KATHOLIEKE UNIVERSITEIT LEUVEN

Faculty of Economics and Applied Economics

Department of Economics

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by

Marijke VERPOORTEN

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DISCUSSION PAPER

Household coping in war- and peacetime: cattle sales in Rwanda, 1991-2001

Marijke Verpoorten*

Catholic University of Leuven, Belgium

Abstract

The economic literature has given due attention to household coping strategies in peacetime. In contrast, little is known about such strategies in wartime. This paper studies the use of cattle as a buffer stock by Rwandan households during 1991-2001, a period characterized by civil war and genocide. It is found that the probability of selling cattle increases upon the occurrence of both peacetime and wartime covariant adverse income shocks. The peacetime cattle sales are largely explained by shifts in the household asset portfolio. In contrast, in 1994, the year of the genocide, almost half of the cattle sales were motivated by the need to buy food. However, we argue that the effectiveness of this coping strategy was severely reduced due to the wartime conditions. First, during the year of ethnic violence, cattle prices plummeted to less than half of their pre-genocide value. Second, we find that households most targeted in the violence did not sell cattle. We discuss several explanations for this latter finding.

JEL: D12, D91, O12

Coping Strategies, Buffer Stock Model, Cattle, Violent Conflict, Rwanda

1 Introduction

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 (e.g. Asfaw and Von Braun,

*Research scholar of the fund for Scientific Research - Flanders, Belgium (FWO), Department of Economics, CES-KULeuven. e-mail: marijke.verpoorten@econ.kuleuven.be

2004, Corbett, 1988, Paxson, 1993, Rosenzweig, 1988). 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 literature on peacetime coping strategies 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 destruction of infrastructure and the lack of safety created by killing and looting soldiers or rebel groups. These may curtail the movement of people and the distribution of food aid, making households dependent on a restricted set of their own coping strategies.

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 during, and in the aftermath of violent conflicts. In order to gain such insights, detailed information on shocks, coping strategies, household consumption, and household income is required. This type of information is hard to collect, certainly in war-affected areas. Because of insecurity and chaos in post-conflict areas, interviewers can usually only collect this information well after the violent shocks occurred. Another complication is the non-randomness of the post-conflict sample since only the survivors of the conflict can provide recall information. Because of these complications, the data used in this study only allow a beginning of an answer to the above questions of interest.

We make use of a dataset of 258 Rwandan peasant households in two provinces, Gikongoro and Gitarama. The dataset was collected in 2002, eight years after the genocide. The dataset is unique because it includes detailed recall information on both war and non-war related household shocks that occurred in the period 1991-2001. Furthermore, the survey recorded all types of cattle transactions within the same period. Data on other household assets, household consumption and income are limited. Therefore, we focus our study on one single coping strategy, i.e. cattle sales. More specifically, we study whether peasant households in the provinces Gitarama and Gikongoro sold cattle to smooth consumption upon the occurence of peacetime and wartime shocks.

The literature on peacetime coping provides 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). 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. 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

to deal with recurrent shocks or in response to unusual stress (Corbett, 1988; Kinsey et al. 1998, McPeak, 2004, Rosenzweig and Wolpin, 1993). However, an equally large number of studies report contradicting results (Fafchamps et al., 1998, Lim and Townsend, 1998, Udry, 1995, Kazianga and Udry, 2006). These latter studies point to the difficulties in using livestock as a buffer, such as its risky return, its terms of trade risk and its indivisibility.

The mixed empirical evidence reflects the trade-offs associated with the use of cattle as a buffer as well as the importance of the empirical setting in which the study takes place, e.g. the general standard of living, the livestock (net) returns, the availability of other coping strategies and safety nets, and the extent of food and livestock market integration. The Rwandan setting provides an interesting case study because of its high population density, possibly reducing transaction costs, and its pasture land scarcity, making livestock maintenance increasingly costly.

However, our main interest lies in studying the trade-offs associated with wartime cattle sales. On the one hand, Rwandan households faced a huge covariant shock in 1994. They had to find ways to make ends meet, but many coping strategies such as informal insurance were undoubtedly under stress in wartime. 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. On the other hand, the more households decided to deplete their cattle, the lower the price of cattle compared to food became, and the less effective this strategy. Besides, 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.

In the theoretical part of this paper, we present a consumption-smoothing model to illustrate these wartime trade-offs, i.e. we include the risky cattle return, the terms of trade risk and the risk of cattle raiding. In the econometric part, we test whether households sold cattle in response to war-related adverse income shocks and other shocks. To this end, we disentangle a direct measure of self-reported shocks into several components, e.g. wartime and peacetime shocks, violent and less violent wartime shocks.

The results reveal that cattle sales were responsive to covariant adverse income shocks both in peacetime and in wartime. Distinguishing between cattle sales in exchange for food and other types of cattle sales, we find that the peacetime sales are largely explained by shifts in the household's asset portfolio, whereas almost half of the wartime sales are explained by consumption smoothing motives. However, it is unlikely that cattle sales were effective to buffer consumption against the wartime shocks. First, during the genocide cattle prices plummeted, while food prices soared. Second, we find that households most targeted in the violence did not sell their cattle in 1994. We discuss three possible explanations for this latter finding.

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. Section three presents our theoretical framework. Section four gives an overview of the data used and presents summary

statistics on income shocks and cattle transactions. Section five tests for the use of cattle sales to cope with adverse income shocks in both war- and peacetime. Section six focuses on cattle purchase behavior and evaluates whether the households in our sample purchased cattle in anticipation of adverse income shocks. Section seven presents some data and results for small livestock, for which the available recall data was much less extended than for cattle. Section eight concludes.

2 Rural livelihood, shocks and coping strategies in Rwanda

2.1 Farm system and food (in)security

Rwanda is the most densely populated country in Africa. Nevertheless 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)[1]. 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 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 cause erosion and at times 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 for some commodities may be moderated by imports from other areas and from neighboring countries. For example, price hikes of beans are partly checked by imports from the Democratic Republic of Congo and Uganda. In Rwanda, the main 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. 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

[1]The use of improved seeds and fertilizer is very limited in Rwanda, even compared to African standards (World Bank, 2005). 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.

market prices, 1986-2002).

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). However, in the region under study, the latter practice has become less common over time. The study of data on 563 marriages in our sample shows that after 1993 approximately 28% of marriages included cattle as a bride price, compared to 62% prior to 1974, 46% during the period 1974-1983 and 39% during 1984-1993. In economic terms, cattle are valuable for rural Rwandan households, mainly because their manure is widely used as fertilizer[2]. Despite these distinct roles of cattle, a nationwide study reveals that only 30 percent of Rwandan farmers owned cattle in 2000, while the proportion of cattle owners in the lowest expenditure quintile was as low as 15 percent (Government of Rwanda, 2002b). The lumpiness of cattle combined with the households' low purchasing power, even in good crop years, may prevent many poor households from accumulating cattle.

In Rwanda, cattle ownership is often associated with the Tutsi ethnic identity. This idea is fed by several myths, such as the "Hamitic hypothesis"[3] and the registration of ethnicity by the Belgian colonial regime[4]. Apart from these myths, the association is based on the fact that, prior to the Hutu revolution of 1959, those in power were identified as Tutsi and acquired wealth in the form of cattle while being in power (Des Forges, 1999). However, in the region under study Tutsi cannot be distinguished from Hutu based on cattle ownership, economic activities, customary practices or language[5]. The association between Tutsi and cattle is materialized in only some parts of the country. For example, the Bagogwe and Bahima in the north of the country are pastoralists and usually identified as Tutsi[6].

Even though in the region under study cattle ownership could not be used to identify Tutsi, the initiators of the genocide surely made use of Tutsi wealth in the form of cattle

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

[3] According to this myth, Tutsi are Hamite cattle herders that migrated to Rwanda and subjugated the indigenous Bantu agriculturalists. This hypothesis has been disseminated through schools in Rwanda since the early 1920s, but is contested by many anthropologists and historians (e.g. Des Forges, 1999; Newbury, 1997, 1998).

[4] It is often said that the Belgian colonial administration classified Rwandans as Hutu or Tutsi on the basis of cattle ownership. However, the procedure for population registration took no account of ownership of cattle. Instead, the number of cattle was used as a tax base (Des Forges, 1999; Mamdani, 2001; Reyntjens, 1985; Inforcongo, 1959)

[5] We note that, despite the homogeneity of economic activities across ethnic groups, inhabitants of these communities knew very well the ethnic identity of their neighbors. The ethnicity for each adult was registered in a personal file at the local administration. Children took the ethnic identity of their father, or, in the absence of recognition by the father, of their mother. Once they reached the age of 18, their ethnic identity was transferred to their personal file (Verpoorten, 2005).

[6] However, even for these groups, getting rid of cattle was certainly not sufficient to hide their ethnic identity. Indeed, they were easily identified without cattle, because they lived concentrated in a certain location and shared distinctive customary practices and linguistic features.

to urge the Hutu population to violence, for example by saying that "the Tutsi cattle were just waiting to be eaten" (Des Forges, 1999, p. 272). However, the role of cattle as a war trophy and a reward for killers is not unique to the genocide nor to Rwanda. Throughout the Rwandan history its rulers tried to win cattle, both in conflicts with other members of the elite and in adventures abroad (Des Forges, 1999). Also in East-African countries such as Kenya, Sudan, Ethiopia and Tanzania cattle raiding has been and still is common between rival groups (Fukui and Turton, 1979; Anderson, 1986; Bukuru, 1996).

Data on cattle raiding during the Rwandan genocide is scarce. According to an estimate put forward by FAO (1997) 80 percent of the cattle stock was lost during the Rwandan genocide. 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)[7].

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 head of cattle (FSRP et al., 1984-1992). One explanation of the decrease might be that land scarcity profoundly affected 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[8].

Besides cattle, Rwandan rural households also keep small livestock. In 2000, farm households owned on average 1.33 goats, 0.43 sheep, and 0.33 pigs. About 80 percent of farm households owned some livestock. Even in the lowest expenditure quintile, the proportion of livestock owners was quite high at 71 percent (Government of Rwanda, 2002b). Although

[7] 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 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.

[8] 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. 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 (Verpoorten, 2006).

most farm households still prefer to own cattle, because of its social prestige and large quantities of manure, they recognize that keeping small livestock has advantages. Households in Gikongoro province 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, mostly kept by large cattle owners because of the advantages of a mixed cattle-sheep grazing system, 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). Peasants mentioned that pigs can be fed with sweet potatoes and have a large off-spring with a litter of 10 to 12 newborns. Few Rwandan peasants eat pork, but besides export opportunities to neighboring countries (mostly Congo), there is a growing urban market for pork meat within Rwanda (Verpoorten, 2006).

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 (Verpoorten, 2006). 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)[9]. 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

[9]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 and a smaller third season: 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.

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).

2.4 Food insecurity during the genocide

Civil war broke out in Rwanda at the end of 1990, when the RPF (Rwandan Patriotic Front) started launching attacks from Uganda. Intermittent hostilities and negotiations between the government and the RPF resulted in a power sharing agreement, but on April 6, 1994 the plane carrying President Habyarimana was shot down. Thereafter, Rwanda sunk into chaos. Within hours, the military, administrators, the Interahamwe militia[10], and ordinary people started to kill Tutsi and moderate Hutu. 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. 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, 1998)[11]. In addition, tens of thousands of people died from deprivation in the refugee camps.

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 strongly affect 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.

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

[11] The death toll among Tutsi remains a debated issue. For a discussion, see Verpoorten (2005).

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.

3 Theoretical framework: the buffer-stock model in a setting of violent conflict

The aim of the theoretical framework is to derive predictions for the use of livestock as a buffer stock by Rwandan households. A good starting point is the buffer-stock model of precautionary savings pioneered by Deaton (1991)[12]. A crucial assumption of the buffer-stock 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[13]. Under these assumptions, it can be shown that economic agents, who maximize their expected intertemporal utility, build up assets when income is "good" and draw it down when income is "bad". To reflect the war conditions, we extend the basic buffer-stock model by adding risky prices, risky cattle returns and the risk of cattle raiding[14]. We distinguish between cattle raiding on the road and at home, at t and at $t+1$ because of their different implications for household cattle sale behavior.

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 we take cattle as the single asset A_t in the model[15]. This asset A_t earns an interest rate r_{t+1} when held over from period t into period $t+1$[16]. Households face risky labor income y_t in each period t. Income is

[12] Consumption-smoothing through saving and dissaving is consistent with common models of intertemporal consumption choice, such as the permanent income model (Friedman, 1957). The data at hand do not allow testing a particular model of consumption smoothing. But, 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 (e.g. empirical evidence provided by Kazianga and Udry, 2006). Several features of the Rwandan context are 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.

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

[14] This extension is similar to the one of Stefan Dercon (2004) who extends the basic Deaton model to incorporate risky prices and risky asset returns.

[15] The model would be more complete if it would allow for household portfolio decisions. However, incorporating this would complicate the model substantially (e.g. Fafchamps et al., 1998). In the empirical analysis we can rule out the possibility of cattle sales as part of an asset portfolio shift by looking exclusively at cattle sales for the purpose of food purchases.

[16] The distribution of this return is a complex function of the expected milk production and off-spring of the

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[17].

The household's intertemporal optimization problem is to decide in each period t how to allocate total liquid wealth, $y_t + A_t$, between consumption and savings. It can be written as follows:

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

s.t.

$$s.t.\;\; p_{t+1}(1-\kappa_{t+1}^{R})A_{t+1} = \frac{p_{t+1}}{p_t}\frac{(1-\kappa_{t+1}^{R})}{(1-\kappa_t^{R})}\left[p_t(1-\kappa_t^{R})A_t + y_t - c_t\right](1+r_{t+1})\,(1-\kappa_{t+1}^{H}), \tag{2}$$

$$A_t \geq 0, \quad A_0 = \bar{A}, \qquad \forall t = 0...\infty, \tag{3}$$

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) and (3) give respectively the budget and the borrowing constraints, where both y_t and A_t are expressed in consumption units. The borrowing constraint implies that a household cannot dissave beyond the value of its current assets. The budget constraint represents the trade-off between the impatience to consume, risky cattle prices, risky cattle return and the risk of cattle raiding. In this equation, p_t and p_{t+1} represent the prices of cattle measured in consumption units in period t and $t+1$ respectively; 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 $t+1$[18]. 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) serves to convert the asset stock at time $t+1$ into

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 $t+1$. 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 (e.g. Fafchamps et al., 1998; McIntire et al., 1992). However, to keep the model simple, we do not explicitly include the cost of livestock caring.

[17] We 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, we refer to Deaton (1991).

[18] 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 paper lies in the effect of political unrest, we chose to model cattle raiding explicitly.

consumption units valued at prices of period $t+1$.

Optimization of (1)-(3) yields two possible outcomes. On the one hand, when the borrowing constraint does not bind, the following equality holds:

$$v\prime(c_t) = \frac{E_t\left[p_{t+1}(1-\kappa^R_{t+1})(1+r_{t+1})(1-\kappa^H_{t+1})v\prime(c_{t+1})\right]}{p_t(1-\kappa^R_t)(1+\delta)} \qquad \forall t = 0...\infty. \tag{4}$$

In words, the household chooses period t consumption such that its marginal utility of consumption in period t equals the discounted expected marginal utility of future consumption. 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:

$$v\prime(c_t) = v\prime\left(p_t(1-\kappa^R_t)A_t + y_t\right) \qquad \forall t = 0...\infty. \tag{5}$$

According to equation (4), 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 $t+1$. Formally, if p_t decreases, the right-hand side of equation (4) 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^R_t. The optimality condition (4) 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[19]. A similar effect is obtained when the expected risk of cattle raiding at home, κ^H_{t+1}, increases. Note that a person's risk of being killed is not explicitly modeled. 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 to go to the upper limit of the interval $[0, 1]$.

Changes in (expectations of) the cattle price, cattle raiding on the road and at home, and the rate of return are likely to have occurred simultaneously during the Rwandan genocide. To start with, as the violence was widespread, the realization of the terms of trade risk was highly plausible[20]. Second, the risk of cattle raiding was very high. Cattle raiding on the road in period t may have made households reluctant to sell cattle, while the expected risk of cattle raiding in $t+1$ may have convinced households to quickly deplete their cattle stock. Third, due to the lack of adequate feeding and watering during the violent conflict, it is likely

[19] 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). 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).

[20] 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.

that the expected return for holding cattle was low, all the more so because households may have anticipated the need to abandon their cattle to take refuge abroad. Since these effects occurred simultaneously, the impact of the violent conflict in Rwanda on cattle sale behavior is ambiguous. In section 5, we disentangle the war-related shocks into several components in order to study the effect of the different parameters of the extended buffer stock model on cattle sale behavior. Before doing so, we present and discuss summary statistics of our data.

4 Summary statistics on adverse income shocks and livestock transactions in Gitarama and Gikongoro, 1991-2001.

4.1 Data used

We use information on a sample of 258 farm households, clustered in 16 communes, ten of which are located in Gitarama province and six in Gikongoro province (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. 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[21]. It is estimated that only 25 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; Verpoorten, 2005).

The sample of 258 households is not a random sample. The history of the dataset dates back to 1990 when 256 households were interviewed. By 2002, 44 of the original households had dropped out. Attrition was especially high among Tutsi-headed households (45.5% versus 21.1% for other households). Consequently, Tutsi accounted for a very small share of the 2002 sample. Therefore, in 2002, it was decided to over-sample Tutsi-headed households, lifting their share from less than 10 percent to 22.5 percent (59/258). Concretely, as the interviewers' wages in 2002 were negotiated based on the original household sample size of 256, they were asked to complete their number of interviews by adding households from Tutsi-survivors (mostly widows). One enthusiastic interviewer added four instead of two Tutsi-headed households, bringing the total number of households interviewed in 2002 at 258. In two cases, additional Hutu-headed households were interviewed because no Tutsi-headed households could be found in the sector.

Verwimp (2003), Justino and Verwimp (2006) and Verpoorten and Berlage (2007) document the dataset in detail and provide information on sample selection. It is found that households who dropped out were more likely to have suffered from severe shocks of the war

[21] 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,Verpoorten (2005) 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.

and the genocide. For example, based on interviews with neighbors, Verwimp (2003) finds that many of the Tutsi-headed households who dropped out were completely exterminated or lost several household members. These latter households were often left with one survivor, a widow, who moved back to her native sector[22]. Besides the shocks of war and genocide, the non-randomness is also related to household size and the age of the household head. Small households and young households were more likely to drop out. However, there is no evidence that the selection into the sample is related to household cattle ownership in 1990 (Justino and Verwimp, 2006; Verpoorten and Berlage, 2007).

Including the "refreshment sample" of Tutsi-headed households partly compensates for the loss of observations on war-related shocks, such as the violent death of household members and the destruction of the household's dwelling. Nevertheless, repeating the regression analysis without the oversampled Tutsi-headed households yields the same qualitative results. In section 5.3 we come back to the non-randomness of the sample and discuss possible implications for our empirical results.

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[23]. The results are summarized in Table 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 sampled 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 at least one 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.

Households may respond differently to adverse income shocks, depending on whether the shocks are idiosyncratic or covariant, and on whether or not they are serially correlated over time. Therefore, 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. These results make sense and are indicative of the quality of the retrospective

[22] In spite of the recent law change that granted women equal inheritance to men, many widows lost land upon the death of their husbands. Women interviewed in Gikongoro said that, in practice, according land rights to a widow depends much on the mercy of her family in law and whether or not the woman has a son that was recognized by her former husband (Verpoorten, 2006).

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

Table 1: Typology of shocks reported

	Households affected 1991-2001 (%)		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
	All hhs	Tutsi-hhs				
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.

data.

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 shocks listed in Table 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 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 (cf. last columns of Table 2). 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. Furthermore, whether or not an income shock results in

Table 2: Adverse income shock index and consumption shortfall over time

	Average 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 1. Horizontally, they sum up to 100. The category of political insecurity is based on the shocks listed in the rows 1-6 of table 1

a consumption shortfall depends on the ability of the household to smooth consumption. Nevertheless the link between shocks and reported food shortages may give an idea about the immediate and persistent effect of shocks on the household's income.

The last two columns of Table 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[24]. Most of the reported shocks listed in Table 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 correlation between the shocks and household food shortages is suggestive for the quality of the self-reported recall information. In this respect, it is noteworthy that the positive correlation between reported shocks and food shortages also holds for the years prior to 1994 (the results for separate years and periods are not reported). The occurrence of food shortages upon adverse income shocks also demonstrates that households do not fully smooth consumption, a general finding for rural areas in developing countries (for an overview, see Dercon, 2004).

We 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, 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 hit household i 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 shows an increasing trend of the shock index over time. This may be due to 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,

[24]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.

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. 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 shortages reached a peak in 1994[25].

4.3 Cattle ownership, prices and transactions

Table 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[26]. Two thirds of these cattle owners own one or two head of cattle, while only a handful own relatively large herds with five to fifteen head of cattle. None of the households depend primarily on livestock for their livelihoods. The lumpiness of cattle together with the scarcity of pasture land and the high maintenance cost of cattle are among the reasons for the small number of cattle in our sample (see section 2).

Column two provides information on the total number of cattle in the sample over time. The following columns show the total number of cattle lost, sold, purchased, born, received, and given in each year. According to the data, the cattle lost in 1994 amounted to about half of the total cattle stock at the start of 1994[27]. 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.

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 head of cattle were sold, almost twice as

[25]The number of years of food shortages varies considerably across households. For example 15 percent of households did not report any year of food shortage, while 12.4 percent reported more than five years of food shortages. 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.

[26]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 of the households (57.8 %) were cattle owners in one or more years of the period studied.

[27]This is smaller than the FAO estimate of 80 percent cattle loss for the whole of Rwanda (FAO, 1997).

Table 3: Cattle ownership and cattle transactions over time

	Proportion of Households owning cattle	Head 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

much as the average number sold in other years[28]. The average price received for a head of cattle during 1991-2001 was about 30,000 RWF, more than half of the annual expenditure per rural inhabitant for this period[29]. In 1994, the cattle price was on average only 11,500 RWF per animal sold. The price observations are set out in Figure 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. These are nominal cattle prices. Real prices would most probably reinforce the picture, but, except for some anecdotic evidence of soaring food prices, there are no records of the 1994 food prices[30].

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 4 shows the results. For the period 1991-2001, the need to purchase food was the main reason for selling cattle in only 17.3 percent of cases, and in only 11.6 percent of cases in peacetime (excluding 1994). Households sold cattle mostly in order to make another investment, be it in physical or human capital. Occasionally, 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. The latter reason was mentioned especially by the elderly in our sample.

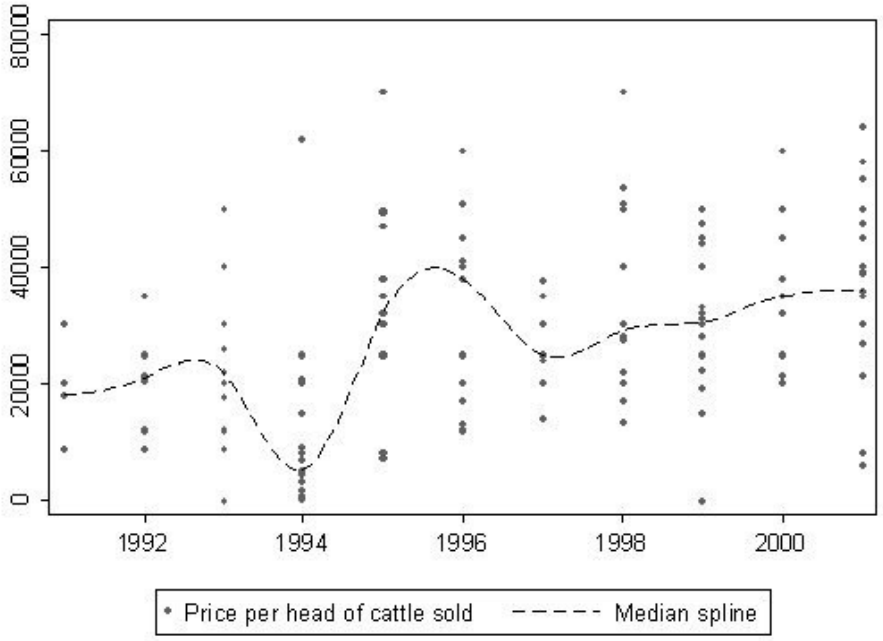
For 1994, the picture looks very different: more than eight out of ten animals were sold either because of the need to buy food (44.4%) or because of insecurity (40.7%). "Insecurity" points here to the fear for cattle raiding or the need to seek refuge. For example, one peasant answered that there was no pasture land in the refugee camps and he was therefore obliged to sell his cattle at a very low price. Selling cattle because of the fear for cattle raiding results

[28]The relatively high number of cattle sales in 1999 is due to the outbreak of foot-and-mouth disease in the South-East of the country.

[29]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)

[30]An indication of the soaring food prices is that the food prices in 1995 were twice as high as in 1993 (World Bank, 2005).

Figure 1: Evolution of nominal cattle prices during 1991-2001



in a shift in the household asset portfolio. This may be considered as an ex-ante strategy, i.e. to get rid of visible wealth that may attract militia. In contrast, cattle sales in order to purchase food rather qualify as an ex-post consumption smoothing strategy.

4.4 Ethnic-base differences in cattle ownership and transactions

In section 2.2 we noted the widespread idea of Tutsi as herders and Hutu as farmers. If this were to be true, cattle ownership could have served to identify Tutsi, and target them for slaughter in 1994. However, the data at hand contradict this idea for the provinces of Gikongoro and Gitarama. Indeed, we find that, both in the initial 1990 sample and in the 2002 post-genocide sample, Tutsi-headed households cannot be distinguished from Hutu-headed households based on economic activities or cattle ownership[31].

In 1994, Tutsi-headed households lost more cattle than Hutu-headed households: 86.2

[31]The comparison of the 1990 data involves 21 Tutsi-headed households and 223 other households. Besides the cattle stock, we compared the contribution of income from six sources: (1) own consumption, (2) crop sale, (3) beer production, (4) livestock, (5) off-farm farm work and (6) off-farm non-farm work. The usual 5% significance level was applied. A significant difference was only found for the contribution of off-farm farm work, which contributed 7.1 percentage points more to the income of Hutu-headed households. Surprisingly, the Hutu-headed households in the 1990 sample owned twice as much cattle as Tutsi-headed households, though this difference was significant only at the 10% level. The comparison of the 2002 data involves 59 Tutsi-headed households and 197 other households. Only if we subdivide income source (6), i.e. off-farm non-farm work, further into skilled and unskilled work, we find that Tutsi-headed households derive significantly (at the 5% level) more income from skilled non-farm work.

Table 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		

% of the cattle owning Tutsi-headed households lost cattle versus 32.8% of Hutu-headed households; 74.2% of the total cattle stock held by Tutsi-headed households was lost versus 33.8% of the total Hutu-held cattle stock. This is not surprising. First, while hiding for the killers, Tutsi may have been forced to leave their cattle behind. Second, as explained in section 2, cattle played a role in the genocide as a war trophy and a reward for killers. To some extent, it can be argued that cattle constituted a particular form of wealth in 1994 because of its - albeit immaterialized - association with Tutsi. On the other hand, we find that also other types of assets of Tutsi-headed households were particularly affected by the violent conflict[32].

Looking at cattle transactions, we do not notice an ethnic-based difference in the peace years. In contrast, ethnicity played a major role in cattle transactions in the year of the genocide. We find that, in 1994, only one (3.4%) of the 29 cattle owning Tutsi-headed households sold cattle (versus 11.8% in peace years). The reason reported for this sale ("to engage in petty trade") was not directly related to the violent conflict. In contrast, 23.3% of the cattle owning Hutu-headed households sold cattle (versus 14.0% in a peace year). Thus, the observed increase in cattle sales during the year of violent conflict is entirely due to sales by hutu-headed households. These descriptive statistics indicate that, for 1994, we don't find evidence for the use of cattle sales as an ex-post or an ex-ante strategy by households most targeted in the genocide. After deepening our understanding of cattle sale behavior in the regression analysis, the next section discusses different explanations for this finding.

[32]These other types of assets are a hoe, machette, radio, bike and furniture. The value of the reported losses of these assets due to the war amounted to 8576 RWF for Tutsi-headed households and 1300 RWF for Hutu-headed households. In addition, table 1 showed that a larger proportion of Tutsi-headed households lost their house due to the violence.

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

In this section, we test whether households sold cattle upon the occurrence of an adverse income shock. To ascertain that these cattle sales do not just reflect shifts in the household asset portfolio (including the ex–ante strategy to get rid of visible wealth), we repeat the test with cattle sold for the purpose of purchasing food as explanatory variable.

5.1 Econometric specification

The dependent variable, z_{it}, is a binary variable taking the value 1 when household i sold cattle in year t, and 0 otherwise[33]. 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 was defined in section 4.2[34]. We interact the shock index with a dummy, d_t, indicating cattle ownership at the start of period t. This yields more precise estimates since only cattle owning households can sell cattle upon the occurrence of a shock. The model can be formulated in terms of the following underlying latent model

$$z_{it}^* = s_{it}d_{it}\gamma + x_{it}\beta + \alpha_i + \varepsilon_{it}, \tag{6}$$

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

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

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, we 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, we included the heads of cattle born, received and given in year t, the number of cattle stolen or killed and the heads of cattle that died from a disease in year t. Finally, we control for household land and labor, which determine the cost 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

[33]No distinction is made between one or more heads of cattle sold, because the number sold rarely exceeds one.

[34]The shock index accords an equal weight to the shocks listed in Table 1. An alternative way is to construct a weighted index to reflect the shocks' negative impact on household income. Lacking income data, we set the weights equal to the estimated coefficients of a logistic regression that calculates the probability of a food shortage for household i given the shocks that hit the household in year t. The weighted index 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 (these results are not reported but can be obtained on request).

induce households to hold on to cattle for their milk[35]. Table 5 gives a description of all variables used in the regression analysis.

The parameters α_i in equation (6) can be treated as random unknown parameters or as fixed unknown parameters. In the first case, the model is 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 at a 5% significance level, we use the fixed effects approach and fit a conditional fixed-effects logit model to the dataset (Hausman and Taylor, 1981). 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 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 household-year observations from 2580 to 830 and to 220, respectively for the binary dependent variables "cattle sold" and "cattle sold in exchange for food"[36].

Table A1 in the Appendix compares the household characteristics across the full sample and the two sub-samples. Comparing the sub-sample of 83 households with the full sample of 258 households, we find that the latter households own fewer cattle, and have on average smaller land and household sizes. However, there are only small differences with respect to the incidence of adverse income shocks and ethnic composition across the different samples. As such, the proportion of Tutsi-headed households among the 83 and 258 households amounts to respectively 20.73% and 22.96%. We can therefore be fairly confident that the sample of 83 households is not a highly particular sub-sample of the sample of 258 households. In contrast, the ethnic composition and incidence of violent shocks is quite different across the 83 households who sold at least one head of cattle in the period 1991-2001 and the 22 households who sold at least one head of cattle in exchange for food. Among these latter 22 households, we only count one Tutsi-headed household. Comparing the FE-results using the sub-samples with the RE-results using the full sample, we find qualitatively similar results, though the estimated coefficients on the different shock variables are smaller in absolute value for the RE-results[37].

[35] We also run regressions including variables to control for the fact that households may want to keep their cattle as a bride price upon the marriage of a son. This practice was discussed in section 2.2. First, we disaggregate the explanatory variable "men 15-65" into two components: men yet to be married and other men. Second, we controlled for "marriages of male household members in year t+1". In both cases, the results are unaffected and the control variables are not significantly different from zero. The results of these additional regressions can be obtained on request.

[36] The observations for 1991 are dropped due to the inclusion of lagged variables. Therefore, the maximum possible number of observations is 2580 (258*10).

[37] This difference is not surprising since the RE-logit approach inlcudes households who did not sell any head of cattle during the period 1991-2001. The RE-results can be obtained on request.

Table 5: Definition and descriptive statistics for the explanatory variables used in regression analysis, 1991-2001

	Description[a]	N=830	
		Mean	Variance
Shock index (t)	Sum of shocks listed in table 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	0.18[d]	0.20[d]
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, we use the transition probabilities listed in table 1. [c] Mean and variance for 1994. [d] Mean and variance for 1991-2002, besides 1994.

5.2 Estimation results

Tables 6 and 7 show the fixed-effects logit estimates, respectively for all cattle sales and cattle sales in exchange for food. We 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 6 (2.20) implies that an increase of the shock index from 0 to 1, results in a 2.20 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 9.03 (exp(2.20)) 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, we find that the probability of a household selling cattle increases with 0.55 percentage points for a marginal increase in the shock index. The results in Table 7 (column 1), with cattle sales in exchange for food as the dependent variable, 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 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, we 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 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 have other less costly ways to deal with idiosyncratic shocks, while the same does not apply to covariant shocks. This reasoning may also apply to our results for Rwanda. Again, the results in Table 7 (column 2) are qualitatively similar.

The persistence of the shock may also matter for cattle sale behavior (conditional upon the ability of households to foresee future shocks or income risk). 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 $t+1$ (certainly when assuming decreasing absolute risk aversion, as in the buffer stock model for precautionary savings). 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, permanent shocks may be difficult to cope with in other ways, whereas households may have access to other less costly strategies to deal with a transitory shock. For

Table 6: Fixed effects logit estimates of the determinants of cattle sales

	1	2	3	4	5	6
Shock index (t)[a]	2.20					1.94
	(0.000)					(0.004)
Idiosyncratic component		0.76				
of shock index (t)		(0.383)				
Common component		3.78				
of shock index (t)		(0.000)				
Temporary component			-0.51			
of shock index (t)			(0.630)			
Persistent component			3.67			
of shock index (t)			(0.000)			
Shock index for 1994 (t)				1.20		
				(0.223)		
Shock index for other years (t)				2.66	2.92	
				(0.000)	(0.000)	
Highly violent component					-0.85	
shock index in 1994 (t)					(0.506)	
Other components of					1.69	
shock index in 1994 (t)					(0.017)	
Common component of cattle						-0.10
lost due to violence (t)[a]						(0.883)
Idiosyncratic component of cattle						-0.66
lost due to violence (t)						(0.030)
Common component of cattle						3.86
lost due to other cause (t)[a]						(0.054)
Idiosyncratic component of cattle						-1.48
lost due to other cause (t)						(0.026)
Cattle lost due to violence (t)	-0.56	-0.60	-0.54	-0.48	-0.47	
	(0.021)	(0.011)	(0.031)	(0.050)	(0.069)	
Cattle lost due to other cause (t)	-1.14	-1.19	-1.11	-1.12	-1.15	
	(0.049)	(0.045)	(0.055)	(0.049)	(0.047)	
Cattle stock (t-1)	1.43	1.36	1.43	1.43	1.40	1.41
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Squared cattle stock (t-1)	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Chi-squared statistic	137.87	143.83	144.06	139.84	144.02	142.06
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); [a]These variables are interacted with a dummy of cattle ownership at the start of period t.

Table 7: Fixed effects logit estimates of the determinants of cattle sales in exchange for food

	1	2	3	4	5	6
Shock index (t)[a]	3.31					2.90
	(0.052)					(0.105)
Idiosyncratic component of		0.50				
shock index (t)		(0.828)				
Common component of		7.15				
shock index (t)		(0.007)				
Temporary component of			1.76			
shock index (t)			(0.483)			
Persistent component of			3.18			
shock index (t)			(0.215)			
Shock index for 1994 (t)				4.73		
				(0.030)		
Shock index for other years (t)				2.56	3.96	
				(0.176)	(0.056)	
Highly violent component of					-76.96	
shock index in 1994 (t)					(1.000)	
Other components of					4.11	
shock index in 1994 (t)					(0.005)	
Common component of cattle						0.55
lost due to violence (t)[a]						(0.785)
Idiosyncratic component of						0.95
cattle lost due to violence (t)						(0.304)
Common component of cattle						4.86
lost due to other cause (t)[a]						(0.174)
Idiosyncratic component cattle						-2.93
lost due to other cause (t)						(0.153)
Cattle lost due to violence (t)	0.92	1.10	0.84	0.96	0.48	
	(0.270)	(0.214)	(0.319)	(0.265)	(0.597)	
Cattle lost due to other cause (t)	-2.01	-1.92	-2.07	-2.03	-2.40	
	(0.204)	(0.245)	(0.206)	(0.187)	(0.121)	
Cattle stock (t-1)	3.54	3.37	3.45	3.57	3.16	3.43
	(0.002)	(0.004)	(0.003)	(0.002)	(0.007)	(0.003)
Squared cattle stock (t-1)	-0.42	-0.40	-0.39	-0.43	-0.33	-0.40
	(0.027)	(0.031)	(0.041)	(0.026)	(0.099)	(0.027)
Chi-squared statistic	42.29	47.04	47.04	43.39	47.96	44.77
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); [a]These variables are interacted with a dummy of cattle ownership at the start of period t.

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, we disaggregate the shock index into a temporary and a persistent component. To calculate the persistent component of the shock index, we first took a weighted sum of the shocks, with the weights equal to the transition probabilities as listed in Table 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 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 7, where the estimated coefficient for the persistent component of the shock index is not significantly different from zero. This suggests that the observed relationship between cattle sales and persistent shocks reflects asset portfolio shifts rather than consumption smoothing behavior. The non-responsiveness of cattle sales in exchange for food to persistent shocks may be explained by a strong precautionary motive.

The main question of interest in this paper is whether buffer stock behavior differs between war- and peacetime. To test for this, we decompose the shock index into shocks that occurred in 1994 and shocks that occurred in other years. The results in column 4 of Table 6 show that cattle sales were less responsive to shocks in 1994 than to shocks in other years. However, the results of Table 7 show the opposite, indicating that, in contrast with the peacetime-years, in 1994 cattle sales were primarily used to smooth consumption[38]. This result for 1994 is obtained despite the bad terms of trade (cf. Figure 1) and the high risk of cattle raiding on the road. However, not all households were equally targeted in the violence. Consequently, some might have faced a higher risk of cattle raiding than others. To test whether lack of safety prevented the war-affected households from selling cattle, we 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[39]. The results in column 5 of both Tables 6 and 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. This finding is in line with the evidence presented in subsection 4.4 that only one Tutsi-headed household sold cattle in 1994.

[38]These results persists even when the shock indices for 1994 and 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). As in the previous regression outputs in table 7, the cattle sale response is only significantly responsive to covariant shocks. These additional regressions are not reported, but can be obtained from the author upon request.

[39]We could also have disaggregated the 1994 shock index into shocks affecting Tutsi-headed households and shocks affecting Hutu-headed households. However, since no single Tutsi-headed household sold cattle in 1994 in exchange for food, the coefficient on this part of the shock index was not identified.

5.3 Why don't we observe cattle sales by targeted households?

We evaluate three different explanations for the finding that households targeted in the violence did not sell cattle: (1) these households were too afraid to go on the road and sell cattle; (2) they tried to sell cattle but their cattle was stolen or lost before the transaction could take place; (3) Tutsi-headed households who sold cattle dropped out of our sample.

In terms of the theoretical model the first two scenarios can be distinguished. In both scenario's, the parameters κ_t^R, $\kappa_{t+1}^R$and κ_{t+1}^H are very high for targeted households, while r_{t+1} is very low. In the first scenario the effect of κ_t^R outweighs the combined effect of r_{t+1}, κ_{t+1}^R and κ_{t+1}^H. Consequently, the household does not try to sell cattle at t (because of the fear for cattle raiding and/or for their own life). In the second scenario the combined effect of r_{t+1}, κ_{t+1}^R and κ_{t+1}^H outweighs the effect of κ_t^R, and the household tries to sell its cattle at t. However, since κ_t^R is high, the actual selling may not take place. Therefore, empirically, it is difficult to distinguish between the two scenarios. Both scenario's yield very low actual cattle sales and a very high loss of cattle. The final outcome is the same, i.e. cattle sales were not an effective coping strategy for targeted households.

An alternative way to test whether (the risk of) cattle raiding precluded 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[40]. However, cattle raiding is expected to be much higher during wartime than during peacetime. Consequently, testing for the dissuasive effect of cattle raiding 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 column 6 of Table 6 show that, in contrast to the risk of raiding and looting, the risk of cattle disease triggers off cattle sales.

According to our third explanation, the finding that targeted households did not sell cattle upon shocks is due to attrition bias. Since we only interviewed the surviving households that could be traced, it could indeed be that Tutsi-headed households who sold cattle dropped out of the sample[41]. However, we argue that even for these households selling cattle was not an

[40] In our sample, the correlation between the price received for cattle and the head 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.

[41] More formally, non-random selection is non-ignorable if it depends on the variable of interest, i.e. cattle sales, even when allowing the selection probability to depend upon the observed explanatory variables (such as cattle ownership, household composition and household shocks). Thus, the fixed effects estimator is inconsistent if the fact whether a households is in the sample or not tells us something about the expected value of the idiosyncratic errors, ε_{it} in equation (6). In the FE-estimator, sample selection may however depend upon the fixed household effect α_i (Verbeek, 2000; Wooldridge, 2002). Let me clarify this with an example. Suppose that the observed explanatory variables do not fully capture risk aversion of the household, and that risk aversion varies over time. If the least risk averse Tutsi-headed households in 1994 had a higher propensity to sell cattle in 1994 as well as a higher risk of being victim of the killings (e.g. while trying

effective coping strategy. From excellent survey work by Ph. Verwimp (2003) we can derive that that at least six Tutsi-headed households who dropped out of the sample were completely exterminated, while the remaining households who dropped out lost several members. It is therefore difficult to maintain that cattle sales were an effective coping strategy for these households.

6 Cattle purchase behavior: forward-looking?

If households built up cattle especially for the purpose of dealing with shocks, households would be inclined to save in the form of cattle in anticipation of shocks (Campbell, 1987, Udry, 1995). Testing for such forward-looking behavior is not straightforward. First and foremost, the test only makes sense if we assume that households can foresee future shocks or, in case of the buffer-stock model for precautionary savings, 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 unusual events this assumption is less likely. Secondly, 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 household to shocks. Alternatively, saving assets may decrease household expenditure for a variety of agricultural inputs, possibly reducing household protection against crop shocks (Udry, 1995).

With these reservations in mind, we test for forward-looking cattle purchase behavior by regressing cattle purchases in year t on the shock indices of year t and $t+1$. The results are presented in Table A2 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 forward-looking cattle purchases. In columns 4 and 5 this finding holds for peacetime shocks. However, the results in columns 4 and 5 suggest that households hit by shocks in 1994 accumulated cattle in the year prior to the genocide.

This latter 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 RPF in the North of the country and sporadic attacks on Tutsi

to sell their cattle) or, alternatively, successfully flee from the violence, the error term ε_{it} in equation will be correlated with the households' selection into the sample and the results will be biased. In this case, the inference made above, i.e. that Tutsi-headed households did not sell cattle in 1994, may be incorrect. Formally, assume that the selection indicator r_{it} can be explained by a random effects probit model, $r_{it}^{*} = q_{it}\delta + \eta_{it}$ where $r_{it} = 1$ if $r_{it}^{*} > 0$ and 0 otherwise, and q_{it} is a vector of exogenous variables including s_{it} and x_{it}. For consistency of the fixed effects estimator, it is required that $cov\{c\varepsilon_{it}, \eta_{it}\} = 0$, with c an appropriate scaling factor for transforming the distribution of ε_{it} from a standard logistic to a standard normal distribution. In theory this can be tested, but in our case information to test formally for attrition bias is lacking. First and foremost, for the households that dropped out, the variables of the vectors s_{it} and x_{it} are only observed for $t = 1990$. Second, for the refreshment sample, q_{it} is not observed for $t = 1990$.Finally, r_{it} is only observed for t=1990 and t=2002, not for the years in between.

within Rwanda[42]. Neither can the possibility that the shocks of 1994 were endogenously determined by cattle accumulation in 1993 be excluded. For example, households who were able to accumulate wealth in the year preceding the ethnic violence may have been more exposed to (envy-driven) assaults. This is in line with the evidence presented by André and Platteau (1998) on the economic profile of the victims of the 1994 events. Alternatively, close links with the local authorities prior to the genocide may have both enabled households to accumulate wealth and increased their involvement in the genocide (for an economic profile of the perpetrators of the genocide, cf. Verwimp, 2005). Finally, a variety of circumstances, unrelated to the outbreak of violence, could have motivated households to purchase cattle in 1993. The observed cattle purchases may even have occurred despite overall dissaving of assets. Lack of information on other assets and the reasons for the cattle purchases prevent us from distinguishing between these different possible scenarios.

7 Available data and hypothesis test for small livestock

The available data on ownership of small livestock is limited to 2002. In that year, the households in the sample owned on average 0.83 goats, 0.19 sheep and 0.23 pigs (compared to 0.77 head of cattle), and these animals were distributed among seventy percent of the households (compared to 35% for cattle). 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. In contrast, we found 27 distress sales of cattle over the period 1991-2001 (Table 4), of which 12 occurred in 1994. These data suggest 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.

We briefly mention the results obtained when taking distress sales of small livestock as the

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

dependent binary variable in the regression analysis and compare them with the results for cattle sales in exchange for food (Table 7). In both cases we use the same control variables, although the cattle stock and the cattle transactions might be less appropriate in the case of small livestock sales. Instead of using the cross-term between s_{it} and d_{it}, we only use s_{it}. Table A3 in the Appendix 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 cattle sale results. 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. Finally, regression (6) in Table A3 indicates that small livestock sales were responsive to the risk of losing cattle because of a livestock disease. This result reflects the regular outbreaks of the highly contagious foot-and-mouth disease among cloven-hoofed animals, such as cattle, sheep and goats.

8 Conclusion

The question addressed in this paper is whether rural Rwandan households used cattle sales to cope with adverse income shocks in the period 1991-2001. Special attention is devoted to cattle sale behavior in 1994, a year of extreme violence in Rwanda. 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, concurrently, other coping strategies may be equally under stress, future cattle raiding may be high and expected livestock returns may be very low, certainly if households anticipate the need 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 paper 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 indicates that in 1994 almost 50 percent of the cattle stock was lost. The frequency of cattle sales over the period 1991-2001 was low, suggesting that in general these households are unwilling to sell cattle. However, it is noteworthy that the number of cattle sold in 1994 was almost double the annual average peacetime sales. Furthermore, 44.4 percent of the cattle sold in 1994 was for the purpose of purchasing food, compared to only 11.6 percent of the cattle sales in other years. Looking at cattle prices, we notice a sharp drop in 1994. A final striking finding for 1994 is the lack of cattle sales as an ex-ante strategy (to ged rid of visible wealth) or an ex-post strategy (to smooth consumption),by Tutsi-headed households.

The regression analysis shows that upon the occurrence of a covariant adverse income

shock, the probability of selling cattle increases. This probability is stronger in peacetime than in wartime. However, the peacetime sales are largely motivated by shifts in the asset composition. When looking only at cattle sales in exchange for food, the wartime response is stronger than the peacetime response, indicating that Rwandan rural households used cattle sales as a buffer in response to the unusual and severe covariant shocks of 1994. However, this form of wartime self-insurance is unlikely to have been effective for smoothing consumption, because the cattle price was extremely low in 1994 while food prices soared. Moreover, the regression analysis demonstrated that households who were targeted in the violence and most severely hit by war-related shocks did not respond with cattle sales. We argue that lack of safety prevented these households from selling cattle: either they were too afraid to go on the road to sell cattle, or their cattle was stolen before it could be sold.

These results need to be qualified because the available data on adverse income shocks and cattle transactions are retrospective yearly data. Furthermore, we could only study the cattle-sale behavior of surviving households and households that could be traced. We cannot exclude the possibility that Tutsi-headed households who dropped out of the sample tried to sell cattle. However, even if they did, we argue that cattle sales were not an effective coping strategy. The argument is based on the fact that the vast majority of Tutsi-headed households that dropped out were completely exterminated or lost several household members. Finally, the result that cattle sales failed as a coping strategy for the households targeted may not be generalized to other massive shocks. It may be applicable only in societies where cattle are perceived as an important war trophy, or moreover - as in the Rwandan psyche - are associated with the ethnic identity of the targeted population.

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Appendix

Table A1: Comparison between the characteristics of the full sample of 258 households, the 83 households included in the fixed-effects model of table 6, and the 22 households included in the fixed-effects model of table 7. The variables' mean value for the 10-year periods 1992-2001 (t) or 1991-2000 ($t-1$) are reported

	N=2580	N=830	N=220
Shock index (t)[a]	0.25	0.23	0.25
Common component of shock index (t)	0.39	0.35	0.37
Idiosyncratic component of shock index (t)	0.40	0.40	0.40
Persistent component of shock index (t)	0.23	0.20	0.21
Temporary component of shock index (t)	0.12	0.12	0.13
Shock index for 1994 (t)[b]	0.33	0.33	0.33
Shock index for other years (t)[c]	0.24	0.18	0.24
Highly violent component of '94 shock index (t)[b]	0.19	0.17	0.07
Other components of '94 shock index (t)[b]	0.46	0.47	0.54
Common component of cattle lost due to violence (t)	0.06	0.06	0.03
Idiosyncratic component of cattle lost due to violence (t)	0.05	0.05	0.05
Common component of cattle lost due to other cause (t)	0.03	0.03	0.04
Idiosyncratic component of cattle lost due to other cause (t)	0.03	0.05	0.05
Cattle lost due to violence (t)	0.06	0.06	0.05
Cattle lost due to other cause (t)	0.03	0.05	0.05
Cattle born (t)	0.05	0.09	0.10
Cattle received (t)	0.02	0.04	0.05
Cattle given (t)	0.02	0.04	0.06
Cattle stock (t-1)	0.84	1.83	1.80
Squared cattle stock (t-1)	3.78	8.35	5.30
Cattle lost (t-1)	0.09	0.11	0.10
Cattle born (t-1)	0.04	0.08	0.09
Cattle received (t-1)	0.02	0.04	0.05
Cattle given (t-1)	0.01	0.03	0.05
Land size (t-1)	0.82	1.11	1.18
Children (t-1)	2.44	2.83	2.38
Women (t-1)	1.40	1.57	1.48
Men (t-1)	1.12	1.29	1.33
Elders (t-1)	0.16	0.18	0.34
Tutsi-headed (%)	22.96%	20.73%	4.55%

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

Table A2: Fixed effects logit estimates of the determinants of cattle purchases upon current (t) and future ($t+1$) 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		0.83			
shock index (t)		(0.399)			
Idiosyncratic component of		0.36			
shock index (t+1)		(0.702)			
Common component of		-1.06			
shock index (t)		(0.348)			
Common component of		1.58			
shock index (t+1)		(0.162)			
Temporary component of			1.59		
shock index (t)			(0.213)		
Temporary component of			-0.30		
shock index (t+1)			(0.802)		
Persistent component of			-1.64		
shock index (t)			(0.173)		
Persistent component of			1.60		
shock index (t+1)			(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					-0.92
shock index in 1994 (t)					(0.656)
Highly violent component of					-0.84
shock index in 1994 (t+1)					(0.598)
Other components of					0.23
shock index in 1994 (t)					(0.804)
Other components of					1.51
shock index in 1994 (t+1)					(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[a]	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); [a]57 households, 9 years.

Table A3: 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					2.94
	(0.001)					(0.001)
Idiosyncratic component of		2.61				
shock index (t)		(0.023)				
Common component of		3.49				
shock index (t)		(0.012)				
Temporary component of			1.93			
shock index (t)			(0.183)			
Persistent component of			2.34			
shock index (t)			(0.037)			
Shock index for 1994 (t)				0.50		
				(0.782)		
Shock index for other years (t)				3.43	3.40	
				(0.000)	(0.000)	
Highly violent component of					-0.68	
shock index in 1994 (t)					(0.689)	
Other components of					0.48	
shock index in 1994 (t)					(0.745)	
Common component of cattle						-3.09
lost due to violence (t)						(0.136)
Idiosyncratic component of						-37.6
cattle lost due to violence (t)						(1.000)
Common component of cattle						6.36
lost due to other cause (t)						(0.036)
Idiosyncratic component cattle						-0.34
lost due to other cause (t)						(0.740)
Cattle lost due to violence (t)	-32.5	-34.4	-32.4	-35.6	-37.0	
	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	
Cattle lost due to other cause (t)	0.14	0.12	0.19	0.23	0.29	
	(0.871)	(0.887)	(0.831)	(0.802)	(0.751)	
Cattle stock (t-1)	1.05	1.01	1.04	0.95	0.93	0.96
	(0.011)	(0.017)	(0.014)	(0.026)	(0.028)	(0.021)
Squared cattle stock (t-1)	-0.08	-0.08	-0.08	-0.07	-0.07	-0.07
	(0.135)	(0.147)	(0.146)	(0.213)	(0.219)	(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).

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