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COW OR GOAT? POPULATION PRESSURE AND LIVESTOCK KEEPING IN BURUNDI

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ABSTRACT

Livestock contributes significantly to livelihoods in developing countries. Yet, most academic studies focus on dairy cattle and neglect that many smallholder farmers in mixed-cropping systems prefer goats, sheep, pigs or poultry over cattle. Using a unique dataset from a national representative agricultural survey in Burundi, we estimate the determinants of livestock keeping with a multivariate probit model. We find that wealthier households keep more livestock, but population density and access to markets are also key determinants. Moreover, even the wealthiest households switch from cattle to smaller animals in densely populated regions, where pressure on land is high and access to pastures limited. This has important policy implications since it questions the emphasis of most development programs by NGOs and governments in Sub-Saharan Africa which promote dairy cattle.

Keywords: livestock, cattle, smallholders, agricultural policy, Burundi

JEL: D13, Q12

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1. INTRODUCTION

Livestock contributes significantly to the livelihoods of many smallholder farmers in developing countries. The benefits of livestock in these agrarian societies are well known and diverse. Besides the production of eggs, milk and meat, livestock plays an important role as a saving, financing and insurance device, it provides manure and draught power and is kept to display status (Moll, 2005; Randolph *et al*., 2007; Herrero *et al*., 2009). Many studies have emphasised the important role of livestock as a way to accumulate wealth and to insure against risk in societies characterised by imperfect credit markets (Dercon, 1998; Doran *et al*., 1979; Turner & Williams, 2002).

In socio-economic literature on livestock-keeping, a majority of the papers focus on cattle. This is understandable when studying pastoralist societies, where cattle are indeed the main source of wealth and income. Yet, even studies in regions characterised by mixed farming systems, which are the predominant systems in sub-Saharan Africa, focus mainly on (dairy) cattle and seem to neglect the role of smaller animals (Dolberg, 2001; De Vries, 2008; Lammers *et al*., 2009). This bias towards cattle also exists in government and NGO policies, which often set up cattle donation or cross-breeding programmes, but rarely facilitate small stock keeping. Moreover, many studies and policies (implicitly) assume that cattle rearing is more profitable than keeping smaller animals. A similar assumption is conveyed in the concept of the livestock ladder. This concept assumes that households start by investing in small stock and gradually, as they gain income, invest in cattle (Todd, 1998; Perry, 2002; Maass *et al*., 2013). In other words, the only reason why farmers do not invest in cattle would be that they do not have the required lump sum needed to cover the initial investment. In terms of policies, and if being cash-strapped is indeed the main reason for low levels of investment in livestock, setting up a micro-credit programme would be the most appropriate development strategy. Yet, rational households are likely to consider the profitability of their investment in livestock before actually making an investment. The expected return on livestock will depend on local, environmental conditions such as population density, rainfall and market access. For instance, goats are less demanding in terms of forage than cattle because they efficiently digest roughage and can survive on marginal lands (Devendra, 2007). Households might prefer to keep goats instead of cattle in densely populated regions, where pressure on land is high and access to forage limited. On the other hand, browsing and grazing of sheep and goats are less easily managed than grazing by cattle, and this may cause damage to cropland in densely populated regions and thus entail a loss of food production. In addition, smaller animals are more prone to theft, which is also more likely in densely populated regions. In sum, the effect of population density on the choice of investing in either large or small stock is ambiguous and requires empirical research. Market access is expected to play a key role, as livestock, and especially cattle, is mainly reared to sell on local markets. A study in Ethiopia, for instance, found that 75% of cattle production occurred within a distance

of 5 hours of travel time to the main markets, while sheep and goat production seemed less centered around the main markets (Tilahun and Schmidt, 2012).

In this article, we argue that households, even if they have the necessary means to invest in cattle, consider the profitability of the investment before investing. Based on a unique dataset of Burundi, we show that besides wealth, population density and market access are important determinants in the choice between investing in cattle or small livestock such as sheep, goats, poultry or guinea pigs. This finding has important policy implications. It questions current rural development strategies that focus, almost blindly, on dairy cattle. The finding also suggests that keeping smaller animals, which are more suited to local, adverse conditions, might be more cost effective in densely populated regions in sub-Saharan Africa in general, and particularly in Burundi.

In the next section we briefly describe the role of livestock in the agricultural system of Burundi. We then describe our dataset, discuss its weaknesses and strengths and provide more details on secondary datasets of rainfall and population densities that played a key role in our study. Before presenting the results, the empirical strategy based on a multivariate probit model will be discussed. In the conclusion we highlight some important policy recommendations.

2. LIVESTOCK IN BURUNDI

Cattle-keeping has been an important socio-economic activity in Burundi for a long time. In pre-colonial times, various tribes and kingdoms defined themselves on the basis of their herds of Ankole cattle, which symbolised power and wealth (Ndumu *et al*., 2008). In more recent times, cattle have remained an important symbol to distinguish Tutsi and Hutu. Tutsi were believed to be wealthier pastoralists, who migrated with their herds to Burundi from the north in the fifteenth and sixteenth century, while Hutu were seen as poorer farmers, probably from central Africa (Uvin, 1999; Maguire, 1995). Goats, sheep, pigs, poultry, rabbits and guinea pigs were introduced later. Their ease of care, size, and fast reproduction, along with the decreasing availability of fodder and grazing lands have made them the most important animals on small farms. Additionally, small livestock are easily marketed and can provide meat for household consumption whenever needed (Hatungumukama *et al.*, 2007a).

Cattle populations in Burundi are mainly dominated by pure breeds of Ankole/Zebu cattle or cross-breeds from the following seven breeds: Ankole, Ayrshire, Brown Swiss, Friesian, Guersey, Montbeliard and Sahiwal (Hatungumukama *et al*., 2007a). The Ankole breed represents more than 90% of the cattle population of Burundi, but it remains difficult to determine the degree of cross-breeding (Ndumu *et al*., 2008). Traditionally, the Ankole breed was considered as sacred and cows were kept for milk production, but rarely for their meat (Wurzinger *et al*., 2006). The Ankole breed evolved through natural selection and it adapted to withstand and reproduce under stressful conditions. Ankole cattle are known to be tolerant to ticks and are known to have

significant resistance against East Coast fever (theileriosis). Moreover, the breed can withstand severe drought and can survive on low-quality feed (Ndumu *et al*., 2008). Yet, milk productivity (1.8 to 2.75 l/day) is low (Grimaud *et al*., 2007; Hatungumukama *et al*., 2007b).

Cattle play an important economic and social role in Burundian society. Milk and meat are an important part of the Burundian diet but are not produced in sufficient quantities. Therefore, milk and meat are almost exclusively consumed by the wealthiest households. The skins are used to manufacture leather goods and the horns are used to make traditional musical instruments *(Idonongo)*. Livestock is also considered as the most efficient tool for transferring and renewing fertility on the doubled-cropped plots, in the absence of expensive chemical fertilisers (Cochet, 1996). Typically, half of the manure is recovered using nocturnal animal holding when dung is collected each morning and transported directly to the cultivated plots. Manure from stables is transported and ploughed into the fields. In addition, cattle are the principal form of capital accumulation and they are generally only sold to cover larger expenses (Cochet, 2004). For instance, cattle are often sold in September when school fees need to be paid. Cattle also provide social prestige to the farmer. The prestige of farmers with a large herd stemmed from its dominant power in the relationship established with poor farmers, with little or no livestock, who were obliged to exchange their labour for cows (*ubugabire*) and/or other livestock-related products such as dung and milk. Finally, cattle also play an important cultural role through the practice of bride wealth. However, the customs of gifts between families are currently being abandoned due to decreasing cattle stock.

Reduction, degradation and overexploitation of natural pastures are major constraints for cattle rearing in Burundi (Hatungumukama *et al*., 2007a). In densely populated areas natural, communal pastures have almost completely disappeared. In other areas pastures gradually shift to more marginalised land with poor soils. At the same time, zero-grazing systems remain the exception in Burundi. Rational management of pastures, forage installation and use of agricultural residues help farmers to some extent to overcome the deficit of animal feed. Particularly during the dry season from July to August, when feed is a critical constraint, fodder conservation through silage and hay is applied (Maass *et al*., 2012). However, the biomass needed for this purposes is also often used as organic fertiliser. For instance, stems of cereal and banana leaves are used for mulching coffee, crop residues from legumes are buried during plowing or composted to fertilise the fields. Meanwhile, the low revenue of smallholder farmers curbs their access to commercial feed concentrates. Most livestock is left to graze on poor pastures and receive limited supplementation or other treatment.

The reduction in availability of feed has greatly reduced cattle stock in the last decades. Compere and Huhn (1975) identified 756 000 cattle in 1968, while it decreased to 479 000 in 1987 and 346 341 in 1996 (République du Burundi, 1997). The decline of cattle from 1970 to 1990 was due to the reduction and loss of natural pastures as a result

of the human population growth. Consequently cattle production has been progressively abandoned in favour of small stock, which are better adapted to the available forage (Hatungumukama *et al*., 2007a). The civil war, which started in 1993, accelerated the decrease of Burundi's dairy cattle population. Many animals were sold and slaughtered indiscriminately due to the insecurity, theft and pillage of livestock, which was rife at the time. Some farmers also migrated with their herds to neighbouring countries (Bundervoet, 2006). Recently, new livestock rehabilitation programmes are trying to revitalise the sector by reversing the trends in herd ownership among households.

The availability of data on the livestock sector is still very limited in Burundi. Few studies have been conducted on livestock selling prices, marketing channels, consumers, as well as different factors influencing the livestock sector markets. In general, the marketing system is complex involving farmers, traders, wholesalers, butchers and retailers. Livestock products are found at many local markets and specific livestock markets are organised for the sale of animals. These livestock markets are held at specific times in every province and sellers must travel long distances to get to these markets. Most markets are held once a week and differ in the animals that are traded. In contrast with cattle, small stock is also often traded within the village.

It is against this background that this article examines the conditions under which households prefer small livestock over cattle. We investigate the determinants of investing in livestock and hypothesise that local, environmental constraints such as rainfall, population density and market access will play a role. As explained above, high population densities, in some areas above 600 persons/km², are particularly challenging for livestock keeping in Burundi.

3. MATERIAL AND METHODS

3.1 Empirical framework

A household in Burundi can choose to invest in different groups of animals. Three groups of livestock are distinguished: cattle (TLU[1]= 0.70), sheep, goats and pigs (TLU below 0.2) and small livestock such as chicken, rabbit, guinea pigs and ducks (TLU=0.01). These investment choices are not mutually exclusive: households are likely to keep more than one type of livestock. This choice will depend on both the profitability of the investment and households' wealth. Consequently, we hypothesise that even if a household is sufficiently wealthy to acquire livestock, it will only do so if this is also a profitable investment. Hence, our model consists of three binary choices, y_{ij} (investment in cattle; investment in sheep, goats and pigs; investment in other small livestock) determined by the local environment, E_i, and by households' wealth, X_i.

$y_{ij} = 1$ *if* $aE_i + \beta X_i + \epsilon_{ij} > O$ $(j = 1,2,3)$

0, otherwise

Where i indicates the household, j the choice variable and $(\varepsilon_1\varepsilon_2\varepsilon_3)$ represent the distribution of the errors and follows the trivariate standard normal distribution, $N(0, \Sigma)$, where Σ is the covariance of the error terms.

It is likely that the errors are correlated because of omitted or unobservable variables that contribute to explaining several investment choices (Assa *et al*., 2014). For instance, a household that is faced with an unexpected adverse shock might decide to sell all its livestock. Consequently, estimating the three equations separately with probit or logit models would result in inefficient estimators, because these estimations would not exploit the interdependency between the equations. Therefore, the three equations will be estimated simultaneously with a multivariate probit model. In many respects, this approach is similar to the well-known Seemingly Unrelated Regression (SUR) models, with the only difference that the dependent variable is not continuous but binary (Greene, 2003). However, the estimation is computationally complex and requires multidimensional integration. We will follow the approach proposed by Cappellari and Jenkins (2003), based on the popular GHK simulator, which has been implemented in Stata by the same authors.

A multivariate probit model only allows the modelling of the three binary choices related to investment in livestock, but does not take into consideration that a household can decide to buy several cows, goats or chicken. At first, this could be considered a weakness of our approach, but as we will see in the descriptive analysis, few households keep more than one cow, and even the number of goats and chicken is fairly limited. In addition, our estimations will be less susceptible to measurement error because it is unlikely that the households did not correctly report keeping livestock, whereas the number of animals kept might be prone to measurement error, particularly for the number of smaller animals.

As a robustness check, the analyses were repeated with hurdle models that also take into consideration the number of animals kept by the household. These count models consist of two parts: the first part explains the decision to invest in livestock using a logit or probit model, while the second part explains the number of animals kept by the households using a binomial count model (Loeys *et al*., 2012). The results were consistent with those from the multivariate probit model and are available upon request.

In order to evaluate the importance of the profitability on the decision to invest in livestock, we need variables that determine the profitability of cattle rearing in a particular context, but that cannot directly be controlled by the household. We consider population density, rainfall in the dry season and access to markets as exogenous variables that influence the profitability of cattle rearing. A higher population density increases the pressure on land and therefore reduces the access to communal land available for grazing and fodder production. Malnourished animals are likely to be less profitable because of lower production of eggs and milk, slow weight gain, a slower rate of reproduction and a higher risk of premature death. Relative to other types of livestock, cattle are especially vulnerable to adverse local conditions (Devendra, 2007).

Consequently, a higher population density should reduce the probability of investing in livestock, particularly for cattle. Similarly, in regions characterised by low rainfall or recurrent periods of droughts, we also expect less livestock relative to regions with sufficient rainfall. Since cattle are primarily raised to be sold, access to markets is expected to raise the profitability of a cattle enterprise. We will use two proxies for market access: whether the nearest provincial road is more than 5km away from the nearest village and the distance of the household's farm to the capital.

Burundi consists of 11 agro-ecological zones, ranging from plains to mountains (République du Burundi, 2013). Differences between these regions might partially explain the profitability of livestock rearing and we therefore included regional dummies in the model. Hence, we examined whether differences in population density, rainfall and distance to the capital within a region influence livestock keeping.

We expect wealthier households to keep more livestock in general, and cattle in particular, for two reasons. First, because nearly all households are credit constrained in Burundi[2], only richer households will be able to make the lumpy investment required to buy cattle (Dercon and Krishnan, 1996). Second, richer households are more likely to need a saving device because they are more likely to regularly make profits and they have few other possibilities to invest besides livestock. Land markets, for instance, are poorly developed and buying, selling or leasing of land is the exception and cannot be considered as an alternative to investing in cattle. We will use land as the main proxy for wealth, because land is the most important asset in Burundi and is mostly inherited from father to son. Moreover, cultivated land has been carefully measured with GPS and is therefore likely to be less prone to measurement error than total agricultural production, which would have been another obvious choice as a proxy for wealth. The main disadvantage of this proxy is the fact that land might also have a direct impact on the profitability of cattle rearing because households with more land might use it for grazing or to produce fodder. It is, however, difficult to come up with a good proxy for wealth that is at the same time uncorrelated with the profitability of livestock keeping. As a second indicator of wealth, we include a variable that indicates whether the households bought fertiliser in the previous year. Fertilisers are rather expensive in Burundi and only richer households therefore have access to it (République du Burundi, 2013). As a third indicator of wealth we include a variable that indicates whether the household head is a woman. Female household heads are generally widows and considerably poorer because of the absence of a male breadwinner. Finally, two more household characteristics are also included in the regression: the age of the household head and the size of the household.

3.2 Data

We use data from a national representative agricultural survey of 2 560 households conducted in 2011/2012 by the statistical office of Burundi and the Ministry of

Agriculture, and financially supported by the Belgian Technical Cooperation and the World Bank. This was the first, nationally representative agricultural survey in Burundi since the 1970s. The main purpose of the survey was to update agricultural statistics and to provide reliable production numbers at provincial level.

A two-stage stratified design was adopted to randomly select the households. First, 20 sectors[3] were randomly selected with a probability proportional to population size within each of the 16 rural provinces[4]. Within each sector, all the households were enumerated and 8 households were randomly selected to participate in the survey. Details of the sampling procedure can be found in a government report on this agricultural survey (République du Burundi, 2013).

The survey contained 14 sections with questions related to agricultural production and the socio-economic status of the household. With regards to livestock, detailed information was collected on the number of animals kept, sold, bought and consumed during the previous year. Unfortunately, no information was collected on the production of milk and eggs, nor on the inputs required to feed the animals or on expenses for veterinary services. Total farm size, which will be our main proxy of wealth, has been measured precisely with GPS. Eight observations were discarded due to missing variables.

This dataset was complemented by secondary sources about population density and rainfall. A national population census was conducted in 2008 by the Government of Burundi, which enables us to calculate population density at communal level (République du Burundi, 2010). A commune in Burundi is an administrative unit that consists of several collines (hills/villages in French), which are the lowest administrative unit. Our sample consisted of 126 communes with an average of 20 interviewed households per commune. The disaggregation of population density at communal levels allows us to examine whether differences in population densities within regions partially explain investment decisions in livestock of the household.

We used rainfall data from the WorldClim project, which makes global climate data freely available from their website (Hijmans *et al*., 2005). The estimates are derived from an interpolation of average monthly weather data from weather stations and have a spatial resolution of 0.86 km². We used one variable of this dataset: average precipitation in the driest quarter. As households were geo-referenced in the dataset, we could link the weather data with the households.

4. RESULTS

4.1 Descriptive statistics

Table 1 shows the total number of animals kept at the time of the interview. Goats are clearly the most popular form of livestock, followed by chickens, guinea pigs and cattle. In general, very few animals are consumed by the household. For instance, none of the

households reported having slaughtered and consumed a cow in the previous year and only 10% of the total stock of guinea pigs was slaughtered. However, the death rate of most animals was rather high and households might have consumed these animals, yet no evidence can be given. The number of animals sold is larger than the number consumed, which confirms that livestock is primarily considered an investment and not intended for own consumption. The two most important reasons for selling livestock that were mentioned during the interviews were the urgent need to take care of a family member and to buy food in times of shortages. This confirms the hypothesis that cattle are an instrument for saving and insuring. Very few animals were given away as a gift, which might indicate that livestock plays a less important ceremonial role in Burundi than in the past. Trade in livestock seems to be relatively exceptional for most animals. Only between 5% and 10% of total stock had changed hands in the previous year.

Table 1 also shows the average price of livestock that households received when selling. Note that these prices are somewhat imprecisely estimated because only few animals were sold albeit that these prices were confirmed by key informants. Cattle are more than eight times as expensive as sheep, goats and pigs, which are nearly five times more expensive than chicken or rabbits. The average price was 293 000 FBU ($188) per cow, which is a considerable amount relative to GDP per person, which is estimated around $600 per capita at purchasing powers parities (IMF, 2015).

In the next section, we will group livestock in three categories: cattle, sheep/goats/pigs and other small livestock (which includes poultry, rabbits and guinea pigs). This simplifies the analyses, but is also in line with recommendations of the FAO, which attribute similar weights to these animals when calculating Tropical Livestock Units (Chilonda and Otte, 2006). In addition, as Table 1 shows, livestock included in each of these categories received a similar market price.

Table 1: Livestock in Burundi

	Number of animals	Bought (%)	Born (%)	Received as gift (%)	Sold (%)	Consumed (%)	Gift (%)	Stolen (%)	Dead (%)	Mean price (sd)1,2
Cattle	1099	10.9	88	1.1	4.1	0.0	1.3	0.9	2.4	293 (152)
Sheep, goats, pigs										
Goats	4251	8.6	22.3	2.1	6.1	0.4	0.5	0.4	7.6	28 (11)
Sheep	703	12.5	22.6	1.3	5.3	0.6	0.6	1.0	6.7	30 (8)
Pigs	649	25.6	27.9	0.3	22.5	0.2	0.6	0.0	11.6	45 (46)
Other small livestock										
Chicken	4124	10.9	51.0	2.2	7.6	3.8	0.6	2.8	29.9	6(7)
Guinea pigs	1846	11.8	39.0	1.8	14.9	9.8	1.8	2.0	25.0	1 (1)
Rabbits	652	19.0	46.0	2.6	14.3	6.0	1.7	0.9	30.2	5 (11)
Ducks	114	3.5	36.0	0.9	2.6	0.9	0.0	0.0	5.3	4 (.)
Other poultry	83	10.8	31.3	2.4	9.6	3.6	0.0	3.6	22.9	1.5 (0)

1 Prices in 1000 FBU=$0.64 (exchange rate: 1 January 2015)

2 Prices are rather imprecisely estimated, because only few animals were sold.

The distribution of livestock for successive quartiles of farm size is shown in Table 2. The median farm size is 0.51ha and the average farm size of the 25% poorest households (first quartile) is less than 0.2ha. This is extremely small by global standards, but in line with neighbouring countries such as Rwanda (Ali and Deininger, 2014). It confirms the extremely high pressure on land. As expected, the likelihood of keeping livestock clearly increases with farm size. The second category of animals, and in particular goats, is the most widespread type of livestock and is kept by more than 50% of the

households, followed by other small livestock and cattle. The number of animals kept, conditional on keeping livestock, also increases with farm size. Hence, richer households are not only more likely to keep livestock, but also to keep more animals than poorer households. However, even the wealthiest households tend to have relatively few animals. For instance, the richest households with cattle keep, on average, less than three animals. Even the number of animals in the category of other small livestock is limited: households that keep small livestock (mostly poultry and guinea pigs) have on average between five and eight animals.

Table 2: Distribution of livestock for successive quartiles of farm size

Successive quartiles of farm size	**Farms size (ha)[2]**	**TLU[3]**	**Cattle**		**Sheep, goats & pigs**		**Other small livestock**	
			%	Animals[1]	%	Animals[1]	%	Animals[1]
1 – smallest	0.16	0.24	8.5	1.37	41.4	2.87	26.7	5.32
2	0.38	0.40	16.8	1.63	53.5	3.14	31.5	5.93
3	0.71	0.63	21.6	2.28	58.6	3.76	39.7	7.38
4 - largest	2.74	0.92	26.5	2.95	67.9	4.61	50.5	7.80

[1] Animals gives the mean number of animals conditional on keeping this type of livestock. Given the large number of households without livestock, the sample means are considerably lower.

[2] 13 farms are larger than 10ha, which biases average farm size in the 4th quartile. Median farm size in this quartile is 1.58ha.

[3] TLU: Cattle=0.7; Sheep/goats=0.1; Pigs=0.2; Small livestock=0.01

4.2 Multivariate probit model

The results of the multivariate probit model explain households' decisions to invest in cattle, sheep, goats and pigs and other small livestock (Table 3). As explained in the methodology, we make a distinction between variables that are used as a proxy for wealth and variables that determine the profitability of the investment. Interpreting the estimated coefficient of multivariate probit models is not always straightforward. Hence, to facilitate their interpretation and gauge the impact of the explanatory variables on investment in livestock, the model was used to predict probabilities of keeping livestock as a function of variables of interests (Figures 1 to 3).

Table 3: Multivariate probit model explaining investment in cattle, sheep, goats and pigs and other small livestock

	Cattle	Sheep, goats and pigs	Other small livestock
Production environment			
Population density *(persons/km²)*	-0.00102***	0.000630**	0.000868***
Rainfall in driest quarter *(mm)*	0.0114***	-0.00108	0.00409*
Market access			
Distance to capital *(km)*	-0.00949***	-0.00184	0.00265**
Nearest provincial at more than 5 km *(yes=1; no=0)*	-0.401*	0.0221	0.0727
Wealth			
Farm size: second quartile	0.450***	0.254***	0.112
Farm size: third quartile	0.585***	0.328***	0.294***
Farm size: fourth quartile	0.849***	0.525***	0.543***
Female headed household *(yes=1; no=0)*	-0.331***	-0.196***	-0.0849
Access to fertilizers *(yes=1; no=0)*	0.193**	0.251***	0.157**
Household characteristics			
Age	0.000173	0.0144	0.000125
Age squared	-0.000012	-0.000125	-0.000023
Household size	0.0886***	0.0779***	0.0668***
Constant	-1.04**	-0.653**	-1.24***
Correlation between error terms	Rho1	Rho2	
Rho 2	0.0474		
Rho 3	0.116***	0.309***	

,,*** significant at the 10%, 5%, 1% level respectively*

2552 observations

Regional dummies were included, but are not reported.

Overall, the model confirms that wealthier households are more likely to keep livestock: households with more land or with access to fertilizers are more likely to keep livestock, whereas female headed households are less likely to own livestock. The probability of keeping livestock increases nearly linearly with wealth, as measured by total landholdings of the households (figure 1). For instance, less than 10% of the households in the first quartile (0.16 ha of land) keep cattle, while more than 20% of the households in the fourth quartile (2.74 ha of land) do so. Yet, besides wealth, there are other factors that explain livestock investment.

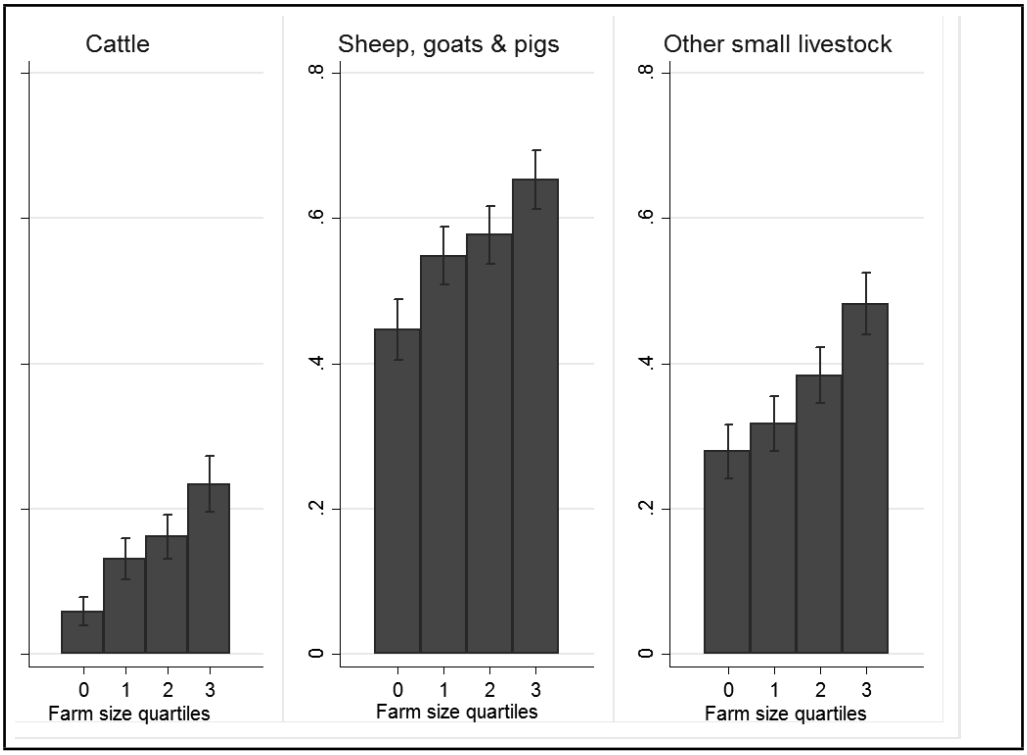

Figure 1: The predicted probability (with 95% CI) of investment in livestock in function of successive quartiles of farm size

The multivariate probit model shows that population density plays an important role in the choice of investing in livestock (Figure 2). In villages characterised by high population density, households are significantly less likely to keep cattle. The probability of keeping cattle is 17% if the population density is 300 persons/km², but decreases to 6% if the population density increases to 600 persons/km². This suggests that households are concerned about the return on their investment and do not only buy cattle if they have the required means to do so. Surprisingly, the probability of investing in other types of animals increases significantly with population density. This suggests that households with sufficient capital still want to invest in livestock, but prefer to invest in smaller animals rather than cattle if population density is high. We assume this is because investing in cattle is not sufficiently profitable or too risky in these areas due to shortages of grazing land. It is indeed well known that cattle are more vulnerable to feed of poor quality relative to goats and other small livestock (Devendra, 1999). Hence, these animals can be considered a substitute for cattle in densely populated regions.

Average rainfall in the driest quarter of the year is positively correlated with the likelihood of keeping cattle and, to a lesser extent, with keeping other small livestock. It does, however, not explain investment in sheep, goats and pigs. The probability of

keeping cattle, for instance, increases from 10% in regions with an average rainfall in the dry season of 25mm to 25% in regions with an average rainfall in the dry season of 65mm (results not shown). With a similar increase in rainfall, the probability of keeping other small livestock increases from 33% to 42%. It may be that limited rainfall in the dry season reduces the availability of feed and is therefore a critical constraint in livestock rearing (Bisou *et al*., 1991)[5].

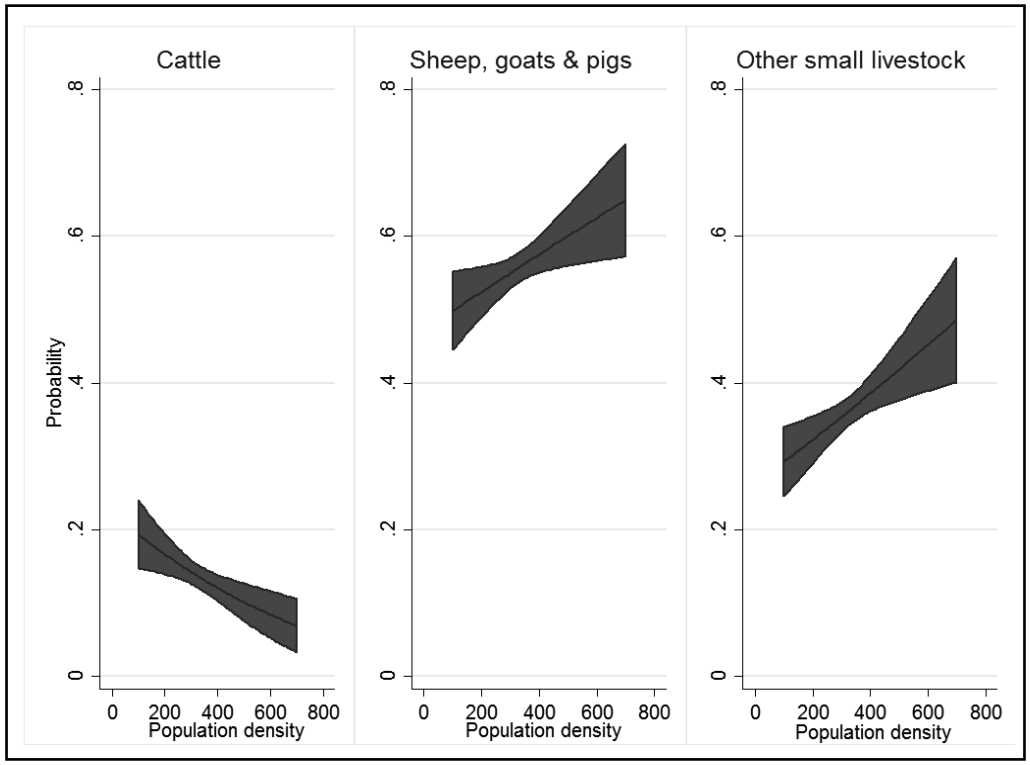

Figure 2: The probability of investing in livestock (with 95% CI) in function of population density

The model also suggests that market access contributes to explaining investment in livestock. The distance of the household to the regional capital shows a large and significant negative correlation with keeping cattle, and a smaller positive correlation with keeping other small livestock. Figure 3 shows that the probability of keeping cattle decreases from 20% to less than 3% when the distance to the capital increases from 50km to 150km. This is a very large correlation given that few households sell their cattle directly in the capital, but rather sell it on local markets to intermediaries. In our view, the correlation is too large to attribute it completely to the beneficial impact of better market access given the market structure in Burundi. Part of the effect might

be attributed to the fact that cattle rearing is very common around the capital because of excellent agro-ecological conditions for cattle rearing. Although regional dummies are included in the model, these might not completely capture the concentration of cattle around the capital. To test whether the effect of the distance is non-linear, we also included the squared distance in the multivariate probit model, but the estimated coefficient was small and insignificant. A second potential explanation is the civil war that ravaged Burundi from 1994 to 2002. However, it is well documented that the civil war was more severe in the region around the capital (Bundervoet, 2006; Voors *et al*., 2012) than in other provinces. Consequently, if recovery of the civil war would still play a role, we would expect less livestock around the capital than in the provinces further away from the capital. This is clearly contradicted by our results. The third, and most likely, explanation is the strong positive correlation between access to Bujumbura and access to regional towns. As such, we cannot determine whether access to a regional town has a more pronounced effect on livestock keeping than access to Bujumbura[6]. It can only be concluded that market access is likely to influence the investment decision of farmers.

The second proxy for market access, which refers to whether the closest provincial road is situated at more than 5km from the village, confirms that market access is an important aspect in the decision to invest in livestock. Households with good access to a provincial road are more likely to keep cattle.

The multivariate probit model estimates the correlation between the error terms of the three investment decisions. As expected, the three error terms are positively correlated, although correlation between the error terms of the first (cattle) and second (sheep, goats and pigs) category of animals is small and insignificant. This confirms that a multivariate probit model is more appropriate than estimating the three investment decisions separately with probit models. The positive correlations also show that a household with one type of livestock is also more likely to keep another type of livestock. Remarkably, the correlation of the error terms between investing in sheep, goats and pigs or other small livestock is significantly higher than the correlation between the other error components. This might suggest that investing in sheep, goats and pigs is a close substitute to investing in other small livestock, while investing in cattle is mainly driven by other factors.

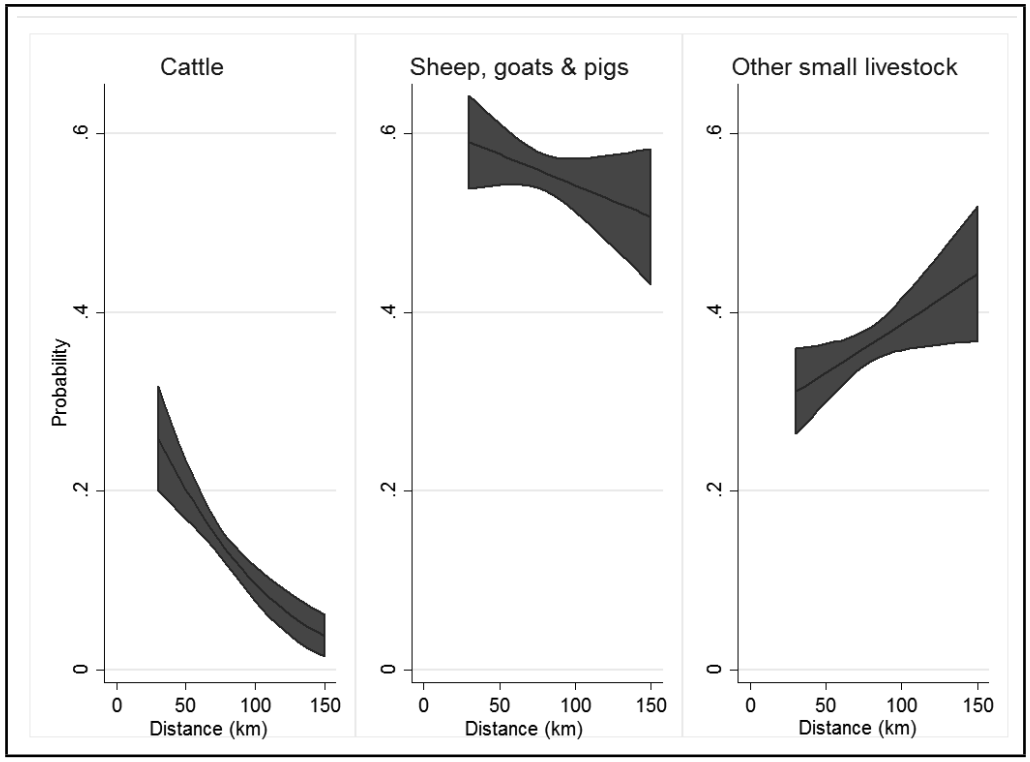

Figure 3: The probability of investing in livestock (with 95% CI) in function of the distance to the capital

5. CONCLUSION

This study explains that not only wealth in terms of land matters for cattle rearing in Burundi. Even relatively wealthy farmers in densely populated regions are unlikely to keep cattle and switch to smaller animals such as sheep, goats, pigs or smaller livestock, which are less vulnerable to feed shortages and feed of a poorer quality. Similarly, poor market access also reduces investment in cattle, which are primarily reared to be sold on the market. Consequently, the concept of the livestock ladder has to be refined. The poorest households indeed invest rather in small stock than cattle, but wealthier households only shift to cattle if the expected return on this investment is sufficiently large. The conditions that influence the expected returns include population density, rainfall and market access.

Our results have important policy implications. While we could not directly calculate the return on investment in livestock, it seems that cattle are not always the most productive investment when comparing ruminants with small livestock, particularly in densely populated regions. At the same time, policy makers in Burundi,

and in sub-Saharan Africa in general, are primarily concerned with developing the dairy sector and seem to neglect other forms of livestock. For instance, the investment plan for the agricultural sector 2012–2017 in Burundi aims to distribute 200 000 cows to smallholder farmers, but does not set targets for any other type of livestock (République du Burundi, 2011; République du Burundi, 2014). Given the role smaller animals can play in poverty and food insecurity alleviation, the fact that these animals might be better adapted to local conditions and their lower cost relative to cattle, might make it worthwhile for both the government of Burundi and NGOs to rethink their strategy towards the livestock sector and to focus more on smaller animals.

Although a policy shift from promoting cattle to promoting smaller animals seems justifiable, more studies are required that examine technical and economic aspects of keeping smaller animals in Burundi such as sheep and goat management to avoid damage to cropland, disease management and nutritional evaluations.

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NOTES

1 Tropical Livestock Units.

2 Less than 10% of the households in our sample reported having taken a loan in the three years prior to the survey.

3 The sectors, or the so called Zone Dénombrement (ZD), represent an administrative unit that have a small geographic scope and include several villages. ZD in predominately urban areas were excluded from the survey.

4 The province Bujumbura Mairie was excluded because it is dominated by the capital Bujumbura and was therefore considered an urban region.

5 Average annual rainfall was not significantly correlated with livestock keeping.

6 As suggested by a reviewer, we conducted an additional robustness check using a dataset from HarvestChoice. This dataset estimates the travel time required for a household to reach the nearest town of 20 000 inhabitants and to reach Bujumbura (HarvestChoice 2015a;

2015b). The correlation between travel time to Bujumbura and travel time to the nearest regional town was 0.93. In addition, the correlation between travel time to Bujumbura and distance to Bujumbura (our preferred proxy of market access) was 0.58. Results remained similar when travel time was used instead of distance to Bujumbura as proxy for market access.

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