic component of		0.59				
shock index (t)		(0.790)				
Common component of		6.92				
shock index (t)		(0.011)				
Temporary component of			1.65			
shock index (t)			(0.487)			
Persistent component of			2.83			
shock index (t)			(0.257)			
Shock index for 1994 (t)				4.20		
				(0.043)		
Shock index for other years (t)				2.18	3.69	
				(0.251)	(0.075)	
Highly violent component of					-74.21	
shock index in 1994 (t)					(1.000)	
Other components of					4.06	
shock index in 1994 (t)					(0.006)	
Common component of cattle						0.59
lost due to violence (t)						(0.767)
Idiosyncratic component of						0.96
cattle lost due to violence (t)						(0.294)
Common component of cattle						5.12
lost due to other cause (t)						(0.154)
Idiosyncratic component cattle						-2.84
lost due to other cause (t)						(0.160)
Cattle lost due to violence (t)	0.93	1.21	0.88	0.93	0.52	
	(0.260)	(0.169)	(0.284)	(0.271)	(0.557)	
Cattle lost due to other cause (t)	-1.91	-1.84	-1.96	-1.87	-2.33	
	(0.221)	(0.250)	(0.219)	(0.220)	(0.128)	
Cattle stock (t-1)	3.74	3.76	3.66	3.80	3.34	3.65
	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)
Squared cattle stock (t-1)	-0.44	-0.44	-0.42	-0.45	-0.35	-0.42
	(0.020)	(0.016)	(0.029)	(0.021)	(0.070)	(0.020)
Chi-squared statistic	41.52	45.81	41.65	42.53	47.42	44.22
Level of significance	0.001	0.000	0.001	0.001	0.000	0.001
Number of observations	220	220	220	220	220	220

Notes: p-value between brackets; control variables included though not reported are: cattle born (t and t-1), cattle received (t and t-1), cattle given (t and t-1), land size (t-1), number of children (t-1), number of women (t-1), number of men (t-1) and number of elders (t-1).

in Burkina Faso have other less costly ways to deal with idiosyncratic shocks, while the same does not apply for covariant shocks. This reasoning may also apply to our results for Rwanda. Again, the results in table 2.7 are qualitatively similar.

The "length of the shock" may also matter for cattle sale behavior. On the one hand, upon an adverse income shock in year t, a household may be reluctant to deplete its cattle stock in year t if the same hardship or worse is expected in year $t+1$. On the other hand, the lumpiness of cattle may make its use as a buffer stock more suitable for coping with long term hardship than for coping with a short term income shortfall, provided that households spread the use of the money obtained from a cattle sale over more than one time period. In addition, households may have access to other less costly strategies to deal with a transitory shock. For example, lower food intake is a strategy that may be easily sustained in the short term, but not in the long term.

To test for different responsiveness of cattle sales according to the length of the shocks, I disaggregate the shock index into a temporary and a persistent component. To calculate the persistent component of the shock index, I first took a weighted sum of the shocks, with the weights equal to the transition probabilities as listed in table 2.1. The temporary component of the shocks was taken as the difference between this weighted sum and the unweighted sum of shocks. Both parts were then normalized to fit the interval [0,1]. The results in column 3 of table 2.6 indicate that shocks that persist over time trigger off more cattle sales than temporary shocks. However, this finding is not supported by the results in table 2.7, where the estimated coefficient for the persistent component of the shock index is not significantly different from zero. This could mean that the observed relationship between cattle sales and persistent shocks reflects asset portfolio shifts rather than consumption smoothing behavior.

The main question of interest in this chapter is whether buffer stock behavior differs between war- and peacetime. To test for this, I decompose the shock index into shocks that occurred in 1994 and shocks that occurred in other years. The results in column 4 of table 2.6 show that cattle sales were less responsive to shocks in 1994 than to shocks in other years. However, the results of table 2.7 show the opposite, indicating that, in contrast with the peacetime-years, in 1994 cattle sales were primarily used to smooth consumption.[22]. This result for 1994 is obtained despite the bad terms of trade (cf. figure

[22] These results persists even when the shock index for 1994 and the one for other years are further decomposed into a common and idiosyncratic part (as in column 2), or into a temporary and persistent part (as in column 3). These additional regressions are not reported, but can be obtained from the author upon request.

2.1) and the high risk of cattle raiding (cf. table 2.3).

However, not all households were equally targeted in the violence. Consequently, some might have faced a higher risk of cattle raiding than others. In terms of equation (2.8) this means that, in 1994, κ_t^R (the risk of having cattle killed or stolen on the road) differed between households. To test whether a high value for κ_{1994}^R prevented the war-affected households from selling cattle, I disaggregated the shock index of 1994 into two components. The first component includes the two most violent shocks (household members killed and house destroyed), while the second captures all other shocks that occurred in 1994. The results in column 5 of both table 2.6 and 2.7 indicate that cattle sales were indeed not significantly responsive to the most violent shocks of 1994, while other less violent 1994 shocks did trigger off cattle sales.

An alternative way to test whether a high κ_t^R significantly reduces cattle sales is to compare cattle sales in times of violent conflict with sales upon the occurrence of a livestock disease. In both situations, livestock prices and the expected return on cattle, r_{t+1}, are low[23]. However, the situations may differ markedly with respect to the value for κ_t^R, in the sense that κ_t^R is expected to be much higher during wartime than during peacetime. Consequently, testing for the dissuasive effect of κ_t^R upon livestock sale can be done by testing whether cattle sales were more responsive to the risk of cattle losses due to disease than to the risk of cattle losses due to raiding and looting. These risks can be measured by regressing the number of cattle losses, respectively due to a disease and due to violence, on the full set of time-varying commune dummies. The unexplained part of the cattle losses is referred to as the "idiosyncratic cattle losses" and they are taken up as control variables in regression 6. The results in table 2.6 show that in contrast to the risk of looting, the risk of cattle disease triggers off cattle sales. This finding is supplementary suggestive evidence for the dissuasive effect of the risk of cattle raiding on cattle sales[24].

Finally, I note that the retrospective nature of the data influences the households' re-

[23] In our sample, the correlation between the price received for cattle and the number of heads of cattle lost per commune in year t is highly negative and significant, both for losses due to livestock disease and for losses due to the war or due to theft.

The expected return on cattle kept at home r_{t+1} is low in both situations, because the longer a household keeps its cattle herd in the affected commune, the higher the risk of loosing it, either due to the contaminating disease, either due to looting rebels and soldiers.

[24] The evidence is only suggestive, because I cannot exclude the alternative interpretation that it are the exceptionally bad terms of trade in wartime that are driving the results in regression 6.

sponses in the sense that less distant events are reported more accurately. Consequently, we observe an increasing time trend for both the shock index (table 2.2) and cattle sales (table 2.3). Comparing the response of cattle sales to adverse shocks between distant and less distant years may therefore mistakenly lead us to the conclusion that this responsiveness is higher for recent years, whereas this result may merely stem from the fact that for those recent years the available information is more precise. However, I argue that this bias is unlikely to drive the results presented in column 4 and 5. First, regressions 4 and 5 compare the responsiveness of cattle sales to adverse shocks between 1994 and all other years, before and after the genocide. Second, although the retrospective nature of the data probably causes underreporting of cattle sales and shocks in the early 1990s, this is unlikely to be the case for 1994. As the genocide was so intense, the events of 1994 were still fresh in the memory of most Rwandans at the time of the interview (2002).

2.6 Cattle as an occasional or a specialized buffer stock? Testing for precautionary savings.

If households built up cattle for the purpose of consumption smoothing, one could speak of the use of cattle as a specialized buffer stock. If not, the term occasional buffer stock seems more appropriate. Distinguishing between these two cannot be done by merely testing whether households buy cattle in years with unusually high income, because such behavior would also be consistent with a simple proportional saving rule[25]. One way to find out whether Rwandan households use cattle as an occasional or as a specialized buffer stock is to test for precautionary savings. Indeed, if households built up cattle for the purpose of dealing with shocks, we can expect households to purchase cattle when uncertainty about future income increases.

Testing for precautionary savings is not straightforward. First and foremost, the test only makes sense if we assume that households can foresee future shocks or increased future income risk. This might be the case for the usual seasonal income fluctuations or for recurrent periods of drought leading to a widespread famine (Corbett, 1988). However, for the data at hand, this assumption is less likely. Secondly, adverse income shocks

[25] I note that, unlike for the cattle sale transactions, the survey for the Rwandan households did not include the reasons for the cattle purchases. Besides, since data on income is not available for our sample, a year with unusually high income can only be identified as a year with relatively few adverse income shocks.

in period $t+1$ might be endogenously determined by household savings in previous periods. For example, dissaving key productive assets may increase the exposure of the households to shocks. Or, alternatively, saving assets may decrease household expenditure for agricultural labor input, possible reducing household protection against crop shocks (Udry, 1995).

With these reservations in mind, I test for precautionary savings by regressing cattle purchases in year t on the shock index of year t and $t+1$. The results are presented in table 2.A.3 in the appendix. In columns 1 to 3 none of the estimated coefficients of the shock indices are significantly different from zero. So, there is no indication for the accumulation of cattle in years with relatively few adverse income shocks, or for a forward-looking self-insurance strategy.

In column 4 and 5 this finding holds for peacetime shocks. However, the results in column 4 and 5 suggest that households hit by shocks in 1994 accumulated cattle in the year prior to the genocide. This result could be interpreted in different ways. It can be argued that in 1993 these households anticipated political unrest and bought cattle as a form of self-insurance. Rwanda has indeed a long history of violent outbursts and tension was rising since 1990 with the invasion of the FPR causing sporadic attacks on Tutsi within Rwanda[26]. Alternatively, a variety of circumstances in 1993 related to the subsequent violence or not, could have motivated these households to buy cattle. Finally, the possibility that the shocks of 1994 were endogenously determined by cattle accumulation in 1993, though far reached, cannot be excluded. For example, households who were able to accumulate wealth in the year preceding the ethnic violence may have felt more threatened by the assaults.

2.7 Available data and hypothesis test for small livestock

The available data on ownership of small livestock is limited to 2002 for the households sampled. In that year, the households in the sample owned on average 0.83 goats, 0.19 sheep and 0.23 pigs, and these animals were distributed among seventy percent of the

[26] Admittedly, cattle was probably one of the most risky assets to have in 1994, so ex post it was certainly not a good asset to built up prior to the genocide. However, although rural households could have anticipated political unrest, it is much debatable whether they could have foreseen the scale of the violence in 1994.

households. Data on the transactions of small livestock is also scarce. Contrary to cattle transactions, transactions of small livestock may be hard to recall by households, not only because small livestock has much less value (both in monetary and non-monetary terms), but also because these transactions are much more frequent. However, there is one type of transaction of small livestock that is less likely to slip one's mind: distress sales in order to buy food. During the interviews in 2002, the households were asked to indicate this type of sales on a timeline. In total, over the period 1991-2001, 111 distress sales of small livestock were reported. In 1994, only 7 distress sales were reported.

Looking at the reasons for cattle sales (table 2.4), we found 27 and 12 distress sales of cattle, respectively over the period 1991-2001 and in 1994. This would mean that, in peacetime, distress sales of small livestock outnumbered distress cattle sales, while the reverse would hold for wartime. Two arguments may support this finding. First, the shocks of wartime may have been so severe and widespread that distress cattle sales were a last resort for households, whereas in peacetime, less drastic measures, such as selling small livestock, may have been more appropriate. Second, in wartime households might have slaughtered small livestock for their meat instead of selling it. This may not have been an option for cattle, as rural households in Rwanda do not have any means to conserve meat for more than a couple of days.

I briefly mention the results obtained when taking distress sales of small livestock as the dependent (binary) variable in the regression analysis and compare them with the results for cattle sales in exchange for food. Table 2.8 shows that small livestock sales were responsive to adverse income shocks (column 1). Regression 2 suggests that both covariant and idiosyncratic shocks trigger off distress sales of small livestock. For cattle, this was only the case for covariant shocks. Regression 3 shows a higher responsiveness of small livestock sales to persistent shocks than to temporary shocks, which is also in the line of the results for cattle. To the contrary, unlike for cattle, the shocks in 1994 did not trigger off small livestock sales, a finding in line with the descriptive data and the arguments presented above.

Table 2.8: Fixed effects logit estimates of the determinants of small livestock sales in exchange for food

	1	2	3	4	5	6
Shock index (t)	2.97 (0.001)					2.94 (0.001)
Idiosyncratic component of shock index (t)		2.61 (0.023)				
Common component of shock index (t)		3.49 (0.012)				
Temporary component of shock index (t)			1.93 (0.183)			
Persistent component of shock index (t)			2.34 (0.037)			
Shock index for 1994 (t)				0.50 (0.782)		
Shock index for other years (t)				3.43 (0.000)	3.40 (0.000)	
Highly violent component of shock index in 1994 (t)					-0.68 (0.689)	
Other components of shock index in 1994 (t)					0.48 (0.745)	
Common component of cattle lost due to violence (t)						-3.09 (0.136)
Idiosyncratic component of cattle lost due to violence (t)						-37.6 (1.000)
Common component of cattle lost due to other cause (t)						6.36 (0.036)
Idiosyncratic component cattle lost due to other cause (t)						-0.34 (0.740)
Cattle lost due to violence (t)	-32.5 (1.000)	-34.4 (1.000)	-32.4 (1.000)	-35.6 (1.000)	-37.0 (1.000)	
Cattle lost due to other cause (t)	0.14 (0.871)	0.12 (0.887)	0.19 (0.831)	0.23 (0.802)	0.29 (0.751)	
Cattle stock (t-1)	1.05 (0.011)	1.01 (0.017)	1.04 (0.014)	0.95 (0.026)	0.93 (0.028)	0.96 (0.021)
Squared cattle stock (t-1)	-0.08 (0.135)	-0.08 (0.147)	-0.08 (0.146)	-0.07 (0.213)	-0.07 (0.219)	-0.07 (0.222)
Chi-squared statistic	32.39	32.63	32.50	36.34	36.52	38.73
Level of significance	0.014	0.019	0.019	0.006	0.009	0.005
Number of observations	410	410	410	410	410	410

Notes: p-value between brackets; control variables included though not reported are: cattle born (t and t-1), cattle received (t and t-1), cattle given (t and t-1), land size (t-1), number of children (t-1), number of women (t-1), number of men (t-1) and number of elders (t-1).

2.8 Conclusion

The question addressed in this chapter is whether rural Rwandan households used cattle sales to cope with adverse income shocks in the period 1991-2001. Special attention is devoted to the cattle sale behavior in 1994, a year of extreme violence in Rwanda.

In order to illustrate the difficulties associated with cattle sales upon adverse income shocks, the theoretical part of the chapter extends the buffer-stock model for precautionary savings to a setting of violent conflict by including risky livestock prices, risky livestock returns and the risk of livestock raiding on the road.

During violent conflict it is likely that livestock prices plummet and that the risk of cattle raiding on the road is high. Both these elements may discourage households to use cattle as a buffer-stock. However, at the same time, expected livestock returns may be very low in times of political unrest, certainly if households expect to flee from the violence. Therefore, a priori, it is unclear if cattle sales will be responsive to adverse income shocks in wartime.

The empirical analysis of this chapter uses data on 258 rural Rwandan households. The data show that the households faced multiple adverse income shocks during the period 1991-2001. The shock index peaks in 1994 because a large number of the households in our sample were severely affected by the war and the genocide.

Approximately one third of the households in the sample owned cattle. The analysis of the herd size over time shows that in 1994 almost 50 percent of cattle died or was stolen. The frequency of cattle sales was very low, suggesting that in general these households are unwilling to sell cattle. It is noteworthy that the number of cattle sold in 1994 was almost double the annual average of sales in peacetime.

Looking at the motives for cattle sales, we find that, in these turbulent times, some households depleted their cattle stock in exchange for food, while others sold cattle because they anticipated an increased risk of cattle raiding or the need to seek refuge. In contrast, a considerable part of cattle sales in peacetime were motivated by shifts in the combination of the asset portfolio rather than by the need to purchase food.

The regression analysis shows that upon the occurrence of an adverse income shock, the probability of selling cattle increases. When looking only at cattle sales in exchange for food, this relationship becomes stronger for wartime, but weaker for peacetime. This finding suggests that Rwandan rural households only used cattle sales as a buffer in response to the unusual and severe shocks of the genocide. Similarly, the analysis of cattle purchase behavior indicates that cattle is an occasional rather than a specialized buffer stock in rural Rwanda.

However, these occasional cattle sales in wartime are unlikely to have been effective for smoothing consumption, because the cattle price was extremely low in 1994. Moreover, the regression analysis demonstrated that households who were targeted in the violence and most severely hit by shocks did not respond with cattle sales. I argue that the lack of safety on the roads prevented these households from selling cattle.

2.A Appendix

Table 2.A.1: Comparison between the characteristics of the 830 households included in the fixed-effects model and the complete sample of households, for 1991-2001

	N=830		N=2580	
	Mean	Variance	Mean	Variance
Shock index (t)[a]	0.23	0.21	0.25	0.22
Common component of shock index (t)	0.35	0.21	0.39	0.23
Idiosyncratic component of shock index (t)	0.40	0.12	0.40	0.12
Persistent component of shock index (t)	0.20	0.20	0.23	0.22
Temporary component of shock index (t)	0.12	0.14	0.12	0.13
Shock index for 1994 (t)	0.33[b]	0.24[b]	0.33[b]	0.24[b]
Shock index for other years (t)	0.18[c]	0.20[c]	0.24[c]	0.21[c]
Highly violent component of '94 shock index (t)	0.17[b]	0.31[b]	0.19[b]	0.33[b]
Other components of '94 shock index (t)	0.47[b]	0.17[b]	0.46[b]	0.18[b]
Common component of cattle lost due to violence (t)	0.06	0.19	0.06	0.20
Idiosyncratic component of cattle lost due to violence (t)	0.05	0.36	0.05	0.46
Common component of cattle lost due to other cause (t)	0.03	0.06	0.03	0.05
Idiosyncratic component of cattle lost due to other cause (t)	0.05	0.26	0.03	0.19
Cattle lost due to violence (t)	0.06	0.43	0.06	0.54
Cattle lost due to other cause (t)	0.05	0.28	0.03	0.20
Cattle born (t)	0.09	0.33	0.05	0.23
Cattle received (t)	0.04	0.21	0.02	0.15
Cattle given (t)	0.04	0.19	0.02	0.13
Cattle stock (t-1)	1.83	2.23	0.84	1.75
Squared cattle stock (t-1)	8.35	24.86	3.78	16.86
Cattle lost (t-1)	0.11	0.51	0.09	0.57
Cattle born (t-1)	0.08	0.30	0.04	0.21
Cattle received (t-1)	0.04	0.20	0.02	0.15
Cattle given (t-1)	0.03	0.18	0.01	0.12
Land size (t-1)	1.11	1.11	0.82	0.95
Children (t-1)	2.83	1.81	2.44	1.75
Women (t-1)	1.57	1.04	1.40	0.90
Men (t-1)	1.29	1.08	1.12	0.98
Elders (t-1)	0.18	0.40	0.16	0.42

[a] All the shock indexes are normalized to fit the interval [0,1] [b]Mean and variance for 1994.
[c] Mean and variance for 1991-2001, besides 1994

Table 2.A.2: Fixed effects logit estimates of the determinants of cattle sales

	1	2	3	4	5	6
Pr(food shortage) (t)	1.24					0.90
	(0.075)					(0.222)
Idiosyncratic component of Pr(food shortage) (t)		0.23				
		(0.822)				
Common component of Pr(food shortage) (t)		1.25				
		(0.020)				
Temporary component of Pr(food shortage) (t)			0.73			
			(0.413)			
Persistent component of Pr(food shortage) (t)			0.83			
			(0.423)			
Pr(food shortage) for 1994 (t)				0.96		
				(0.232)		
Pr(food shortage) for other years (t)				1.22	-4.37	
				(0.079)	(0.677)	
Violent component of Pr(food shortage) in 1994 (t)					-3.22	
					(0.040)	
Other components of Pr(food shortage) in 1994 (t)					6.21	
					(0.548)	
Common component of cattle lost due to violence (t)						0.13
						(0.838)
Idiosyncratic component of cattle lost due to violence (t)						-0.62
						(0.036)
Common component of cattle lost due to other cause (t)						4.06
						(0.037)
Idiosyncratic component of cattle lost due to other cause (t)						-1.48
						(0.023)
Cattle lost due to violence (t)	-0.48	-0.51	-0.49	-0.46	-0.50	
	(0.046)	(0.033)	(0.046)	(0.067)	(0.046)	
Cattle lost due to other cause (t)	-1.12	-1.15	-1.12	-1.12	-1.19	
	(0.049)	(0.047)	(0.048)	(0.048)	(0.037)	
Cattle stock (t-1)	1.49	1.49	1.48	1.49	1.50	1.48
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Squared cattle stock (t-1)	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Chi-squared statistic	128.39	130.74	128.42	128.58	132.31	133.43
Level of significance	0.000	0.000	0.000	0.000	0.000	0.000
Number of observations	830	830	830	830	830	830

Notes: p-value between brackets; control variables included though not reported are: cattle born (t and t-1), cattle received (t and t-1), cattle given (t and t-1), land size (t-1), number of children (t-1), number of women (t-1), number of men (t-1) and number of elders (t-1)

Table 2.A.3: Fixed effects logit estimates of the determinants of cattle purchases upon adverse income shocks and anticipated adverse income shocks

	1	2	3	4	5
Shock index (t)	0.02				
	(0.980)				
Shock index (t+1)	0.72				
	(0.332)				
Idiosyncratic component of shock index (t)		0.83			
		(0.399)			
Idiosyncratic component of shock index (t+1)		0.36			
		(0.702)			
Common component of shock index (t)		-1.06			
		(0.348)			
Common component of shock index (t+1)		1.58			
		(0.162)			
Temporary component of shock index (t)			1.59		
			(0.213)		
Temporary component of shock index (t+1)			-0.30		
			(0.802)		
Persistent component of shock index (t)			-1.64		
			(0.173)		
Persistent component of shock index (t+1)			1.60		
			(0.148)		
Shock index for 1994 (t)				0.21	
				(0.877)	
Shock index for 1994 (t+1)				1.94	
				(0.050)	
Shock index for other years (t)				0.59	0.62
				(0.484)	(0.476)
Shock index for other years (t+1)				0.07	0.08
				(0.929)	(0.921)
Highly violent component of shock index in 1994 (t)					-0.92
					(0.656)
Highly violent component of shock index in 1994 (t+1)					-0.84
					(0.598)
Other components of shock index in 1994 (t)					0.23
					(0.804)
Other components of shock index in 1994 (t+1)					1.51
					(0.052)
Cattle stock (t-1)	-0.19	-0.20	-0.14	-0.19	-0.23
	(0.355)	(0.336)	(0.504)	(0.350)	(0.273)
Squared cattle stock (t-1)	-0.03	-0.03	-0.04	-0.03	-0.02
	(0.336)	(0.358)	(0.226)	(0.278)	(0.446)
Chi-squared statistic	33.71	35.73	36.45	36.77	37.13
Level of significance	0.014	0.017	0.014	0.013	0.023
Number of observations	513	513	513	513	513

Notes: p-value between brackets; control variables included though not reported are: cattle born (t and t-1), cattle received (t and t-1), cattle given (t and t-1), land size (t-1), number of children (t-1), number of women (t-1), number of men (t-1) and number of elders (t-1).

Chapter 3

Economic Mobility in Rural Rwanda: A Study of the Effects of War and Genocide at the Household Level

3.1 Introduction

In this chapter I study economic mobility of a set of rural households in Rwanda between 1990 and 2002. This period was characterized by war, genocide, the flight of a substantial fraction of the population to neighbouring countries and the imprisonment of more than 100,000 (presumed) perpetrators of the genocide. It is evident that the war, the genocide and their aftermath have inflicted massive suffering on the Rwandan population and that the economic and social dislocation related to those events has resulted in severe short term welfare losses.

This chapter focuses on the longer run. The question addressed is whether the events have had a persistent impact on the households' income and assets. The answer to this question is relevant for economic policy. If households affected by the violence have not been able to restore their assets and income earning capacity, government and donors' policies may target the (innocent) victims of the war and the genocide. On the other hand, if households did succeed in redressing their economic situation, more general policies aimed at rural development are called for.

I use household data obtained from surveys in 1990 and 2002 covering the same 188 rural households in two provinces. The 2002 survey includes recall information on the extent of shocks suffered during war and genocide, such as the number of household members killed or imprisoned, the number of months of refuge abroad, and the loss of household assets in wartime. The high frequency of these war-related shocks in the sample allows a unique analysis of the long term economic consequences of violent conflict at the household level.

The approach taken is to test for the existence of persistent effects of war, genocide and related shocks by studying changes in household income and assets. More specifically, I explain household income and assets in 2002 by initial conditions in 1990 and by shocks in the intervening years. However, when studying material welfare for two years only, absolute changes in income and assets may be outliers with respect to a trend. Therefore, I also look at the movement of households in the income and asset ranking.

Due to attrition and missing variables for some households, the panel data set used includes 188 households, instead of the 256 originally surveyed in 1990. Attrition is a common caveat of panel data, but in the dataset used for this study the dropout of households is especially high because of the killings and the displacement of a large fraction of the Rwandan population. Overall, attrition in the sample amounts to 23.3 percent, but for Tutsi-headed households it is as high as 45.5 percent. In the text, I discuss and address possible attrition bias[1].

This research relates to three strands in the economic literature: economic mobility, the effects of violent conflict and the transitory or persistent character of shocks. By now there exists a vast literature on economic mobility, measured by changes over time in household consumption, income or assets. Most empirical studies for developing countries, covering time intervals from five to twenty years, find substantial economic mobility, and a variety of determinants explaining upward or downward movement in the welfare distribution[2]. Ou focus is on war-related shocks as determinants of economic mobility.

Apart from economic mobility this chapter also relates to the literature on the consequences of war and violence. Research on the economic consequences of violent conflict in Africa is relatively recent and mostly based on cross-country evidence. Among others,

[1]Besides attrition, another common caveat of panel data sets concerns the break-up of households. If the household division is non-random, estimated of economic mobility may be biased (cf. Foster and Rosenzweig, 2002; Rosenzweig, 2003). The study of non-random household division in the sample is beyond the scope of this text.

[2]For an overview of the results of economic mobility studies, I refer to Baulch and Hoddinott (2000).

Easterly and Levine (1998) and Collier (1999) show that war affects long term economic growth through the loss of physical capital, a fall in foreign direct investment and a decrease in government expenditure for the provision of schooling and health care. Since poverty is also a determinant of violent conflict, Sub-Sahara Africa may be trapped in a downward cycle of poverty, conflict and low growth rates[3]. The precise mechanisms generating this downward cycle are yet to be studied. So far, despite the high number of violent conflicts in Sub-Saharan Africa during the last quarter of a century and the increased availability of household panel data, studies using such data to explain the mechanisms underlying the effects of violence are scarce. One exception is an interesting study by K. Deininger (2003), who makes use of two surveys of Ugandan households to demonstrate that the presence of civil strife at the community level reduces households' propensity to invest and diversify activities. In contrast to Deininger, I look at the effects of a variety of war-related household level shocks on changes in both the households' income and assets and in their ranking.

Thirdly, there exists a vast literature on the effects of adverse income shocks at the household level. It is evident that adverse income shocks stemming from weather conditions or violence have an immediate impact on household welfare unless households have recourse to formal or informal insurance mechanisms. Surveys of the literature suggest that insurance mechanisms at best succeed in partially protecting the households' economic position in the short term (Morduch, 1995; Townsend, 1995). In addition, there is evidence of the adverse effects of shocks, such as famine and rainfall irregularities, on long-term economic outcomes (see for example Dercon, 2004a). The adverse effects of shocks may persist because the affected households lose human, physical or social capital, reducing their future income earning capabilities. In wartime, insurance mechanisms are unlikely to operate effectively or at all (cf. discussion in chapter 2). Besides loosing physical assets, the households' social networks may be strongly affected, active members may be killed or handicapped and the indirect shocks of violent conflict, such as lack of food or medical care, may lead to permanently lower human capital levels[4]. These are the underlying reasons for expecting persistent effects of violent conflict on household welfare.

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[3] For poverty as a determinant of violent conflict see Azam (1995), Collier and Hoeffler (1998), and Elbadawi and Sambanis (2000).

[4] The evolution of human welfare indicators, such as education enrollment, malnutrition and mortality in war and post-war years has been studied in by Ichino and Winter-Ebmer (2004) and Ghobarah, et al. (2003).

Economic studies on the Rwandan war and genocide include André and Platteau (1998), Verwimp (2005), McKay and Loveridge (2005), and Lopez and Wodon (2005). The two former studies use household data to study the economic causes of the escalating violence in Rwanda. André and Platteau (1998) study the relationship between socio-economic status and the victims of the violence, while Verwimp (2005) analyzes the economic profile of the perpetrators of the genocide. Both studies mention the competition for land and off-farm jobs as causes of the violence in Rwanda. Lopez and Wodon (2005) study economic recovery in the postwar years using aggregate data. They conclude that, although by 2002, GDP per capita had rebounded to its 1990 level, it would have between 25 and 30 percent higher in the absence of the war and the genocide. The same authors find rapidly improving child survival and nutrition, and a complete return of primary education enrollment to its pre-genocide trend line. Using information on agricultural production, household income and child malnutrition, McKay and Loveridge (2005) also suggest considerable recovery in the post-war period. Despite this post-war recovery, the proportion of people below the poverty line increased, from two out of five persons in the early 90's to three out of five in 2000/2001 (Government of Rwanda, 2002a; Piron and McKay, 2004). This increase in poverty went hand in hand with increasing inequality. A comparison of two nationwide surveys indicates that the gini coefficient of income inequality rose from 0.29 in 1984/86 to 0.45 in 2000/2001 (Government of Rwanda, 2002b).

In contrast to McKay and Loveridge (2005) and Lopez and Wodon (2005), I use household panel data and information on shocks of the war, the genocide and their aftermath at the household level to test for the persistent effect of the events on material welfare. Similar to the conclusions based on aggregate data I find that income as well as assets rebounded in the post-war years to reach by 2002 their 1990 level. I do not find a statistically significant link between the shocks related to the war, genocide and their aftermath and household income and assets in 2002. The only violence related event that shows a statistically significant link with household welfare in 2002 is the fact of having at least one household member being actually in prison as a genocide suspect. Of course, entire households have disappeared as a result of the violence and households suffered from loss of family members and material losses. As illustrated in section three of this chapter, there were also temporary consumption losses. But the analysis suggests that by 2002 surviving households that suffered from severe shocks of the 1994 war and genocide and their aftermath were not systematically worse off than the other households in the sample.

The chapter is structured as follows. Section two describes the data used. Section three presents evidence on the shocks of war and genocide, and their aftermath at the household level. In section four I measure household material welfare by household income and assets, compare household material welfare in 1990 and 2002 and analyze time dependence of household welfare over this period. In section five I use regression analysis to test whether war-related shocks had an impact on economic mobility between 1990 and 2002, while controlling for initial conditions. The final section concludes.

3.2 The data set

The data set covers 188 rural households, located in 16 different clusters in Gikongoro and Gitarama Province (see Figure.1). I have two observations, the first for 1989-1990, and the second for 2001-2002. The 1989-1990 survey collected socio-economic data during seasons 1989 B (April 1989 – September 1989) and 1990 A (October 1989 – March 1990). In 2002, similar data were collected for season 2001 B (April 2001 - September 2001) and season 2002 A (October 2001 - March 2002)[5]. In the text I refer to the time periods 1989/1990 and 2001/2002 respectively as 1990 and 2002.

The collection of the data proceeded in three steps. First, the 1990 data stem from a national farm survey carried out by the Division of Agricultural Statistics (DSA) of Rwanda's Ministry of Agriculture and Livestock (MINAGRI). This survey was based on a nationwide random sample of 1,248 farm households. It provided information on topics such as subsistence production, crop sales, livestock production, non-farm income, beer brewing, transfers, land area, household composition and schooling.

Second, in 1999 and 2000, Ph. Verwimp tried to trace the households of the 1990 survey in three provinces of central and southwest Rwanda: Gitarama, Kibuye and Gikongoro, with 160 households (10 clusters) in the former and 96 (6 clusters) in each of the latter two provinces. Reasons for choosing these provinces included among others the availability of information needed to locate the households in the sample (Verwimp,

[5]The data for season 2001 B were collected on a re-call basis and were limited to subsistence production and crop sales. Re-call data on other income sources of season 2001 B, such as income from beer brewing, livestock and off-farm income were not collected. However, these three latter income sources hardly vary across the two seasons (Clay, 1997). Therefore, annual income obtained from these sources is more or less equal to twice the income from one season. In contrast, crop income does vary quite a lot across seasons because the coffee and sorghum harvest mainly occur in season B.

2003a). In this second stage only demographic and criminological data were collected.

Third, data on households' economic activities were collected in February and March of 2002 as part of a study for the Belgian Department for Development Cooperation (DGOS) under its Policy Research Program. The questions asked in the 2002 survey were comparable to those of the 1990 survey. Additionally, we were interested in finding out what had happened to the households between 1990 and 2002. Therefore, we collected recall information about war-related shocks, other adverse income shocks, household consumption shortfalls, changes in physical capital (land ownership and cattle stock) and changes in household composition over the period 1991-2001. Because of financial constraints, the 2002 survey was limited to the 256 households initially surveyed in Gikongoro and Gitarama.

However, not all of these 256 households could be located. From the 256 households in Gikongoro and Gitarama, 44 had dropped out by 2002. "Dropped out" means that the household was no longer living in its initial location and could not be found in the same or in neighbouring administrative sectors. Of the 212 remaining households, 13 could not be considered as the same households, because all former household members had been replaced by distant family or even by neighbours. For eleven of the remaining 199 households, some crucial information was missing in the 1990 data set. Overall, attrition in the sample amounts to 23.3 percent (57/245), but for Tutsi-headed households it is as high as 45.5 percent (10/22). The panel data set I eventually use for the analysis of economic mobility has complete data on 188 households that could be identified in both years and for which I have adequate information.

3.3 War-related and other shocks, 1991-2001

It is well known that rural households in developing countries regularly face adverse income shocks such as illness, drought, crop diseases, insect plagues, and, in some cases, war-related violence. The data set contains retrospective information on all these types of household level shocks for the eleven years between 1990 and 2002. I will focus on the shocks stemming from violent conflict, but for the sake of comparison, the other shocks, for which I will control, in the regression analysis. are also listed.

Table 3.1 gives the proportion of households affected by each type of shock within the eleven-year period, 1991-2001. The results show that almost forty percent of the households had crop damage due to political insecurity, e.g. because they left their fields unattended, or because they could not purchase the necessary inputs. Almost one out of five households lost at least one member due to violence, but this proportion amounts to nine out of ten for the Tutsi-headed households. The Tutsi-headed households in the sample were also more affected by cattle raiding (42%) and the destruction of their houses (58%) due to violence. Two shocks were more common among the Hutu-headed households: seeking refuge abroad (17%) and imprisonment of a household member (12%). By 2002, one third of the imprisoned household members in our sample had been released.

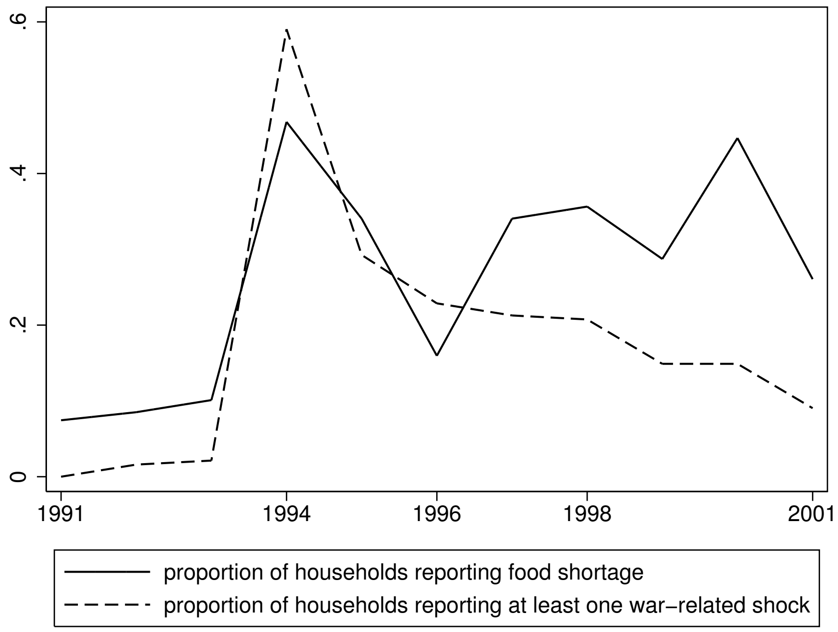
Table 3.1: Typology of shocks by ethnic group

	Households affected, 1991-2001 (%)		
	Hutu- & Twa-headed hhs (176)[a]	Tutsi-headed hhs (12)	All hhs (188)
War-related shocks			
Crop shock due to political insecurity	38.1%	58.3%	39.4%
Violent death of household member(s)	14.2%	91.7%	19.1%
House destroyed due to violence	5.7%	58.3%	9.0%
Cattle killed or stolen	14.2%	41.7%	16.0%
Households seeking refuge	17.0%	0.0%	16.0%
Households with member in prison	11.9%	0.0%	11.2%
Other shocks			
Crop shock: rainfall	93.2%	100.0%	93.6%
Crop shock: insects or diseases	47.2%	50.0%	47.3%
Crop shock: high temperature, frost	39.8%	58.3%	41.0%
Crop shock: animal trampling, theft of crops	11.9%	16.7%	12.2%
Crop shock: labor shortage due to illness	25.0%	8.3%	23.9%
Natural death of household member	46.0%	41.7%	45.7%
House destroyed due to heavy rainfall	10.8%	0.0%	10.1%
Cattle lost due to disease or natural death	15.3%	50.0%	17.6%

[a] Twa are a small ethnic group in Rwanda.There are four Twa-headed households in the sample.

Figure 3.1 gives the evolution over time of the proportion of households suffering from war-related shocks. The figure shows a peak in 1994, but some households were also affected in the post-war years, mainly because one or more of their members were imprisoned or because they resided temporarily in a refugee camp. To gain an insight in the immediate effect of shocks at the household level, we asked households to indicate on a timeline in which years they did not have enough food to eat. Figure 3.1 shows that the proportion of households reporting a food shortage peaks in 1994, which suggests that the adverse income shocks occurring in 1994 were difficult to cope with. In addition, food shortages were rather frequently mentioned in the most recent years under study. This is probably due to the retrospective nature of the data, because people remember more vividly recent than far away shortages.

Figure 3.1: The proportion of households reporting war-related shocks and food shortages for the years 1991-2001 (based on recall data collected during the 2002 survey)



Attrition may have a downward bias on the shocks in our sample. Indeed, a large proportion of the households that dropped out of the sample suffered from severe shocks. In some cases, all members of the Tutsi-headed households were killed in the ethnic violence. In other cases, households took refuge in neighbouring countries and did not return (for more information on the households that dropped out, see Verwimp, 2003a). The panel data set used is therefore not representative for the households that suffered from the shocks of war and genocide. It may also not be representative for the households that survived the violence, if the surviving households that could not be traced differ systematically from the households included in the panel. I will come back to this point in section five.

3.4 Material welfare and economic mobility, 1990-2002

In this section, I discuss material welfare and economic mobility in our sample of 188 households. After explaining how I measure material welfare, I present a comparison of the average levels of material welfare in 1990 and 2002. Then, looking beyond these static measures, I proceed with the measurement of economic mobility using transition matrices and regression analysis.

3.4.1 Measuring material welfare: income per adult equivalent and an asset index

Changes in material welfare over time can be measured by income or expenditures. Expenditures are the preferred measure of material welfare, but because of lack of data I use income as a measure of household welfare. The use of income rather than expenditures may overstate the extent of economic mobility, especially in a predominantly agricultural setting where income varies greatly from year to year and households try to smooth consumption across years. To the extent that households succeed in smoothing their consumption, the use of income data overstates economic mobility. In addition, measuring income is prone to errors, for example because of the difficulty of accounting correctly for the value of subsistence production. This may also result in an upward bias of economic mobility. (For a discussion see McCulloch and Baulch, 2000). Besides income, I make use of an asset index to analyze economic mobility. In general, physical assets are measured with less error and are indicators of the long-run economic status of households.

To measure income, I use information on five income sources: subsistence agriculture, crop sales, beer brewing, livestock production and off-farm earnings[6]. I calculated gross income by taking the sum over the monetary values of these different income sources[7].

[6]Ideally, I should also include income from transfers. However, this information is only available for the 1990 survey. Leaving out transfers may result in a biased income measure. Such a bias is likely to be small since transfers are the least important income source. In the 1990 survey, transfers made up only 3% of total income. The contribution of transfers to income was positively correlated with the dependency ratio and the age of the household head, but the average share of transfers in income did not exceed 6% for households in the top deciles of the dependency ratio or the age of the household head. I do not have data to verify whether these observations hold for 2002.

[7]It is not clear how best to include livestock production in income. The return on livestock may

To obtain net income, I subtracted the cost of hiring in casual labor and of the inputs needed for beer brewing. I did not have satisfactory data on other agricultural inputs, such as chemical fertilizer and pesticides. However, the net income measure is likely to be a good approximation since farming in Rwanda is still overwhelmingly traditional, relying almost exclusively on manure for fertilizing the soil and on the use of small hand implements (hoes and machetes) for most tasks. To calculate monetary values of subsistence agriculture and livestock production, I used prices at the provincial level, except for beer and crop sales, for which I could use the prices reported by the households. Between 1990 and 2002, the general rural price level rose approximately by a factor of three (McKay and Loveridge, 2005; Government of Rwanda, 2005)[8]. Therefore, to obtain income in prices of 2002, I multiplied the 1990 income by three.

The two most important assets of Rwandan rural household are livestock (cattle, goats, sheep, and pigs) and land. Information on these assets is available for both 1990 and 2002. I use principal component analysis to assign weights to these different assets[9]. Basically, I pool the data of 1990 and 2002, and determine a linear combination that transforms the five assets into one index (the first principal component), which accounts for as much of the variability in the five assets as possible[10]. Table 3.2 shows

be in the form of manure, meat, milk, eggs and off-spring. Besides, households may sell livestock. In Rwanda, livestock is kept largely for its manure. The use of manure increases land productivity. Consequently this livestock return is captured by income from subsistence agriculture and crop sales. Livestock is hardly ever kept for meat consumption, because most rural Rwandans are too poor to consume sizable amounts of meat (Kangasniemi, 1998). However, selling eggs or milk contributes to cash income. Therefore, I included the revenue from eggs and milk sales in livestock income. Including the receipts from livestock sales in revenue is problematic because livestock sales are rare and irregular. The estimated income would be highly dependent on whether households happened to sell livestock during a period. An alternative approach is to assume that the income from livestock is proportional to the value of livestock holdings (Kangesniemi, 1998). I applied this method. The proportionality factor I use is the calculated average probability of selling cattle.

[8] McKay and Loveridge (2005) report price levels of 106.7 in 1990 and 348.4 in 2000. Information on the Consumer Price Index for the period 1999-2005, published by the Government of Rwanda on their website, indicates that, after a slight increase in 2001, the price level in 2002 was again at its 2000 level. Inflation for the period 1990-2002 would therefore be more or less 328%. Since a considerable part of this increase is due to increased prices for housing, water, electricity, gas and other mostly urban consumption good, this price index is likely to overestimate inflation in rural areas. Therefore, although somewhat arbitrary, I adjust it downwards to 300% for our sample.

[9] I thank a referee for suggesting this procedure. Note however that an analysis using (implicit) prices for livestock and land yields similar results (cf. Verpoorten and Berlage, 2004).

[10] For 2002, I have also information on other durable assets such as a hoe, a machete, a chair, a mattress, a bed, a bike and a radio, but this information is lacking for 1990. Repeating the principal component analysis for 2002 with the additional assets, I find that the Spearman rank correlation coefficient between the two asset indices amounts to 0.73. So, adding these durable goods does not substantially change

the results. The first column shows the assets' scoring factors obtained from the principal component analysis. This is the weight with which the asset (normalized by its mean and standard deviation) enters the linear combination for the first principal component. For a discussion and an illustration of this method see Filmer and Pritchett (2001).

Table 3.2: Scoring factors and summary statistics for the variables entering the computation of the first principal component (for pooled data of 1990 and 2002, 376 observations)

	Scoring factors	Mean	St. dev	Scoring factor/St.dev
Land size (hectare)	0.500	0.913	(0.934)	0.536
Cattle	0.539	0.710	(1.326)	0.406
Goats	0.446	0.795	(1.396)	0.320
Sheep	0.451	0.250	(0.797)	0.566
Pigs	0.237	0.247	(0.829)	0.285

Note: the figures in the last column can be read as the change of the asset index upon a one unit change in the asset.

3.4.2 Comparison of material welfare and other household characteristics between 1990 and 2002

As mentioned in the introduction, studies comparing the Rwandan economic situation in 1990 and 2002, suggest that income per capita in Rwanda reached its pre-genocide level by 2002 (Lopez and Wodon, 2005; McKay and Loveridge, 2005). I find a similar result in our household panel data set. Table 3.3 shows that the average net income per adult equivalent was not significantly different between 1990 and 2002. However, this result has to be taken with care, not only because our sample is small and not necessarily representative, but also because the income measure is highly susceptible to weather conditions. For example, for one administrative sector in our sample (Kigoma) 1990 was a poor crop year, but this sector profited from an extraordinary banana harvest in 2002[11]. Leaving out this commune, I find a small decrease of income per adult equivalent from 26,354 RWF in 1990 to 23,256 RWF in 2002. When studying economic mobility, I

the asset ranking of households. The percentage of the covariance of the five assets, explained by the first principal component is 35 percent. This percentage amounts to 34 percent, when including the additional durable goods.

[11] When visiting Kigoma in 2002, many of the inhabitants were drunk in daytime. This was not a one-day event as our interviewer complained of night noise during her three-week stay in Kigoma. Drinking banana and sorghum beer is a popular activity in Rwanda and people were spending their occasional surplus in feasting and drinking.

will control for regional weather conditions. For now, it seems safe to state that in our panel data set there is no indication of a significantly lower or higher average income in 2002 than in 1990.

Similar to income, our other measure of material welfare, the ownership of physical assets, does not differ significantly between 1990 and 2002. The land owned on average by a household decreased from 0.96 ha in 1990 to 0.87 ha in 2002, but the difference was not statistically significant. Moreover, land ownership per adult equivalent remained constant at approximately 0.22 ha. The total livestock, expressed in TLU (tropical livestock units), was also similar in both years. Looking at the different types of livestock, I note that there were no significant differences between 1990 and 2000, except for a significant decline in the number of sheep. This information on asset ownership provides additional evidence that material welfare in 2002 was close to its pre-war level.

In table 3.3, I also list some information on household composition in 1990 and 2002. I observe considerable increases in the dependency ratio (from 107 to 128) and in the proportion of female-headed households (from 18% to 43%)[12]. These increases stem both from the large numbers of male casualties and prisoners. Three out of four households who lost a member due to violence became female-headed, while more than 70 percent of households who had a member in prison in 2002 were female-headed. Note that in 2002 only 7.4 percent of the sample households had a member who was still in prison, compared to 11.9 percent in 1995. So, approximately one third of prisoners was released in the meantime.

Finally, the gini coefficient for inequality suggests that the income distribution has become more skewed during 1990-2002[13]. Concurrently the inequality of land and livestock ownership increased over the period under consideration. This finding of an increasingly unequal land and income distribution corresponds to the results of several studies (Clay, 1997; André and Plateau, 1998; Government of Rwanda, 2002b; Piron and McKay, 2004; McKay and Loveridge, 2005). Some of these studies which use data prior to 1990, suggest that inequality in Rwanda was on the rise since the mid eighties and increased rapidly in the period leading up to the genocide. However, static inequality measures offer no information on the movement of households through the income distribution. To get insights in such movements, we must analyze economic mobility.

[12] The dependency ratio is calculated as the ratio of dependent over active household members (*100).

[13] Part of the increased income inequality is due to the outstanding harvest of Kigoma commune in 2002. When leaving out Kigoma, the gini of income per adult equivalent increases from 0.39 to only 0.46 instead of to 0.50.

Table 3.3: Summary statistics for household characteristics of 188 households of Gitarama and Gikongoro Provinces

	1990		2002	
	Mean	St.error	Mean	St.error
Material welfare: income				
Annual household net income /ae (RWF)	25,855	(1486)	27,300	(2344)
Material welfare: assets				
Land size (hectare)	0.960	(0.063)	0.866	(0.073)
TLU[a]	0.954	(0.099)	0.907	(0.111)
Cattle	0.711	(0.089)	0.686	(0.102)
Goats	0.775	(0.102)	0.793	(0.100)
Sheep	0.319	(0.070)	0.181	(0.043)
Pigs	0.262	(0.077)	0.234	(0.038)
Household composition				
Household size	5.410	(0.167)	4.963	(0.172)
Adult equivalent[b]	4.822	(0.155)	4.593	(0.165)
Dependency ratio[c]	107.0	(6.339)	127.8	(7.685)
Female headed (% of households)	17.6%	(0.028)	42.6%	(0.036)
Household member imprisoned (% of households)			7.4%	(0.019)
Inequality				
Gini of net income /ae	0.39	(0.020)	0.5	(0.026)
Gini of land size	0.439	(0.018)	0.518	(0.024)
Gini of TLU	0.480	(0.022)	0.535	(0.025)

[a]One TLU is 175 kg of life mass. Cattle = 1 TLU, Pig = 0.25 TLU, Sheep=Goat=0.15 TLU.
[b]The adult equivalent is based on the calorie needs of household members, depending on their age and sex. The reference is an adult, aged 20-39 years, engaging in moderate activities. I took the same values as those used in the IHLCS (Government of Rwanda, 2002b).
[c]The dependency ratio is calculated as the ratio of dependent over active household members (*100).

3.4.3 Measuring economic mobility: transition matrices and regression analysis

Economic mobility can be measured in different ways. Overviews of economic mobility measures can be found in Atkinson, Bourguignon and Morrison (1992), Maasoumi (1998), Fields (2001) and Amiel and Bishop (2003). In this subsection I use inter-temporal transition matrices and regression analysis to quantify time dependence in our sample, i.e. the extent to which a household's current economic position is determined by its position in the past. The more households move through the income or asset distribution, the lower the time dependence.

Table 3.4 shows two quintile transition matrices. The rows of the two 5 by 5 matrices correspond respectively to the income per adult equivalent and the asset quintiles of the base period and the columns to the corresponding income per adult equivalent and asset quintiles of the final period. The entries in the transition matrix indicate the percentages of households in the base period quintile that ended up in the indicated final period quintile. Between brackets the absolute numbers are given. For example, element (1,1) of matrix A indicates that 16 percent of households that belonged to the lowest income quintile in 1990 remained in that quintile in 2002, while element (1,5) indicates that 30 percent of households in the lowest quintile in 1990 reached the top quintile in 2002. The latter result is almost entirely driven by the progress of households in Kigoma commune. Economic mobility is much lower for the asset index. In matrix B, 45 percent of the poorest households in 1990 remained in the lowest asset quintile in 2002, while only 8 percent reached the upper quintile.

Table 3.4: Inter-temporal quintile transition matrices

Matrix A : Household income/adult equivalent; 188 households						
		Income quintiles in 2002				
		1	2	3	4	5
Income	1	16% (6)	19% (7)	16% (6)	19% (7)	30% (11)
quintiles	2	18% (7)	26% (10)	26% (10)	18% (7)	10% (4)
in 1990	3	26% (10)	26% (10)	16% (6)	21% (8)	11% (4)
	4	26% (10)	13% (5)	18% (7)	18% (7)	24% (9)
	5	11% (4)	16% (6)	24% (9)	24% (9)	24% (9)
Matrix B: Asset index; 188 households						
		Asset quintiles in 2002				
		1	2	3	4	5
Asset	1	46% (17)	19% (7)	11% (4)	16% (6)	8% (3)
quintiles	2	26% (10)	18% (7)	29% (11)	18% (7)	8% (3)
in 1990	3	13% (5)	37% (14)	26% (10)	11% (4)	13% (5)
	4	8% (3)	13% (5)	13% (5)	34% (13)	32% (12)
	5	5% (2)	14% (5)	22% (8)	22% (8)	38% (14)

Note: Absolute numbers between brackets.

From the transition matrices we can calculate immobility ratios. This is the fraction of households that remain in the same quintile over time, i.e. the sum of the absolute numbers on the diagonal as a percentage of all households. I obtain immobility ratios of 20.2[14] percent and 32.4 percent, respectively for income per adult equivalent and household assets. These results are comparable with the findings on time dependence of income and assets by other authors. For example, for India, Lanjouw and Stern (1991,

[14]When leaving out the households of Kigoma, the immobility ratio for income increases from 20.2% to 27.3%.

1993) found an income immobility ratio of 25.7 percent over a 12-year period. Using land ownership, Swaminathan (1991a, 1991b) found an immobility ratio of 48.2 percent over 8 years for a sample of Indian households. For a detailed overview of the results of mobility matrices, I refer to Baulch and Hoddinott (2000).

The above analysis of income mobility in the sample suggests that household income in 1990 is hardly related to household income in 2002. This result is mainly due to the predominance of agricultural crop income, which accounted for 69.4% and 59.6% of total household income in our sample, respectively in 1990 and in 2002[15]. Rwandan agriculture is rain fed and the outcome of the agricultural season is highly dependent on weather conditions, such that agricultural productivity may be more or less uncorrelated over time. In industrialized countries where only a small part of income varies with weather conditions, immobility ratios are much higher. For example, Burkhauser, Holtz-Eakin and Rhody (1998) found an immobility ratio of 50.4 percent over five years for US income quintiles.

In order to controll for mobility stemming from location specific factors including weather variability, I also use regression analysis to determine the extent of time dependence of material welfare in our sample. I regress material welfare in 2002 on material welfare in 1990 and commune dummies. Besides the logarithm of income per adult equivalent and the household asset index, I use two other measures of (positional) material welfare, i.e. the income per adult equivalent rank and the asset rank. The latter measures, constructed by ranking the observations of both income per adult equivalent and the asset index in ascending order from 1 to 188, give an idea of positional movement. In addition, they allow an easy interpretation of the estimated coefficients. The results, presented in table 3.5, show that time independence of income per adult equivalent cannot be rejected. There is however strong evidence for time dependence of the asset index. Regression (2) indicates that a one unit increase of the household's asset index in 1990 results in an approximately 0.34 higher asset index in 2002. Regression (4) gives time dependence in terms of household rankings. It shows that on average, a higher asset rank of one in 1990 results in an 0.39 higher asset rank in 2002.

[15]The decline of the contribution of crop income to total income went hand in hand with the increased importance of non-farm income. For a detailed discussion of the different income sources and their importance for explaining economic mobility, I refer to Verpoorten and Berlage (2004).

Table 3.5: OLS regression to determine time dependence of material welfare

	Log income /ae in 2002 (1)		Asset index in 2002 (2)		Income/ae rank in 2002 (3)		Asset rank in 2002 (4)	
Base year wealth								
Log income/ae in 1990	0.08	(0.10)						
Asset index in 1990			0.34*	(0.07)				
Income/ae rank in 1990					0.07	(0.08)		
Asset rank in 1990							0.39*	(0.07)
Constant	8.59*	(1.01)	-0.27	(0.39)	58.5*	(17.8)	45.9*	(16.9)
Commune dummies	Yes		Yes		Yes		Yes	
Nr of observations	188		188		188		188	
R^2	28.1%		21.4%		26.3%		26.4%	

Notes: standard errors between brackets; significant at *1% level.

3.5 Shocks as determinants of long term material welfare

In this section I try to identify the effect of the shocks of the genocide on households' material welfare in 2002. I start with the presentation of an empirical framework. Thereafter, I discuss the results of the regression analysis, first assuming ignorable selection in our sample, and then addressing possible attrition bias.

3.5.1 Estimation strategy

We can think of material welfare of household i in commune j in year t, W_{ijt}, as being a function of initial conditions at time $t-\Delta$, household level shocks during the same interval, $S_{ij\Delta}$, commune specific characteristics and events, D_{jt} (including rainfall at time t), and unobserved household characteristics ε_{ijt}. We obtain the following structural form:

$$W_{ijt} = g_1(V_{ijt-\Delta}, S_{ij\Delta}, D_{jt}) + \varepsilon_{ijt}. \tag{3.1}$$

Equation (3.1) can be estimated with a panel data set. With our data $t-\Delta =$ 1990 and $t = 2002$, $i = 1, ..., 188$, and $j = 1, ..., 16$. In the absence of attrition bias, the estimation of expression (3.1) would provide us with the conditional expectation of households' material welfare in 2002, given their material welfare and other initial conditions in 1990, household level shocks between 1990 and 2002, and commune specific characteristics and events.

$$E\{W_{ijt} \mid V_{ijt-\Delta}, S_{ij\Delta}, D_{jt}\} = g_1(V_{ijt-\Delta}, S_{ij\Delta}, D_{jt}). \tag{3.2}$$

Whether or not attrition bias occurs depends on the nature of the selection rule. Suppose we can represent the selection of a household into the panel data set by the following process:

$$\begin{aligned} p^*_{ijt} &= X_{ijt-\Delta}\beta + \eta_{ijt} \\ p_{ijt} &= 1 \text{ if } p^*_{ijt} > 0, \quad 0 \text{ otherwise}, \end{aligned} \tag{3.3}$$

with η_{ijt} an independently distributed error term, and $X_{ijt-\Delta}$ covariates at $t-\Delta$. The selection rule is ignorable if the probability that $p^*_{ijt} > 0$ depends only upon the exogenous variables included in equation (3.1) and not upon the phenomenon that we are explaining (Rubin, 1976). In that case, the correlation between ε_{ijt} and η_{ijt} is zero and we can ignore attrition in our sample.

If the selection rule is not ignorable, then estimating (3.1) for the 188 households in our panel data, will not yield (3.2). Instead:

$$E\{W_{ijt} \mid V_{ijt-\Delta}, S_{ij\Delta}, D_{jt},\ p_{ijt}=1\} = g_1(V_{ijt-\Delta}, S_{ij\Delta}, D_{jt}) + g^*_2(X_{ijt-\Delta}\beta), \tag{3.4}$$

with $g^*_2(X_{ijt-\Delta}\beta) = E\left\{\varepsilon_{ijt} \mid \eta_{ijt} > -X_{ijt-\Delta}\beta\right\}$ (Verbeek, 2000). In this case, we can define the function of interest, g_1, only after having estimated the parameters β of the selection process.

In our regression analysis, I start by assuming that the selection rule is ignorable. Then, I relax this assumption and address possible attrition bias. For this purpose, I assume that g_1 is linear, and, that the selection correction function, g^*_2, is nonlinear, stemming from a probit model (Heckman, 1979).

3.5.2 Least squares estimation

I use again four measures of material welfare in 2002 as dependent variables: the logarithm of income per adult equivalent, the household asset index, the income per adult equivalent rank, and the asset rank. In equation (3.1), these are represented by W_{ijt}. The explanatory variables of interest are the war-related shocks, presented in table 3.1 ($S_{ij\Delta}$). In addition, I include three indices of non war-related shocks, corresponding to the time periods 1994-1996, 1997-1999 and 2000-2001 to allow distinction between shocks that happened at the time of the genocide, in the aftermath of the genocide, and most recently. The indices are constructed by taking a weighted sum of the non war-related shocks presented at the bottom of table 3.1 ($S_{ij\Delta}$)[16]. I test for time dependence in material welfare by including material welfare in 1990. Additional information on initial conditions, such as household composition in 1990, are also included to capture household strategies ($V_{ijt-\Delta}$). Finally, commune dummies control for changes in material welfare at the commune level, such as changes stemming from regional weather variability (D_{jt}).

Table 3.6 shows the regression results. Similar to regressions (1)-(4), I find no evidence for significant time dependence of household income, but household assets in 2002 are significantly related to asset ownership in the base year. The coefficients of other initial conditions are not significantly different from zero, except for household size in equations (2) and (4). The latter result is due to the use of household assets instead of household assets per adult equivalent. The estimated coefficients of the war-related shocks are not significantly different from zero, except for the coefficient of having a household member in prison until 2002. This analysis suggests that, by 2002, the households included in our panel data set had recovered from war-related shocks that occurred in 1994, such as the loss of household members due to violence and the destruction of a household's house.

Regression (5) indicates that households of which a member was still in prison in 2002 had an income per adult equivalent of approximately 44 percent lower than other households. According to regression (7), this translates into a loss of about 26 places in the income ranking. In contrast, households with members released from prison before 2002, did not have a significantly lower income level in 2002.

A reason for the income loss of households with a member in prison might be that prisoners become dependent members of the household. From our interviews I learned that households bring food and other basic necessities (e.g. soap) to the prisoner on a weekly or two-daily basis. For the prisoner's household this implies a cost not only in terms of expenditure, but also in terms of time, especially when the prison is far from the household's residence. When I control for the change in the dependency ratio between 1990 and 2002, the effect of having a member in prison is no longer significant. The same is true when controlling for the change from a male household head in 1990 to a female household head in 2002. These changes in household composition, which

[16] The weights for these indices were obtained from a logistic regression of the occurrence of household food shortage in year t upon the shocks in year t. The weights correspond to the calculated probability of a shock leading to household food shortage.

Table 3.6: Least squares estimates of the determinants of material welfare in 2002

	Log income /ae in 2002 (5)		Asset index in 2002 (6)		Income/ae rank in 2002 (7)		Asset rank in 2002 (8)	
Initial conditions (1990)								
Log income/ae	0.04	(0.13)						
Asset index			0.29*	(0.09)				
Income/ae rank					0.09	(0.11)		
Asset rank							0.363*	(0.09)
Household size	0.03	(0.04)	0.11†	(0.04)	2.41	(2.35)	4.656†	(1.83)
Dependency ratio	-0.02	(0.08)	-0.04	(0.11)	-2.13	(5.00)	1.054	(5.20)
Age HH head	0.01	(0.01)	-0.01	(0.01)	0.17	(0.30)	-0.296	(0.32)
Years of education household head	0.02	(0.03)	0.07	(0.06)	0.51	(2.01)	2.696	(1.73)
Female headed household	-0.06	(0.16)	0.14	(0.21)	-3.51	(9.50)	9.696	(10.3)
Land owned	0.08	(0.11)			1.81	(6.61)		
Cattle owned	0.03	(0.07)			1.84	(4.06)		
War-related shocks								
Crop shock due to political insecurity	0.26	(0.17)	0.21	(0.21)	14.95	(10.2)	11.063	(9.55)
Number of members dead due to violence	-0.09	(0.11)	-0.11	(0.12)	-5.55	(6.55)	-7.477	(5.39)
House destroyed due to violence	-0.02	(0.30)	-0.02	(0.26)	-4.37	(17.0)	1.048	(13.5)
Cattle killed or stolen	-0.06	(0.23)	-0.12	(0.39)	-2.14	(14.2)	-5.191	(15.4)
Number of months refuge abroad	0.00	(0.00)	-0.00	(0.01)	0.20	(0.22)	-0.235	(0.26)
Member imprisoned and still in prison in 2002	-0.45†	(0.23)	0.06	(0.37)	-25.8†	(12.5)	3.744	(16.4)
Member in prison, but released by 2002	-0.19	(0.24)	-0.02	(0.60)	-11.4	(16.7)	-2.985	(16.9)
Other shocks								
Shock index, 1994-1996	0.99	(1.07)	-0.94	(1.14)	43.0	(60.6)	-30.254	(51.4)
Shock index, 1997-1999	0.17	(0.53)	-0.02	(0.79)	11.1	(31.8)	-25.641	(30.8)
Shock index, 2000-2002	-1.41‡	(0.79)	-1.05	(1.20)	-49.5	(47.2)	-51.739	(40.8)
Constant	8.48*	(1.60)	0.93	(1.08)	29.5	(55.8)	103.34†	(48.0)
Commune dummies	Yes		Yes		Yes		Yes	
Nr of observations	188		188		188		188	
R^2	35.3%		28.7%		31.7%		34.7%	

Notes: standard errors between brackets; significant at the ‡10% level, †5% level, *1% level; all inferences are based on the Huber/White robust standard errors, because of heterogenteity with respect to the destruction of a household's house, and a commune dummy.

are strongly related to the imprisonment of a household member, appear to be highly significant determinants of income mobility.

The above results of the least squares estimation are robust to including maximum years of education of the household members instead of the years of education the household head, and average age of the adults of the household instead of the age of the household head. Neither do results change substantially when scaling the assets by the same adult equivalent scale as used for income, except for a decreased significance of the effect of household size in 1990.

3.5.3 Robustness to possible endogeneity and multicollinearity of shocks

Some of the shocks included might be endogenous. For example, whether or not a member was still in prison by 2002 may depend on the welfare position of the household. A relatively wealthy household may have a high social status or may be able to pay bribes, raising the probability of its member's liberation from prison. Furthermore, perpetrators or victims of the genocide may have had a distinct economic profile (cf. studies by André and Platteau, 1998, and Verwimp, 2005).

I therefore instrument the war-related shocks. As instruments I use the exogenous explanatory variables in our regression ($V_{ijt-\Delta}, D_{jt}$), ethnicity of the household head in 1990, and variables indicating the severity of civil strife at the sector level. The latter variables include the number of Tutsi killed in a sector as a proportion of the total number of Tutsi included in the 1990 survey, the number of Hutu killed as a proportion of the total number of Hutu surveyed in 1990, the number of Hutu perpetrators of the genocide as a proportion of the total number of Hutu included in 1990, and the proportion of surveyed individuals in 1990 who took refuge abroad[17]. Additionaly, I include the proportion of Tutsi in the total population of the administrative sector in 1990[18]. Summary statistics for these indicators of civil strife at the sector level are listed in table 3.7.

To instrument the war-related shocks, I first run probit regressions of the shocks upon our instruments. Then I use the fitted probabilities from this probit regression as instru-

[17]These data were gathered by Ph. Verwimp in 1999/2000. For households who could not be traced at that time, the information was obtained from neighbours or relatives (for details, see Verwimp 2003, 2005).

[18]For Gikongoro, this information was obtained from population data of the local administration (for a description of these data, see Verpoorten, 2005), while the data for Gitarama stem from the survey work by Ph. Verwimp (2003, p. 109).

Table 3.7: Indicators of (ethnic) violence at the sector level

Indicators of (ethnic) violence at the commune level, '90-'96	Mean	St.dev
The proportion of Tutsi in the population in 1990	0.165	(0.145)
Tutsi killed in 1994 as a proportion of the total number of Tutsi	0.356	(0.344)
Hutu killed in 1994 as a proportion of the total number of Hutu	0.031	(0.033)
Hutu perpetrators in 1994 as a proportion of the total number of Hutu	0.147	(0.154)
Persons taken refuge abroad as a proportion of the total population, '94-'96	0.230	(0.244)

Notes: the sector is an administrative subdivision of the commune; the proportion of tutsi in an administrative sector in Gikongoro Province is based on population data of the local administration; all other indicators stem from research done by Ph.Verwimp (2003a) and are based on information of more than 95 percent of the individuals included in the 1990 survey.

ments for the IV estimation of equation (3.1). This procedure, described in Wooldridge (2002, p. 623-625), yields consistent estimates for both the coefficients and standard errors, provided that the instruments are valid. The results are reported in table 3.8, and are qualitatively similar to the least squares estimates of table 3.6. Moreover, neither the Wu-Hausman F test nor the Durbin-Wu-Hausman χ^2 test reject the hypothesis that the war-related shocks are exogenous.

Finally, because several of the war-related shocks included are correlated, I repeated the least squares regressions (5)-(8) entering each of these shocks separately[19]. Doing so, the estimated coefficients do not change substantially, and all qualitative conclusions remain the same. It seems therefore that, with the exception of having a household member in prison in 2002, the shocks of war, genocide and their aftermath did not have a persistent effect on the material welfare of the households affected. Whether this conclusion is likely to hold for the complete set of households initially interviewed in 1990 is the topic of the next subsection.

3.5.4 Estimation of the Tobit II model

As already stated, of the 256 households initially surveyed in 1990, 57 could not be traced. The drop-out was especially high among Tutsi-headed households. The omission of these households may cause attrition bias in the analysis of the long term effects of shocks on material welfare. Such bias occurs if the selection rule is non-ignorable, i.e. if selection into the sample depends upon the variable of interest (W_{ijt}), even when allowing the selection probability to depend upon the exogenous variables ($V_{ijt-\Delta}, S_{ij\Delta}, D_{jt}$).

[19]These results are not presented, but can be obtained from the author on request.

Table 3.8: Instrumental variable estimation of the determinants of material welfare in 2002

	Log income /ae in 2002 (9)		Asset index in 2002 (10)		Income/ae rank in 2002 (11)		Asset rank in 2002 (12)	
Initial conditions (1990)								
Log income/ae	0.02	(0.18)						
Asset index			0.27‡	(0.15)				
Income/ae rank					0.04	(0.14)		
Asset rank							0.39†	(0.16)
Household size	0.01	(0.06)	0.08	(0.11)	0.83	(3.77)	3.79	(4.21)
Dependency ratio	0.02	(0.15)	-0.46	(0.30)	1.14	(8.52)	-17.6	(13.5)
Age head	0.00	(0.01)	-0.00	(0.02)	-0.02	(0.46)	0.01	(0.68)
Years of education of household head	0.00	(0.05)	0.01	(0.11)	-0.12	(2.72)	0.07	(3.55)
Female headed household	-0.02	(0.21)	0.18	(0.38)	-1.14	(11.6)	13.1	(17.9)
Land size owned	0.06	(0.13)			0.38	(6.87)		
Cattle owned	0.10	(0.10)			6.15	(5.48)		
War-related shocks								
Crop shock due to political insecurity	-0.27	(0.94)	2.44	(1.47)	-12.3	(54.1)	162	(105)
Number of members dead due to violence	-0.05	(0.61)	1.07	(1.22)	-6.75	(33.5)	25.8	(48.2)
House destroyed due to violence	0.48	(0.86)	-2.40	(2.30)	29.8	(52.1)	-65.3	(80.2)
Cattle killed or stolen	-1.4é	(0.97)	-0.73	(2.17)	-77.0	(50.7)	-46.0	(87.8)
Number of months refuge abroad	0.02	(0.01)	-0.03	(0.03)	1.49	(0.91)	-1.76	(1.17)
Member imprisoned and still in prison in 2002	-1.73†	(0.83)	0.43	(1.76)	-100†	(49.8)	1.72	(68.0)
Member in prison, but released by 2002	0.12	(0.81)	-0.03	(1.56)	18.3	(41.4)	10.4	(60.0)
Other shocks								
Shock index, 1994-1996	-0.16	(1.27)	0.51	(2.63)	-25.2	(80.6)	0.48	(113)
Shock index, 1997-1999	0.67	(0.73)	-0.77	(1.36)	41.9	(43.0)	-40.4	(62.3)
Shock index, 2000-2002	-1.67‡	(0.99)	0.18	(1.88)	-70.1	(61.8)	-15.5	(84.0)
Constant	9.43*	(2.10)	0.36	(2.70)	69.5	(76.4)	112	(101)
Commune dummies	Yes		Yes		Yes		Yes	
Nr of observations	188		188		188		188	

Notes: the war-related shocks are instrumented. Apart from the exogenous regressors included, I use the ethnicity of the household head in 1990, and several indicators of (ethnic) violence at the commune level (described in table 3.7), as additional instruments; standard errors between brackets; significant at the ‡10% level, †5% level, *1% level.

A number of econometric techniques exist to test and control for sample selection bias[20]. In this text, I report the results of the two-step estimation of the tobit II model (Heckman, 1979)[21]. The results are presented in table 3.9 and table 3.10. The first stage results stem from the probit maximum likelihood estimation of the selection equation. The variables included in this equation are the initial conditions in 1990, the war-related shocks at the commune level (described in table 3.7), and ethnicity of the household head in 1990[22]. The results show that the probability of selection is significantly lower for Tutsi-headed households, households with a relatively old head, and households living in a commune that was characterized by a high proportion of Hutu perpetrators of the genocide. The selection probability increases with income per adult equivalent and household size in 1990.

Looking at the second stage, I find approximately the same results as for the least squares estimation showed in table 3.6, except for the estimated coefficient of a crop shock due to political insecurity, which is now positive and significant in regressions (13) and (15). In none of the estimated tobit II models, the inverted Mill's ratio (or Heckman's lambda) is significantly different from zero[23]. According to these results, the hypothesis of no sample selection bias in the least squares estimations (5)-(8) cannot be rejected. However, I cannot claim to have dealt with attrition in a completely satisfactory way, because the presence of nonrandom selection induces a fundamental identification problem. The validity of the Heckman model depends on the (non-testable) exclusion restrictions, and on the assumptions of the form of functions $g_1$and g_2^*.

[20] For an overview, see Little and Rubin (2002).

[21] Maximum likelihood estimation of the model yields similar results.

[22] Information on war-related and other adverse income shocks at the household level is missing for the 57 households that dropped out. Instead, the war-related shocks at the commune level are used. In addition, the ethnicity of the household head may be a good indication for the selection probability, because many individuals from Tutsi-headed households were killed (Verwimp, 2003). This variable is not significant in the second stage equation and therefore may be excluded from this stage to facilitate the identification of the parameters of the functions g_1 and g_2^*.

[23] The estimated coefficient on Heckman's lambda gives the estimated covariance between the error terms of the first stage and the second stage equation. A negative covariance indicates that there is unobserved heterogeneity that affects material welfare and the probability of selection in the opposite direction.

3.6 Conclusion

In 1994, the Rwandan population lived through a war and a horrifying genocide. This resulted in both human and material losses, an outflow of refugees and a high number of imprisoned (presumed) perpetrators of the genocide. To get an insight in the impact of the shocks of war, genocide and their aftermath at the household level, I studied income and asset mobility between 1990 and 2002 in a data set of 188 rural Rwandan households.

The data confirm that the war and the genocide had a devastating impact on Rwandan rural households. Evidence was found for the massive killing of Tutsi, for the large scale destruction of houses and the loss of cattle, and for large numbers of refugees and prisoners. Besides these direct effects of the war and the genocide, households had to deal with the indirect effects of warfare. Due to the widespread insecurity, many households left their fields unattended, leading to a standstill in food production. As a result of both the direct and indirect effects of the violent conflict, about half of the households included in the sample reported food shortages in 1994.

Looking at the situation in 2002, the survey data suggest that income per adult equivalent and asset ownership were again at the level of 1990. This result of a considerable post-war recovery is in line with the data on GDP per capita. The household panel data set allowed to study this recovery in more detail. Did households' relative welfare position change during the recovery? Was the recovery only a matter of those households who were relatively unaffected by war, genocide and their aftermath, leaving severely affected households far behind in the income distribution?

Ou results show that three out of four households had moved to another income quintile in 2002 compared to their starting position in 1990. However, with the exception of the imprisonment of a household member until 2002, I found no relation between income and asset mobility and the violent shocks linked to the war, the genocide and their aftermath. This study suggests that by 2002 the negative effects of those shocks on material welfare did no longer persist. However, I should qualify this finding. The panel data set used covers only two provinces and two years. Moreover, although I have tried to take care of attrition bias, such bias cannot be entirely ruled out.

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Table 3.9: Two-step estimation of the determinants of material welfare in 2002 (tobit II model, second stage)

SECOND STAGE	Log income /ae in 2002 (13)		Asset index in 2002 (14)		Income/ae rank in 2002 (15)		Asset rank in 2002 (16)	
Initial conditions (1990)								
Log income/ae	-0.01	(0.14)						
Asset index			0.35*	(0.10)				
Income/ae rank					0.07	(0.10)		
Asset rank							0.36*	(0.13)
Household size	-0.00	(0.05)	0.15†	(0.06)	1.35	(3.02)	7.66‡	(4.29)
Dependency ratio	0.001	(0.08)	-0.09	(0.13)	-0.26	(4.73)	-3.08	(9.02)
Age head	0.01	(0.01)	-0.02‡	(0.01)	0.33	(0.37)	-0.84	(0.70)
Years of education of household head	0.03	(0.03)	0.06	(0.05)	0.92	(1.80)	2.67	(3.14)
Female headed household	-0.06	(0.18)	0.12	(0.27)	-3.01	(10.2)	10.2	(18.8)
Land size owned	0.04	(0.11)			-0.50	(6.19)		
Cattle owned	0.01	(0.07)			0.27	(4.00)		
War-related shocks								
Crop shock due to political insecurity	0.31‡	(0.16)	0.18	(0.23)	16.47‡	(9.59)	8.04	(15.9)
Number of members dead due to violence	-0.08	(0.10)	-0.14	(0.15)	-4.47	(6.10)	-10.6	(10.5)
House destroyed due to violence	0.06	(0.23)	-0.16	(0.32)	-2.36	(13.8)	-9.6	(22.4)
Cattle killed or stolen	0.05	(0.24)	-0.21	(0.33)	4.36	(14.2)	-12.0	(22.8)
Number of months refuge abroad	0.00	(0.00)	-0.00	(0.01)	0.19	(0.22)	-0.16	(0.36)
Member imprisoned and still in prison in 2002	-0.44‡	(0.23)	0.11	(0.33)	-23.9‡	(13.8)	6.17	(22.4)
Member in prison, but released by 2002	-0.03	(0.38)	0.03	(0.50)	-0.72	(21.7)	-0.27	(34.3)
Other shocks								
Shock index, 1994-1996	0.93	(0.89)	-0.96	(1.28)	37.8	(53.3)	-32.9	(88.1)
Shock index, 1997-1999	0.16	0.48)	-0.03	(0.68)	11.6	(28.6)	-23.5	(45.7)
Shock index, 2000-2002	-1.39†	0.67)	-1.08	(0.97)	-47.4	(40.0)	-50.9	(66.7)
Constant	9.40*	1.87)	0.46	(1.27)	43.5	(60.8)	55.0	(90.6)
Commune dummies	Yes		Yes		Yes		Yes	
Nr of observations	188		188		188		188	
Heckman's Lambda	-0.65	(0.66)	1.32	(1.13)	-26.2	(44.9)	94.9	(77.0)

Notes: the estimated coefficient on Heckman's lambda gives the estimated covariance between the error terms of the first stage and the second stage equation; estimating the Tobit II model with maximum likelihood yields similar result; standard errors between brackets; significant at the ‡10% level, †5% level, *1% level.

Table 3.10: First stage of two-step estimation of the determinants of material welfare in 2002 (tobit II model)

	1 if part of panel data, 0 otherwise							
FIRST STAGE	(13')		(14')		(15')		(16')	
Household level variables in 1990								
Log income/ae	0.30‡	(0.16)						
Asset index			0.13	(0.09)				
Income rank					0.00	(0.00)		
Asset rank							0.00	(0.00)
Household size	0.13†	(0.05)	0.09‡	(0.05)	0.12†	(0.05)	0.09‡	(0.05)
Dependency ratio	-0.04	(0.12)	-0.10	(0.11)	-0.04	(0.12)	-0.10	(0.53)
Age head	-0.01	(0.07)	-0.01‡	(0.01)	-0.01	(0.01)	-0.01‡	(0.01)
Education head	-0.02	(0.05)	-0.00	(0.05)	-0.02	(0.05)	0.00	(0.04)
Female-headed	0.09	(0.26)	0.03	(0.26)	0.09	(0.26)	0.05	(0.26)
Land size owned (ha)	0.12	(0.17)			0.13	(0.17)		
Cattle owned	-0.05	(0.11)			-0.05	(0.11)		
Tutsi-headed	-0.76†	(0.32)	-0.71†	(0.32)	-0.74†	(0.32)	-0.74†	(0.32)
Commune level variables '90-'96								
Tutsi in commune (%)	0.42	(1.01)	0.07	(0.43)	0.29	(1.00)	0.03	(0.96)
Tutsi killed (%)	0.03	(0.43)	4.12	(3.39)	0.04	(0.43)	0.07	(0.42)
Hutu killed (%)	4.08	(3.46)	-2.16	(1.02)	3.99	(3.44)	4.15	(3.38)
Hutu perpetrators (%)	-2.21†	(1.06)	-2.62†	(0.60)	-2.15†	(1.05)	-2.16†	(1.02)
Individuals taken refuge abroad (%)	0.07	(0.63)	1.29	(0.46)	0.10	(0.63)	0.30	(0.60)
Constant	-2.05	(1.74)	1.29*	(0.46)	0.52	(0.57)	1.01†	(0.44)
Nr of observations	236		236		236		236	

Notes: the first stage is estimated with 236 observations instead of 256 because information was incomplete for some of the 256 households initially included in the survey; the commune level variables used in the first stage are described in table 3.7; standard errors between brackets; significant at the ‡10% level, †5% level, *1% level.

Bibliography

Africa Data Dissemination Service (ADDS), rainfall data 1998-2001, FEWS NET.

Alderman, H., 1996. Saving and economic shocks in rural Pakistan. Journal of Development Economics 51: 343-365.

Amiel, Y. and Bishop, J. A., 2003. Inequality, Welfare and Poverty: Theory and Measurement. Oxford, Elsevier Science.

André, C. and Platteau, J.P., 1998. Land Relations Under Unbearable Stress: Rwanda Caught in the Malthusian Trap. Journal of Economic Behavior and Organization 34: 1-47.

Asfaw, A. and Von Braum, J., 2004. Is Consumption Insured against Illness? Evidence on Vulnerability of Households to Health Shocks in Rural Ethiopia. Economic Development and Cultural Change 53: 115-129.

Atkinson, A.B., Bourguignon, F. and Morrison, C., 1992. Empirical Studies of Earnings Mobility. New Jersey, Harwood Publishers.

Azam, J.P., 1995. How to pay for the peace? A theoretical framework with references to African countries. Public Choice 83: 173-184.

Baines, E., 2003. Body Politics and the Rwandan Crisis, Third World Quarterly 24: 479-493.

Banister, J., 1987. China's Changing Population. Stanford CA: Stanford University Press.

Barret, Ch., Chabari, F., Von Bailey, D., Little, P. D., and Coppock, D.L., 2003. Livestock pricing in the Northern Kenyan Rangelands, Journal of African Economies 12: 127-155.

Baulch, B. en Hoddinott J., 2000. Economic Mobility and Poverty Dynamics in Developing Countries. London, Frank Cass Publishers.

Becker, J., 1996. Hungry Ghosts: Mao's Secret Famine. New York: Free Press.

Blarel, B., Hazell, P., Plaze, F. and Quiggin, J., 1992. The economics of farm fragmentation: evidence from Ghana and Rwanda. The World Bank Economic Review 6: 233-254.

Borton, J., Brusset, E. and Hallam, A., 1996. The International Response to Conflict and Genocide: Lessons from the Rwanda Experience, Study III: Humanitarian Aid and Effects, Steering Committee of the Joint Evaluation of Emergency Assistance to Rwanda, Copenhagen.

Brück, T., 2004. Coping Strategies in Post-War Rural Mozambique. HiCN Working Papers 02, Households in Conflict Network.

Burkhauser, R.V., Holtz-Eakin, D. and Rhody, S.E., 1998. Mobility and Inequality in the 1980s: A Cross-National Comparison of the U.S. and Germany. In The distribution of Welfare and Household Production: International Perspectives, eds. Jenkins, S., Kapteyn, A. and Van Praag, B. Cambridge: University Press.

Clay, D.C., 1996. Fighting an Uphill Battle: Population Pressure and Declining Land Productivity in Rwanda. MSU International Development Working Paper 58, Michigan State University, Department of Agricultural Economics.

Clay, D.C., Kampayana, T. and Kayitsinga, J., 1997. Inequality and the Emergence of Non-farm Employment in Rwanda. In Changing Rural Social Systems: Adaptation and Survival, ed. Johnson, N.E., Wang, Ch-L. East Lansing, Michigan State University Press.

Clay, D.C., Reardon, T., Kelly, V. and Mpyisi, E., 2002. Input Use and Conservation Investments among Farm Households in Rwanda: patterns and determinants. In Natural Resource Management in African Agriculture: Understanding and Improving Current Practices, eds. Barrett, Ch., Place, F. and Aboud, A. CAB International Publishing in association with the International Centre for Research in Agroforestry, 335 pp.

Collier, P., 1999. On the economic consequences of civil war. Oxford Economic Papers 51: 168-183

Collier, P. and Hoeffler A., 1998. On economic causes of civil war. Oxford Economic Papers 50: 563-573

Corbett, J.E.M., 1988. Famine and household coping strategies. World development 16: 1099-112.

Cutler, P., 1986, The response to drought of Beja famine refugees in Sudan, Disasters 10.

Dabalan, A., Paternostro, S., Pierre, G., et al., 2004. The returns to participation in the non-farm sector in rural Rwanda. Policy Research Working Paper Series No 3462, The World Bank.

Davies, N., 1998. Europe: A History. New York: Harper Perennial.

De Lame, D., 1996. Une colline entre mille ou le calme avant la tempëte : transformations et blocages au Rwanda rural. Annales Sciences Humaines 154. Musée Royal de L'Afrique Centrale Tervuren. Belgique.

Deaton, A., 1997. The analysis of household surveys: a microeconometric approach to development policy. Baltimore, Maryland, USA and London, Johns Hopkins University Press.

Deaton, A., 1990. Savings in Developing Countries: Theory and Review. World Bank Economic Review, Special Issue: Proceedings of the First Annual World Bank Conference on Development Economics: 61-96.

Deaton, A., 1991. Saving and Liquidity Constraints. Econometrica 59 (5) : 1221-1248

Deininger, K., 2003. Causes and Consequences of Civil Strife: Micro-Level Evidence From Uganda. Oxford Economic Papers 55: 579-606.

Dercon, S., 1996. Risk, Crop Choice and Savings: Evidence form Tanzania. Economic Development and Cultural Change. 44: 385-514.

Dercon, S., 2004. Growth and Shocks: evidence from rural Ethiopia. Journal of Development Economics 74: 309-29.

Dercon, S., 2004. Insurance against poverty. Oxford University Press.

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

Donovan, C., Mypisi, E. and Loveridge, S., 2002. Forces Driving Changes in Rwandan Smallholder Agriculture 1990-2001. Research Report, Rwanda Food Security Research Project / MINAGRI.

Easterly, W. and Levine, R., 1997. Africa's Growth Tragedy: Policies and Ethnic Divisions. The Quarterly Journal of Economics 112: 1203 – 1250.

Elbadawi, I. and Sambanis, N., 2000. Why are there so many civil wars in Africa? Understanding and preventing violent conflict. Journal of African Economies 9: 244-269

Fafchamps, M. and Gavian, S., 1997. The Determinants of Livestock Prices in Niger. Journal of African Economies 6: 255-95.

Fafchamps, M. and Lund S., 2003. Risk-sharig networks in rural Philippines. Journal of Development Economics 71: 261-287.

Fafchamps, M., Udry, Ch. and Czukas, K., 1998. Drought and savings in West Africa: are livestock a buffer stock? Journal of Development Economics 55: 273-305.

Fafchamps, M., 1998. The Tragedy of the Commons, Livestock Cycles and Sustainability. Journal of African Economies 7: 384-423.

FAO, 1997. Crop and food supply assessment mission to Rwanda – 1 Special Reports and Alerts July 1997.

FEWSNET, Famine Early Warning System, monthly reports on website.

Fields, G.S., 2001. Distribution and development: a new look at the developing world. New York: Russell Sage foundation.

Filmer, D. and Pritchett, L., 2001. Estimating Wealth Effects without Expenditure Data – or Tears: An Application to Educational enrollments in the States of India. Demography 38: 115–132.

Food Security Research Project (FSRP), MINAGRI/MSU/USAID, Databases for 1984-1992.

Foster, A. D. and Rosenzweig, M., 2002. Household Division and Rural Economic Growth. Review of Economic Studies 69: 869-70.

Friedman, M., 1957. A Theory of the Consumption Function. NBER, Princeton.

Ghobarah, H.A., Huth, P. and Russet, B., 2003, Civil Wars Kill and Maim People—Long After the Shooting Stops, American Political Science Review 97: 189-202.

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, 2003. Recensement Général de la Population et de l'Habitat Rwanda, 16-30 Août, 2002: rapport sur les résultats préliminaires. Kigali, Service National de Recensement.

Government of Rwanda, 2005. Consumer Price Index. Kigali: Ministry of Finance and Economic Planning, Statistics Department.

Grunewald , F.., 1998, Characterizing Disasters, Groupe Urgence Rehabilitation Developpement (GURD) working chapter.

Hausman, J. and Taylor, W., 1981. Panel Data and Unobservable Individual Effects. Econometrica 49: 1377-1398.

Heckman, J., 1979. Sample Selection Bias as a Specification Error. Econometrica 47: 153-161.

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

Ichino, A. and Winter-Ebmer, R., 2004. The Long-Run Educational Cost of World War II. Journal of Labor Economics 22: 57-86

INFORCONGO, 1959. Bruxelles, Office de l'information et des relations publiques pour le Congo Belge et le Ruanda-Urundi, 337 pp.

Kangasniemi, J., 1998. People and bananas on steep slopes: Agricultural intensification and food security under demographic pressure and environmental degradation in Rwanda. PhD. dissertation submitted to Michigan State University.

Kimball, M. S., 1988. Precautionary savings in the small and in the large. Econometrica 58: 53-73.

Kinsey, B., Burger, K., and Gunning, J.W., 1998. Coping with Drought in Zimbabwe: Survey Evidence on Responses of Rural Households to Risk. World Development, 26: 89-110.

Klasen, S. 1994. "Missing women reconsidered". World Development, 22: 1061-71.

Lanjouw, P., Stern, N., 1991. Poverty in Palanpur. World Bank Economic Review 5: 23-55.

Lanjouw, P., Stern, N., 1993. Agricultural Change and Inequality in Palanpur, 1957-1984. In The Economics of Rural Organization, ed. Hoff, K., Braverman, A., Stiglitz, J. Oxford, University Press.

Lim, Y. and Townsend, R. M., 1998. General Equilibrium Models of Financial Systems: Theory and Measurement in Village Economies. Review of Economic Dynamics 1: 59-118.

Little, R.J.A. and Rubin, D.B., 2002. Statistical Analysis with Missing data. Second Edition. John Wiley & Sons, New Jersey.

Lopez, H. and Wodon, Q., 2005. The Economic Impact of Armed Conflict in Rwanda. Journal of African Economies, 14: 586-602.

Maasoumi, E., 1998. On Mobility. In Handbook of Applied Economic Statistics, ed. Giles, D., Ullah, A. New York, Marcel Dekker.

Maddala, G. S., 1987. Limited Dependent Variable Models Using Panel Data. Journal of Human Resources 22:305-338.

Malinvaud, E., 1970. The Consistency of Nonlinear Regressions. The Annals of Mathematical Statistics 41: 956-969.

Mamdani, M., 2001, When Victims Become Killers. Princeton University Press, Princeton, 364 pp.

McCulloch, N., Baulch, B., 2000. Stimulating the Impact of Policy Upon Chronic and Transitory Poverty in Rural Pakistan. The Journal of Development Studies 36: 100-130.

McIntire, J., Bourzat, D. and Pingali, P., 1992. Crop-Livestock Interaction in Sub-Saharan Africa. World Bank Regional and Sectoral Studies. World Bank, Washington, DC.

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.

McPeak, J., 2004. Contrasting income shocks with asset shocks: livestock sales in northern Kenya. Oxford Economic Papers 56: 263-284.

Migeotte, F., 1997. Une colline Rwandaise à travers ses pratiques d'élévage. Annales Sciences Humaines 160. Musée Royal de L'Afrique Centrale Tervuren, Belgique.

Miranda, M.J., and Fackler, P.L., 2002. Applied Computational Economics and Finance. MIT Press.

Morduch, J., 1995. Income Smoothing and consumption smoothing", Journal of Economic Perspectives 9:103-114.

Morduch, J., 1990. Risk, production and savings: theory and evidence from Indian households. typescript Harvard University.

Mpyisi E., Weber, M., Shingiro, E. and Loveridge, S., 2003. Changes in Allocation of Land, Production and Farm Size in the Rwandan Smallholder Sector Over the Period 1984/1990 to 2002. Agricultural policy synthesis 6E. Rwanda Food Security Project/MINAGRI.

Mundlak, Y., 1978. On the Pooling of Time Series and Cross Section Data. Econometrica 46: 69-85.

Newbury, D., 1998. Understanding Genocide, African Studies Review, 41 (1), p. 73-97.

ONAPO, 2001, Enquête Démographique et de Santé, République de Rwanda, Ministère de la Santé, Office National de la Population.

PASAR market prices 1986-2002, EU-sponsered food security project monitoring changes in commodity prices.

Paxson, Ch., H., 1993. Using Weather Variability to estimate the response of savings to transitory income in Thailand. Journal of Political Economy 101: 39-72.

Piron, L.H. and McKay, A., 2004. Aid in Difficult Environments: Rwanda Case Study. Background Paper 4 for ODI study on Poor Performing Countries, Overseas Development Institute.

Prunier, G., 1998. The Rwanda Crisis: History of a Genocide, Third Impression, London, Hurst & Company, 424 pp.

Ravallion, M., 1997. Famines and Economics. Journal of Economic Literature 35: 1205-1242.

Reitlinger, G., 1953. The Final Solution: the Attempt to Exterminate the Jews of Europe, 1939-1945. New York: Beechhurst Press.

Reyntjens, F., 1985. Pouvoir et droit au Rwanda, Tervuren, Musée Royale de l´Afrique Centrale, 508 p.

Reyntjens, F., 1997. Estimation de nombre de personnes tuées au Rwanda en 1994. In eds. Marysse, S., Reyntjens, F., L'Afrique des grands lacs: annuaire 1996/1997, Paris: L'Harmattan, p. 179-186.

Reyntjens, F., 1997. Estimation du nombre de personnes tuées au Rwanda en 1994. In eds. Marysse, S., Reyntjens, F., L'Afrique des grands lacs: annuaire 1996/1997, Paris: L'Harmattan, p. 179-186.

Rozensweig, M.R., 1988. Risk, Implicit Contracts and the Family in Rural Areas of Low-income Countries. The Economic Journal 98: 1148-1170.

Rosenzweig, M.R., 2003. Payoffs from Panels in Low-Income Countries: Economic Development and Economic Mobility. American Economic Review 93, 112-117.

Rosenzweig, M.R. and Wolpin, K.I., 1993. Credit Market Constraints, Consumption Smoothing, and the Accumulation of Durable Production Assets in Low-Income Countries: Investments in Bullocks in India. Journal of Political Economy 101: 223-244.

Rubin, D.B., 1976. Inference and Missing Data. Biometrika 63: 581-592.

Samset, I. and Orrvar, D., 2003. Rwanda: Presidential and Parliamentary Elections 2003, NORDEM report 12/2003, The Norwegian Institute of Human Rights, 59 pp.

Sandford, S. and Habtu, Y., 2000. Report of the Pastoral Appraisal Team: On Emergency Response Interventions in Pastoral Areas of Ethiopia. London: DFID.

Sen, A., 1990. "More Than 100 Million Women Are Missing". New York Review of Books (December 20): 61-66.

Sliwinski, M., 1995. Le Génocide Khmer Rouge: Une Analyse Démographique. Paris: L'Harmattan.

SNR, 1982. Recensement Général de la Population et de l'Habitat, 1978, Résultats Définitifs, Kigali, Service National de Recensement, Ministère du Plan.

SNR, 1994. Recensement Général de la Population et de l'Habitat au 15 Août, 1991, Résultats Définitifs, Kigali, Service National de Recensement, Ministère du Plan.

SNR, 2003. Recensement Général de la Population et de l'Habitat Rwanda: 16-30 Août 2002: rapport sur les résultats préliminaires, Kigali, Service National de Recensement, Ministère des Finances et de la Planificiation Economique.

Stewart, F. and Fitzgerald, V., 2001. War and underdevelopment. 1 : The economic and social consequences of conflict. Oxford: Oxford University Press.

Swaminathan, M., 1991a. Measuring Mobility in Wealth: Some Estimates from a South Indian Village. Oxford Bulletin of Economics and statistics 53: 261-277.

Swaminathan, M., 1991b. Gainers and Losers: A Note on Land and Occupational Mobility in a South Indian Village, 1977-1985. Development and Change 22: 261-277.

Toulmin, C., 1995. Tracking through Drought: Options for Destocking and Restocking. In Living with Uncertainty: New Directions in Pastoral Development in Africa. (ed.) I. Scoones, Intermediate Technology Publications, London.

Townsend, R., 1994. Risk and Insurance in Village India. Econometrica 62: 539-591.

Townsend, R., 1995. Consumption Insurance: An evaluation of risk-baring systems in low income economies. Journal of Economic perspectives 2: 83-102.

Udry, Ch., 1995. Risk and Saving in Northern Nigeria. The American Economic Review 85: 1287-1300.

UN, 25 November, 1994, United Nations Commission of Experts Established to Security Council Resolution 935 on Rwanda, Final Report, Geneva.

Uvin, P., 1994. Violence and UN population data. Nature, 372: 495-496.

Uvin, P., 1998. Aiding Violence: the Development Enterprise in Rwanda, West Hartford, Kumarian Press, 288 p.

Verpoorten, M., Berlage, L., 2004. Genocide and Land Scarcity: Can Rwandan Rural Households Manage?. Centre for the Study of African Economies, Working paper, WPS 2004/15.

Verwimp, Ph., 2003a. Development and Genocide in Rwanda: A Political Economy Analysis of Peasants and Power under the Habyarimana Regime. Ph.D. Diss. Catholic University of Leuven.

Verwimp, Ph., 2003b. Testing the double-genocide thesis for central and southern Rwanda. Journal of Conflict Resolution 47: 423-442.

Verwimp, Ph., 2005. An economic profile of peasant perpetrators of genocide: micro-level evidence from Rwanda. Journal of Development Economics 77 : 297–323.

Vickery, M., 1984. Cambodia: 1975-1982. Boston: South End Press.

Von Meijenfeldt, R., 1995. At the Frontline for Human Rights: Evaluation of European Union Participation in the Human Rights Field Operation in Rwanda. An assignment of the commission of the European communities.

Wooldridge, J.M., 2002. Econometric Analysis of Cross Section and Panel Data, MIT Press, 740 pp.

World Bank, 2004. World Development Indicators 2004 (WDI) CD-ROM.

Zeldes, S., 1989. Optimal consumption with stochastic income: deviations from certainty equivalence. Quarterly Journal of Economics 104: 275-98.

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