

# What Drives Livestock Renting in Rural Nepal? Maoist War or Resource Constraints

Jeetendra P. Aryal and Stein T. Holden  
Department of Economics and Resource Management  
Norwegian University of Life Sciences (UMB),  
P.O. Box 5003, N-1432 Ås, Norway

---

## Abstract

This paper examined the factors that drive livestock rental market participation by using farm household data. Furthermore, it assessed if there exists any association between livestock and land rental markets. Double hurdle models were applied on both sides of the livestock rental markets separately. Results show that low caste households are more likely to rent in livestock as compared to high caste; and this is similar for male headed households and households with more male labor. Caste however, does not affect the likelihood to rent out livestock. The larger the owned livestock the less is the probability to rent in livestock and the amount to rent in. Owned livestock holding only affected the amount to rent out but not the likelihood. Owned land holding increased the amount of livestock to rent out. Households with migrated members are less likely to rent in and more likely to rent out livestock. Migration reduced the amount of livestock rented in and increased the amount rented out. This indicates that livestock renting is partly driven by land poverty and partly by Maoist war. A bivariate ordered probit model showed a significant positive association between the decision to participate in livestock and land rental markets.

**Key words:** livestock rental market; land rental market; caste; Maoist war; Nepal

---

## 1. Introduction

Livestock is an important asset for farm households in rural areas of developing countries as a provider of multiple services and commodities like traction power, manure, and productive asset stock, insurance, source of cash, meat, milk and wool. In addition, it can be a major source of income. Livestock contributes nearly 20 per cent of total household income in the rural hills of Nepal (NRB 1988).

Livestock is typically a more liquid asset than land as livestock sales markets are not exposed to the same legal restrictions and also livestock are mobile in contrast to the immobile land

resources. This has on the other hand caused land to be favored for collateral purposes while livestock due to its mobility and fragility are considered unsuitable for such purpose (Binswanger and Rosenzweig 1986). Related to this is also the empirical phenomenon that rental markets to land tend to be more developed and functioning than sales markets for land while the opposite is the case for livestock. Binswanger and Rosenzweig (1986) explain the poor development of rental markets for livestock and their services like ploughing services by the considerable moral hazard problem and fragility of animals. Another reason could be the short season for such demand in rainfed agriculture while one could expect more of such rental services in irrigated agriculture (Holden, Otsuka et al. 2009). This may also explain why there have been very many empirical studies of land rental markets but hardly any studies of livestock rental markets.

Contrary to the statements above we found livestock rental markets to be quite common in our study area in Nepal and so was the case with land rental markets. The puzzles are therefore why livestock rental markets are preferred to livestock sales markets and how these relate to the asset distribution of households and the functioning of other input and output markets. In particular we relate livestock renting to the discriminatory caste<sup>1</sup> system that is of primary importance for the asset distribution as well as factor market access (Banerjee and Knight 1985; Ito 2009) in Nepal. We are not aware of any earlier studies on this.

Using farm household data collected in 2003 in the western hills of Nepal, we examined household participation in the livestock and land rental markets. Given the fact that land and livestock are complementary inputs in farming, households with land also need livestock for manure and traction power. One of our hypotheses is that livestock renting occurs as a complementary contract to a land rental contract when a land-poor (often low caste) household obtains a temporary land rental contract, it may fail to buy the complementary livestock resources due to its poverty and therefore prefer a livestock rental contract to gain the benefits

---

<sup>1</sup> Caste system exists in Hindu religion. Caste refers to hierarchically ranked categories based on hereditary membership. It fixes the social status of individuals at birth and prevents movements from one category to another. The major caste groups are: *Brahmins* (the highest caste); *Chhetries* (the second highest caste); *Baishyas* (the third highest caste); and *Sudras* (often called *Dalits* or *Scheduled castes*- the lowest caste). *Dalits* face severe discrimination due to the practice of untouchability, which prevents them to participate in many religious functions and even, entering into the houses of other caste groups. This study classified all households into two broad groups: Low caste (*Dalits* households only) and High caste (All other categories except *Dalits*).

from land and livestock synergies (traction power, manure, and fodder production). Therefore, the livestock rental market can serve as a way to overcome the capital constraint of the poor households. This can also relate to the lumpiness of livestock investments.

Our second hypothesis is that households that have surplus livestock (and land) resources but temporarily lack labor to manage these resources, prefer to rent out rather than sell their land and livestock resources as they plan to use these again in the future. Our study was in a period with Maoist dominance in the study area and particularly many rich (mostly high caste) households felt threatened by this attack and this has caused many male heads of such households to have left the area and the male labor force is therefore reduced in these households. Keeping livestock requires more labor endowment in the household and thus, households with less labor endowment are more likely to rent out livestock. Thirdly, tenants who have rented in land may also rent in livestock with the same landlord and this may also help to control the related moral hazard in such contracts. The local presence of part of the family (e.g. wife and children) in high caste households may also help in the monitoring and enforcement of land and livestock contracts. This implies that we should expect interactions between participation in these two markets, making it relevant to analyze jointly the decisions to participate in these two markets. We apply bivariate ordered probit models for the joint decisions to participate on both sides of these markets. We find a strong positive correlation between participation on the same side in the two markets. Households that rented out livestock were also more likely to rent out land and households more likely to rent in livestock were more likely to rent in land. Households renting out both livestock and land were in almost all cases high caste households, while households that rented in livestock and land were in most cases low caste households.

## **2. The role of livestock and livestock renting in Nepal**

Large ruminants, especially oxen, are the integral part of Nepalese agriculture. Of the total draught animals in Nepal, 94 per cent are cattle bullocks (Rajbhandari and Pradhan 1991). Oxen, cows and buffaloes are the major large ruminants kept by the farm households in Nepal, while sheep and goats constitute the main type of small ruminants. Resource poor farmers in the hills, who cannot invest on cattle and buffalo, usually prefer sheep and goat husbandry. Despite the role of livestock in agriculture, there is still lack of organized market for livestock and its products in the rural areas of Nepal. In addition, unlike buffalo, oxen and cows are not sold for

the purpose of meats in Hindu society and therefore, markets for cows and oxen are limited outside the rural areas where agriculture is not the major activity.

Labor-rich tenants may rent in livestock from landlords because they require both manure and traction power for agricultural production. In case of high-caste landlord and low-caste tenant, there may also be an interlinked contract for working as a ploughman and agricultural laborer (Adhikari 1992).

On the other hand, given that the period of data collection when Maoist war was at its peak in Nepal, there are reasons to believe that male members of the many households, especially rich high caste households, move away from their home and wait until the war ends. Under such circumstances, households need to manage their resources temporarily and thus, rented out both land and livestock mostly to their low-caste tenants expecting that they can get it back when the war ends.

### **3. Introduction to Study Area and Data**

Data for this study was collected from 500 households in the Mardi watershed of western Hills of Nepal in 2003. This paper utilizes data from 489 households as 11 households were dropped from the analysis due to some inconsistencies. The settlements in the study area are 15-45 km far from the main city centre, Pokhara. The Hills and Mountains of higher than 1200 m are the major topographical feature of this region (Thapa and Weber 1995).

Agriculture is the main economic activity in this area. Integration of crop and livestock is the main characteristic of the agriculture as livestock is essential not only for traction power but also for sustainable crop production through the use of manure. This is one of the possible reasons why the land and livestock rental market decisions are inter-related. Almost all households in the study area own livestock (ACAP 1999). Buffaloes, cows and oxen are the major large livestock, while goats and sheep are the main small ruminants.

The interesting feature here is that households participated both in land and livestock rental markets. Table 1 presents the livestock and land rental market participation of the sample households. Nearly 13 per cent of the total sample households rented in livestock while 11.4 per cent rented out. Nonparticipation in the livestock rental market is higher than that of the land rental market possibly implying that there are larger transaction costs in the livestock rental

markets as compared to the land rental market (Binswanger and Rosenzweig 1986). This is also shown by ranking all sample households on the basis of net land leased-in and net livestock leased-in separately (see Figure 1). About 28 percent households that rent in livestock have also rented in land. Likewise, 36.6 per cent of the households that rent out livestock have also rented out land. None of the sample households that have rented out land were found to rent in livestock and similarly, very few households that have rented in land were found to rent out livestock.

**Table 1 Livestock and land rental market participation of the sample households**

Livestock Land	Rent in		Owner operated		Rent out		Total
	number	per cent	number	per cent	number	per cent	
rent in	33	28.2	81	69.2	3	2.6	117
owner operated	29	10	238	82.1	23	7.9	290
rent out	0	0	52	63.4	30	36.6	82
Total	62	12.7	371	75.9	56	11.4	489

Another interesting feature is that households that rent out both land and livestock are mostly high caste households whereas households that rent in both land and livestock are mostly low caste households. Table 2 summarizes livestock and land rental market participation of the sample households by caste. Out of 30 households that rent out both land and livestock, 28 are high caste households.

**Table 2 Livestock and land rental market participation of the sample households by caste**

Livestock Land	Rent in				Owner operated				Rent out				Total
	High Caste		Low Caste		High Caste		Low Caste		High Caste		Low Caste		
	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	
rent in	9	7.7	24	20.5	50	42.7	31	26.5	3	2.6	0	0	117
owner operated	12	4.1	17	5.9	207	71.4	31	10.7	21	7.2	2	0.7	290
rent out	0	0	0	0	48	58.5	4	4.9	28	34.2	2	2.4	82
Total	21	33.9	41	66.1	305	82.2	66	17.8	52	92.8	4	7.2	489

Note: Of the total sample households, 107 households are low caste households.

Table 3 presents the major characteristics of farm households' participating in the land and livestock rental markets. The percentage of female-headed households is significantly higher among the households renting out livestock (land), whereas households renting in livestock (land) are mostly male headed. Out of total households renting in livestock only 19.35 per cent have at least one adult member migrated, while it is much higher, 82.14 per cent, in case of

households renting out livestock. Of the total households that rent in livestock 66.12 per cent are low caste households, while in case of households renting out livestock the percentage of low caste households is only 7.17. There are significant differences in own land holding, operational land holding, and family labor endowment (standard labor unit) between the households that rent in livestock (land) and the households that rent out livestock (land).

**Table 3 Characteristics of households participating in land and livestock rental markets**

Variables	Land			Livestock		
	Rent in	Rent out	t-test	Rent in	Rent out	t-test
Male Head (%)	52.14	19.51	4.90***	70.96	14.81	7.56***
Literate (%)	26.49	35.36	1.34	22.58	33.96	1.36
Low caste (%)	49.53	5.61	6.03***	66.12	7.17	8.91***
At least 1 adult member migrated (%)	25.64	73.17	7.47***	19.35	82.14	10.17***
Age of household head (years)	48.82	51.01	1.42	48.23	51.02	1.42
Owned land (ha)	0.24	0.61	6.29***	0.24	0.73	5.47***
Standard labor unit	5.05	3.54	5.63***	4.78	3.50	2.16**
Standard labor unit/Owned land	35.18	9.65	5.87***	27.00	7.55	4.71***
Operational land (ha)	0.51	0.39	2.44**	0.42	0.61	2.09**
Standard labor unit/Operational land	13.44	18.34	2.37**	15.09	11.43	1.61
Standard labor unit/own livestock	4.99	1.64	2.68***	4.15	1.19	5.87***
Standard labor unit/operated livestock	3.87	2.09	1.41	1.25	5.03	3.49***
Own livestock (in TLU)	2.37	3.82	4.52***	1.45	3.28	8.74***
Own livestock/Owned land	15.59	9.69	2.56**	6.60	8.33	1.34
Own livestock/Operated land	6.51	19.07	5.42***	11.09	5.34	3.49***
Operated livestock (in TLU)	3.05	3.37	0.96	3.46	1.61	8.17***
Operated livestock/owned land	21.48	8.81	4.28***	22.91	2.64	6.15***
Operated livestock/Operated land	8.96	16.77	3.29***	13.88	5.16	4.74***
Total	117	82		62	56	

Note: t-test shows the difference between the households that rent in land (livestock) and the households that rent out land (livestock).

Significance levels: \*: 10% level, \*\*: 5% level, \*\*\*:1% level

Unit of operated livestock holding does not differ significantly between the households that participate in two sides of the land rental market while this differs significantly between the households that participate in two sides of livestock rental market. Owned livestock per unit of owned land differs significantly between the households that rent in land and the households that rent out land, but it is not significant in livestock rental market.

Family labor endowment, which is measured here as standard labor unit, can be an important factor in determining the participation of the households in the land and livestock rental market. This is mainly due to the fact that there are labor market imperfections in the study area and hence, the hired labor cannot perfectly substitute the family labor. Standard labor unit significantly higher among the households that rent in land and similar is the case for the households that rent in livestock. In addition, standard labor unit per unit own land holding also differ significantly between the households that rent in land (livestock) and rent out land (livestock).

Of the total households, that rented-in both livestock and land, 63.4 per cent have rented in from the same household. The Gini coefficient for ownership land holding is 0.49 while it is 0.42 for the operational land holding implying that the land rental market has reduced inequality in the distribution of land. The Gini coefficient for ownership of livestock holding is 0.40, while it is 0.38 for operational livestock holding.

#### 4 Theoretical framework

A farm household has initial endowments of land  $\bar{A}$  and livestock  $\bar{N}$ .  $A_j$  and  $N_j$  are land and livestock resources transacted in the land and livestock rental markets. Consider that  $\bar{L}$  is the labor endowment of the household. The production function,  $q$  is then given by

$$1) q = q(N, A; \bar{L}); \text{ where } q_N, q_A, q_{\bar{L}}, q_{NA}, q_{N, \bar{L}}, q_{A, \bar{L}} > 0; q_{NN}, q_{AA}, q_{LL} < 0$$

$$N = \bar{N} + N_j \text{ and } A = \bar{A} + A_j$$

where  $N$  and  $A$  refer to operational holding of livestock and land resources respectively. Assume a linear non-negative transaction cost in both rental markets for land and livestock,  $\tau_N, \tau_A$ , and rental prices,  $P_N, P_A$ , excluding the transaction cost. The transaction cost is primarily the monitoring cost for the owners of livestock and land, causing a reduction in the return to the owner. For simplicity, we assume tenants do not face transaction costs but adding such a cost would not change the key results.

A general parsimonious model allowing renting in and out of livestock and land can be presented as follows where households are assumed to maximize their net income subject to their resource constraints and market opportunities:

$$2) y = P_q q(\bar{N} + N_i - N_o, \bar{A} + A_i - A_o; \bar{L}) + (P_N - \tau_N) N_o + (P_A - \tau_A) A_o - P_N N_i - P_A A_i$$

In equation (2),  $N_o, N_i, A_o$  and  $A_i$  refer to the units of livestock rented out, units of livestock rented in, area of land rented out and area of land rented in respectively. In the model,  $N_o, N_i, A_o$  and  $A_i$  are endogenous variables and assumed to be non-negative. Also, if  $N_i > 0$ , then  $N_o = 0$  and vice versa, and similarly for land. Table 4 summarizes the first order conditions for different feasible outcomes, ignoring the possibility of renting out all land and livestock.

**Table 4: First order conditions for different feasible outcomes**

		Land rental market		
		Rent out	Non-participant	Rent in
Livestock rental market	Rent out	$P_q \frac{\partial q}{\partial A} = P_A - \tau_A$	$P_q \frac{\partial q}{\partial A} = P_A^*$	$P_q \frac{\partial q}{\partial A} = P_A$
		$P_q \frac{\partial q}{\partial N} = P_N - \tau_N$	$P_q \frac{\partial q}{\partial N} = P_N - \tau_N$	$P_q \frac{\partial q}{\partial N} = P_N - \tau_N$
	Non-participant	$P_q \frac{\partial q}{\partial A} = P_A - \tau_A$	$P_q \frac{\partial q}{\partial A} = P_A^*$	$P_q \frac{\partial q}{\partial A} = P_A$
		$P_q \frac{\partial q}{\partial N} = P_N^*$	$P_q \frac{\partial q}{\partial N} = P_N^*$	$P_q \frac{\partial q}{\partial N} = P_N^*$
	Rent in	$P_q \frac{\partial q}{\partial A} = P_A - \tau_A$	$P_q \frac{\partial q}{\partial A} = P_A^*$	$P_q \frac{\partial q}{\partial A} = P_A$
		$P_q \frac{\partial q}{\partial N} = P_N$	$P_q \frac{\partial q}{\partial N} = P_N - \tau_N$	$P_q \frac{\partial q}{\partial N} = P_N$

The shadow prices for the non-participant households lie between the prices for the renting out households and renting in households i.e.  $P_A - \tau_A < P_A^* < P_A$  and  $P_N - \tau_N < P_N^* < P_N$ .

In order to arrive at testable hypotheses from this theoretical framework, we carried out comparative statics (Chiang 1984; Silberberg and Suen 2001). The key comparative statics results are summarized in Table 5.

**Table 5 Comparative statics for households renting in or renting out both land and livestock<sup>2</sup>**

Households renting in both land and livestock	Households renting out both land and livestock
$\frac{\partial N_i}{\partial N} = \frac{P_q q_{AA}}{P_q^2 (q_{NN} q_{AA} - q_{AN}^2)} < 0$	$\frac{\partial N_o}{\partial N} = \frac{-P_q q_{AA}}{P_q^2 (q_{NN} q_{AA} - q_{AN}^2)} > 0$
$\frac{\partial N_i}{\partial A} = \frac{-P_q q_{NA}}{P_q^2 (q_{NN} q_{AA} - q_{AN}^2)} < 0$	$\frac{\partial N_o}{\partial A} = \frac{-P_q q_{AA}}{P_q^2 (q_{NN} q_{AA} - q_{AN}^2)} > 0$
$\frac{\partial N_i}{\partial L} = \left( \frac{-q_{NA}}{q_{NN}} \right) \frac{\partial A_i}{\partial L} = \left( \frac{-q_{AA}}{q_{AN}} \right) \frac{\partial A_i}{\partial L}$	$\frac{\partial N_o}{\partial L} = \left( \frac{-q_{NA}}{q_{NN}} \right) \frac{\partial A_o}{\partial L} = \left( \frac{-q_{AA}}{q_{AN}} \right) \frac{\partial A_o}{\partial L}$
$\frac{\partial A_i}{\partial N} = \frac{-P_q q_{AN}}{P_q^2 (q_{NN} q_{AA} - q_{AN}^2)} < 0$	$\frac{\partial A_o}{\partial N} = \frac{P_q q_{AN}}{P_q^2 (q_{NN} q_{AA} - q_{AN}^2)} > 0$
$\frac{\partial A_i}{\partial A} = \frac{P_q q_{NN}}{P_q^2 (q_{NN} q_{AA} - q_{AN}^2)} < 0$	$\frac{\partial A_o}{\partial A} = \frac{P_q q_{AN}}{P_q^2 (q_{NN} q_{AA} - q_{AN}^2)} > 0$
$\frac{\partial A_i}{\partial L} = \left( \frac{-q_{NN}}{q_{NA}} \right) \frac{\partial N_i}{\partial L} = \left( \frac{-q_{AN}}{q_{AA}} \right) \frac{\partial N_i}{\partial L}$	$\frac{\partial A_o}{\partial L} = \left( \frac{-q_{NN}}{q_{NA}} \right) \frac{\partial N_o}{\partial L} = \left( \frac{-q_{AN}}{q_{AA}} \right) \frac{\partial N_o}{\partial L}$
Households renting in livestock but not participate in land rental market	Households renting out livestock but not participate in land rental market
$\frac{\partial N_i}{\partial N} = \frac{1}{P_q q_{NN}} < 0$	$\frac{\partial N_o}{\partial N} = \frac{-1}{P_q q_{NN}} > 0$

Furthermore, comparative statics with respect to transaction costs in land and livestock rental markets showed that increasing transaction costs are found to have negative impacts on amounts of land and livestock rented out.

Based on the above analysis, following hypotheses are derived:

1. Amounts of livestock rented in decrease with ownership holdings of livestock.
2. Amounts of livestock rented out increase with ownership holdings of livestock.
3. Amounts of livestock rented in decrease with ownership holdings of land.
4. Amounts of livestock rented out increase with ownership holdings of land.

<sup>2</sup> In our sample, none of the households renting in livestock have rented out land. Similarly, only 3 households that rented out livestock though they have rented in land. These two cases are therefore, not dealt here.

5. Low-caste households are relatively poorer in land and livestock and thus, more likely to rent in livestock (+rent in more).
6. Low-caste households are relatively poorer in land and livestock and thus, less likely to rent out livestock (+rent in less).
7. Labor-poor households are more likely to rent out their livestock holding (+rent out more) and less likely to rent in (+rent in less) than labor rich households.
8. Low-caste households are relatively more land and livestock-poor and tend to rent in both land and livestock.
9. There is positive correlation between amounts of land and livestock rented in or rented out.

These hypotheses can be linked to the local conditions prevailing in the study area. Some of the rationale for the presence of livestock rental market in the study area can be summarized as follows:

1. Imperfections in the land rental market trigger adjustment through livestock renting to balance land and livestock endowments.
2. Poverty and liquidity constraints of poor potential tenant households create incentives to rent in livestock which is a lumpy asset where renting can facilitate smoother adjustment.
3. Livestock rental markets can be a way of sharing risk in livestock production and sharing other resources.
4. Temporarily absent households prefer to rent out both their land and livestock resources rather than selling them to lower the cost of returning.
5. Maoist threats have caused particularly the high caste households to have left the areas and rented out their land and livestock resources.
6. Low caste households with limited or no land resources overcome their land and cash constraints by going into land and livestock sharing contracts with limited or initial payment requirements.
7. Land-livestock synergies create incentives to increase the livestock/land ratio on small farms.

## 5. Empirical Estimations

Tobit and the double hurdle models were used in order to identify the factors that influence the probability and level of livestock rental market participation by farm households. Furthermore, a bivariate ordered probit model was applied to test if there is any association between livestock and land rental market participation. The details of these econometric models are described below.

### 5.1 Participation in the livestock rental market

In order to know the factors influencing livestock rental market participation, we estimated censored Tobit and double hurdle models because the dependent variable in our case contains both zero and non-zero values. The models were estimated for each side of the livestock rental market separately allowing asymmetric responses across the market.

The standard censored Tobit model is given by:

$$y^* = \mathbf{x}\boldsymbol{\beta} + u, \quad u | \mathbf{x} \sim N(0, \sigma^2)$$

Where  $\mathbf{x}$  is the vector of independent variables,  $\boldsymbol{\beta}$  is the vector of coefficients and  $u$  is the error term. The variable net livestock leased in,  $nlsli$  takes zero, negative and positive values. Its construction is similar to the concept of net land leased in,  $nli$  (Bliss and Stern 1982; Skoufias 1995). In estimating the leasing in model, we consider only zero and positive values because the value of net livestock leased in is positive for households renting in livestock. On the other hand, in estimating leasing out model, we consider only zero and negative values of net livestock leased in because it is negative for households that rent out livestock. So, the renting in model is left censored whereas the renting out model is right censored. However, it does not affect the basic structure of the Tobit model. Therefore, in the Tobit model, the probability of non-participation in the livestock rental market is given by:

$$P(y = 0) = 1 - \Phi(\mathbf{x}\boldsymbol{\beta} / \sigma)$$

And the density for positive values (or negative values for households renting out livestock) is:

$$f(y | \mathbf{x}, y > 0) = \left[ \Phi\left(\frac{\mathbf{x}\boldsymbol{\beta}}{\sigma}\right) \right]^{-1} \frac{1}{\sigma} \phi\left(\frac{y - \mathbf{x}\boldsymbol{\beta}}{\sigma}\right)$$

where  $\Phi$  is the standard normal cumulative distribution function and  $\phi$  is the standard normal probability density function. This equation actually represents a truncated regression for positive values of the continuous decision of how much livestock to rent in or rent out given that a household has already decided to participate ( $y > 0$ ) in the livestock rental market. The Tobit model occurs if the participation decision (probit model) and the extent of participation (how much to rent in or rent out), represented by truncated regression model, have the same explanatory variables. Therefore, the log-likelihood function for the Tobit model can be expressed as:

$$\ln L = \sum_0 \ln \left[ 1 - \Phi \left( \frac{\mathbf{x}\boldsymbol{\beta}}{\sigma} \right) \right] + \sum_+ \ln \left[ \frac{1}{\sigma} \phi \left( \frac{y - \mathbf{x}\boldsymbol{\beta}}{\sigma} \right) \right]$$

The Tobit model, however, assumes that the same mechanism determine both the zeros and the positives and the amount of the variable in question given that the variable is positive (Wooldridge 2002; Cameron and Trivedi 2009). Therefore, in case of the Tobit model, a variable which increases (decreases) the probability of participation in livestock rental market also increases (decreases) the amount of livestock rent in or rent out.

The double hurdle model allows more flexibility assuming that the decision to participate and the amount of participation may be influenced by different variables. In these models, the first part or the hurdle is to decide whether to participate or not and having decided that, for the participants the second part deals with how much to participate. Of the variants of the double hurdle model, we estimated the Cragg model (Cragg 1971; Wooldridge 2002), in which the first part corresponds to the farm households' choice of whether to participate or not in the livestock rental market (a probit model) and the second part corresponds to the extent of participation in the livestock rental market given that it has decided to participate (a truncated model). Therefore, the log-likelihood function for the Cragg model is:

$$\ln L = \sum_0 \ln \left[ 1 - \Phi(\mathbf{z}\boldsymbol{\gamma}) \right] + \sum_+ \left\{ \ln \Phi(\mathbf{z}\boldsymbol{\gamma}) + \ln \phi \left[ \frac{1}{\sigma} \left( \frac{y - \mathbf{x}\boldsymbol{\beta}}{\sigma} \right) \right] - \ln \Phi \left( \frac{\mathbf{x}\boldsymbol{\beta}}{\sigma} \right) \right\}$$

The Cragg model nests the Tobit model, when  $\mathbf{z} = \mathbf{x}$  and  $\boldsymbol{\gamma} = \boldsymbol{\beta}/\sigma$ . We compared the Cragg model (two part model) and the Tobit model by using likelihood ratio test (Cameron and Trivedi

2009). The test led us to reject the Tobit model in favor of double hurdle model in both sides of the market and thus only the results of double hurdle models are presented.

## 5.2 Association between land rental market and livestock rental market

In order to find out if there exists any relation between land and livestock rental markets participation, a bivariate ordered probit model was applied. Ordinal dependent variables, net livestock leased-in (*nlsli*) and net land leased-in (*nli*), have three alternative outcomes. In each rental market, a household can either rent-out or remain autarky or rent-in. Bivariate ordered probit models can be derived from the latent variable model (Sajaia 2008). Assume that two latent variables  $y_1^*$  and  $y_2^*$  are given by:

$$\begin{aligned} y_{1i}^* &= \mathbf{x}'_{1i} \boldsymbol{\beta}_1 + \varepsilon_{1i} \\ y_{2i}^* &= \mathbf{x}'_{2i} \boldsymbol{\beta}_2 + \gamma y_{1i}^* + \varepsilon_{2i} \end{aligned}$$

where  $\boldsymbol{\beta}_1$  and  $\boldsymbol{\beta}_2$  are vectors of unknown parameters,  $\gamma$  is an unknown scalar,  $\varepsilon_1$  and  $\varepsilon_2$  are the error terms. The explanatory variables in the model satisfy the conditions of exogeneity such that  $E(\mathbf{x}_{1i} \varepsilon_{1i}) = 0$  and  $E(\mathbf{x}_{2i} \varepsilon_{2i}) = 0$ .

We observe two categorical variables  $y_1$  and  $y_2$  such that:

$$y_{1i} = \begin{cases} 1 & \text{if } y_{1i}^* \leq c_{11} \\ 2 & \text{if } c_{11} < y_{1i}^* \leq c_{12} \\ \vdots & \vdots \\ J & \text{if } c_{1J-1} < y_{1i}^* \end{cases} \quad y_{2i} = \begin{cases} 1 & \text{if } y_{2i}^* \leq c_{21} \\ 2 & \text{if } c_{21} < y_{2i}^* \leq c_{22} \\ \vdots & \vdots \\ K & \text{if } c_{1K-1} < y_{2i}^* \end{cases}$$

The unknown cutoffs satisfy the condition that  $c_{11} < c_{12} < \dots < c_{1J-1}$  and  $c_{21} < c_{22} < \dots < c_{2K-1}$ .

Under the assumption that observations are independent, the log likelihood for the entire sample in case of bivariate ordered probit is given by:

$$\ln \ell = \sum_{i=1}^N \sum_{j=1}^J \sum_{k=1}^K I(y_{1i} = j, y_{2i} = k) \ln \Pr(y_{1i} = j, y_{2i} = k)$$

Given that  $\varepsilon_{1i}$  and  $\varepsilon_{2i}$  are distributed normally, the system of equations are estimated by full-information maximum likelihood (Sajaia 2008).

## 6. Results and Discussions

### 6.1 Participation in livestock rental market

The results of the double hurdle models for both sides of the livestock rental markets are presented in Table 6. The table shows that there were substantial differences between which variables were significant in the probit versus the truncated models on each side of the livestock rental market.

Hypothesis 1 can be accepted as having more livestock was negatively associated with the likelihood to rent in livestock and the amount of livestock rented in, given that the household decided to rent in. Hypothesis 2 cannot be rejected as the amount of livestock rented out was positively affected by the own livestock. However, unlike the case of renting in livestock, owned livestock holding did not significantly affect the likelihood to rent out livestock. Hypothesis 3 can safely be rejected (in case of renting in) as having more land was found to have no impact on the probability to and level of renting in livestock. On the other hand, own land holding size positively affected the probability of renting out livestock (at 1 per cent level of significance) but had no impact on amount to be rented out. This indicates that land poverty also affects the livestock rental market participation by the farm households.

Low caste households were found to have significantly higher probability of renting-in livestock as compared to high caste households and thus, hypothesis 5 cannot be rejected. But in case of amount of livestock to be rented-in the low caste dummy is significant only at 10 per cent level. As low caste households are often discriminated in regular outside job market (Ito 2009), they are more dependent on agricultural sector either as farmers or as laborers. Low caste households are found to rent out significantly lower unit of livestock as compared to high caste. However, caste dummy did not affect the likelihood to rent out livestock (which had highly significant effect before the introduction of migration dummy).

Male headed households were found to have significantly higher probability of renting in and lower probability of renting out livestock as compared to female headed households. But in both cases, sex of household head did not affect the amount of livestock to be rented in or rented out. Households with more adult males were found to have higher probability of renting in and lower probability of renting out livestock. In addition, the amount of livestock to be rented out was also reduced significantly (at 5 per cent level) with the increase in adult males in the household. Male

headed households have advantage in making decisions and managing the requirements to keep livestock, given the patriarchal structure of the Nepalese rural society.

Migration of adult household member significantly lowered not only the probability to rent in, but also the amount of livestock rented in. On the other hand, migration dummy significantly increased both the probability of renting out livestock and amount rented out. Therefore, we can safely conclude that households with migrated adult member are more likely to rent-out livestock as compared to the households with no migrated adult member. This shows the reality of the study area as the data were collected during the period of Maoist war. Due to the Maoist war male members of many households left the village because they were forced either to support the Maoist or to leave the village. It may be the reason why low caste dummy turned out to be insignificant after we introduced migration dummy.

## **6.2 Association between livestock and land Rental market participation**

Integration of crop and livestock is one of the main characteristics of agriculture in the study area and therefore, there are possibilities that households' decisions to participate in livestock and land rental market can be inter-related. In order to test this, we estimated bivariate ordered probit model. For the sake of comparison, we also carried out univariate ordered probit models for livestock and land rental market separately. Table 7 provides the results of these models.

Results show that all of the variables which significantly affected the livestock (land) rental market participation in univariate ordered probit model were also found to be significant in bivariate ordered probit model. However, the size of coefficient and the level of significance were found to have changed slightly. As both models show that low caste households had higher probability of renting-in livestock as well as land as compared to high caste households, hypothesis 8 is not rejected. Results show that increase in ownership land holding reduced the probability of renting in both livestock and land. This means land poverty partly drives both renting-in livestock and land.

Another important result is that male headed households were more likely to rent-in livestock as well as land. Similarly, household with more male labor endowment were more likely to rent-in livestock and land. In addition, households with migrated adult member were found to affect negatively the probability of a household to rent-in livestock and land. These results supported

that Maoist war was partly responsible for livestock rental market participation by the farm households despite the issue of moral hazard associated with livestock rental market.

The variable of interest in our case is ‘Constant ( $\theta$ )’, which shows the association between the two rental markets under consideration. Hypothesis 9 cannot be rejected as this variable was positive and highly significant. It implies that there was significant positive association between livestock and land rental market participation and hence the rental arrangements were integrated to each other. Furthermore, households that rent-in livestock were more likely to rent-in land and the households that rent-out livestock were more likely to rent-out land. This result is also supported by the descriptive statistics, which we presented in Table 1 before.

## 7. Conclusions

This paper looked for the possible reasons why households participated in livestock rental market instead of selling/buying it. In addition, we assessed whether there exists any relation between livestock and land rental market participation decisions of the households.

We estimated the double hurdle model for each side of the livestock rental market separately and found that low caste households are more likely to rent in and less likely to rent out livestock as compared to high caste households. It is in line with our hypothesis that poverty and liquidity constraints of poor potential tenant households create incentive to rent in livestock, which is a lumpy asset where renting in facilitate the adjustment of land/livestock ratio. As male headed households have higher probability to rent in and lower probability to rent out livestock, it partly implies that temporarily absent households, who left their village due to Maoists threat, have rented out their livestock resources. It resembles the situation in the study area where Maoists threatened the rich households (mostly high caste households) and households supporting other political parties. These households (mostly the adult male members of the household) had either to compromise with the Maoists or to go out of the village. The significant positive effect of migration on both the likelihood of renting out livestock and the unit of livestock rented out also supported this hypothesis. Another important factor is the size of own land holding which increases the likelihood of participation in livestock rental market significantly. It thus implies that imperfections in land rental market may trigger adjustment through livestock renting to balance land and livestock endowments.

Another important query of the study is to see whether there is any association between land and livestock rental market participation decisions of the household. The results of the bivariate probit model clearly exhibited that there are significant positive association between participation decisions on the same side in the two markets. This means households that rented out (in) livestock were also more likely to rent out (in) land.

Overall the policy issue related to it is whether the participation in the livestock rental market is a short-term phenomenon emerged as a response to Maoist war or a response to resource poverty. This has important policy implications because the first issue is related to the overall political stability of the nation, while the second one is more related to the resource distribution among the households, especially between the low caste and high caste households.

#### References

ACAP (1999). Socio-Economic Survey Report of Lwang Sector, Annapurna Conservation Area Project (ACAP) and Institute for Policy Research & Development (IPRAD).

Adhikari, J. (1992). Ethnicity, Off-farm Income and Resource Use in the Semi-Subsistence Farming System of Kaski District, Nepal. Department of Geography, Australian National University. **Doctor of Philosophy**.

Banerjee, B. and J. B. Knight (1985). "Caste Discrimination in the Indian Urban Labour Market." Journal of Development Economics **17**: 277-307.

Binswanger, H. P. and M. Rosenzweig (1986). "Behavioral and Material Determinants of Production Relations in Agriculture." Journal of Development Studies **22**(3): 503-539.

Bliss, C. J. and N. H. Stern (1982). Palampur: The Economy of an Indian Village. Delhi and New York, Oxford University Press.

Cameron, A. C. and P. K. Trivedi (2009). Microeconometrics Using Stata, STATA Press.

Chiang, A. C. (1984). Fundamental Methods of Mathematical Economics. Singapore, McGraw-Hill Book Company.

Cragg, J. (1971). "Some Statistical Models for Limited Dependent Variables with Application to the Demand for Durable Goods." Econometrica **39**(5): 829-844.

Holden, S. T., K. Otsuka, et al., Eds. (2009). The Emergence of Land Markets in Africa: Assessing the Impacts on Poverty, Equity, and Efficiency. Environment for Development, Resources for the Future (RFF).

Ito, T. (2009). "Caste Discrimination and Transaction Costs in the Labor Market: Evidence from Rural North India." Journal of Development Economics **88**(2): 292-300.

NRB (1988). National Statistics, 1987/88, Nepal Rastra Bank.

Rajbhandari, H. B. and S. L. Pradhan (1991). Livestock Development and Pasture Management: Background Papers to the National Conservation Strategy for Nepal, The World Conservation Union (IUCN).

Sajaia, Z. (2008). "Maximum Likelihood Estimation of a Bivariate Ordered Probit Model: Implementation and Monte Carlo Simulations." The Stata Journal **vv**(ii): 1-18.

Silberberg, E. and W. Suen (2001). The Structure of Economics: A Mathematical Analysis. Singapore, McGraw-Hill.

Skoufias, E. (1995). "Household Resources, Transaction Costs, and Adjustment through Land Tenancy." Land Economics **71**(1): 42-56.

Thapa, G. B. and K. E. Weber (1995). "Natural Resource Degradation in a Small Watershed in Nepal." Natural Resource Forum **19**(4): 290-298.

Wooldridge, J. M. (2002). Econometric Analysis of Cross Sectional and Panel Data. London, MIT Press, Cambridge, Massachuttes, London, England.

**Table 6 Analysis of livestock rental market participation**

	Renting in (Yes=1)		Renting out (Yes=1)	
	Probit	Truncreg	Probit	Truncreg
Caste dummy: low(1)	0.520** (0.236)	0.628* (0.354)	-0.682 (0.427)	-1.477** (0.654)
Value of Asset (In Rs.)	-0.003 (0.046)	-0.012 (0.059)	-0.087** (0.039)	-0.003 (0.055)
Owned livestock (in TLU)	-0.258*** (0.072)	-0.406*** (0.145)	-0.034 (0.048)	0.285*** (0.107)
Owned land holding (ha)	-0.117 (0.291)	0.269 (0.483)	0.747*** (0.194)	-0.054 (0.215)
Age of household head (years)	-0.007 (0.008)	0.016 (0.011)	0.015* (0.009)	0.004 (0.012)
Sex head dummy: male(1)	0.885*** (0.207)	0.258 (0.266)	-0.587** (0.262)	0.077 (0.342)
Number of adult males	0.250*** (0.080)	0.146 (0.106)	-0.436*** (0.101)	-0.228** (0.107)
Number of adult females	-0.203* (0.104)	-0.141 (0.137)	0.142 (0.100)	-0.061 (0.139)
Migration dummy: yes (1)	-0.550** (0.216)	-0.734** (0.297)	1.807*** (0.258)	1.062** (0.412)
Constant	-0.755 (0.461)	1.174* (0.693)	-2.274*** (0.531)	0.162 (0.782)
Sigma constant		0.848*** (0.076)		0.830*** (0.078)
Wald chi2	109.943	55.849	113.251	25.826
Number of observations	433	62	427	56

Significance levels: \*: 10% level, \*\*: 5% level, \*\*\*:1% level

**Table 7 Analysis of association between land and livestock rental markets participation**

Market participation <sup>1</sup>	Ordered probit		Bivariate ordered probit	
	livestock	land	livestock	land
Caste dummy: low(1)	0.777*** (0.212)	0.365** (0.177)	0.778*** (0.212)	0.362** (0.177)
Value of Asset (In Rs.)	0.039 (0.025)	0.003 (0.026)	0.040 (0.024)	0.003 (0.026)
Owned livestock (in TLU)	-0.068*** (0.023)	-0.066** (0.026)	-0.070*** (0.023)	-0.067** (0.026)
Ownership holding (ha)	-0.510*** (0.136)	-0.517*** (0.146)	-0.518*** (0.132)	-0.516*** (0.146)
Age of household head (years)	-0.014** (0.006)	-0.013*** (0.005)	-0.014** (0.006)	-0.013*** (0.005)
Sex head dummy: male(1)	0.777*** (0.168)	0.475*** (0.139)	0.770*** (0.167)	0.479*** (0.139)
Number of adult males	0.281*** (0.055)	0.336*** (0.053)	0.287*** (0.056)	0.336*** (0.053)
Number of adult females	-0.125* (0.064)	-0.002 (0.062)	-0.123** (0.063)	-0.002 (0.062)
Migration dummy: yes(1)	-1.135*** (0.157)	-0.772*** (0.123)	-1.127*** (0.155)	-0.773*** (0.123)
Constant (cut1)	-2.376*** (0.345)	-1.646*** (0.299)		
Constant (cut2)	0.987*** (0.357)	0.460 (0.286)		
Constant (athrho)				0.344*** (0.077)
Wald chi2	165.235	141.637		169.893
N	489	489		489

Significance levels: \*: 10% level, \*\*: 5% level, \*\*\*:1% level

1. There are three categories: rent out (-1); non-participation (0) and rent in (1)

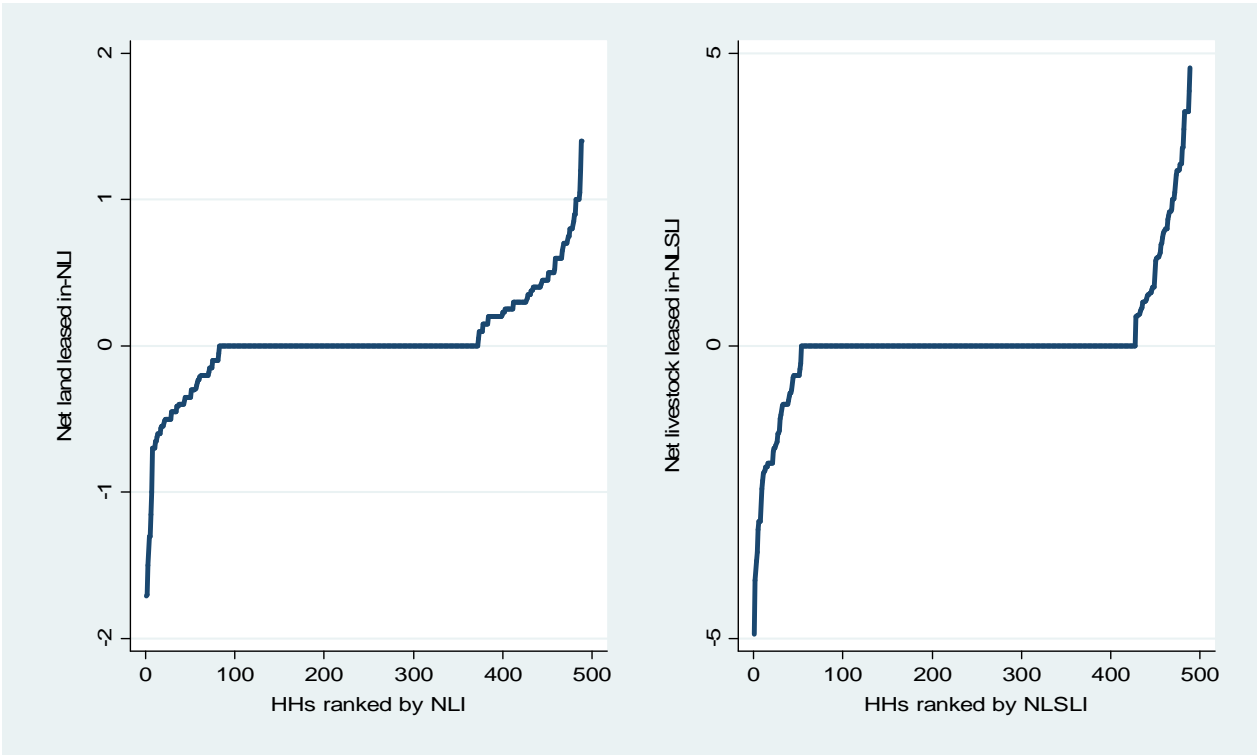


Figure1 Households ranked by Net land leased in and Net livestock leased in

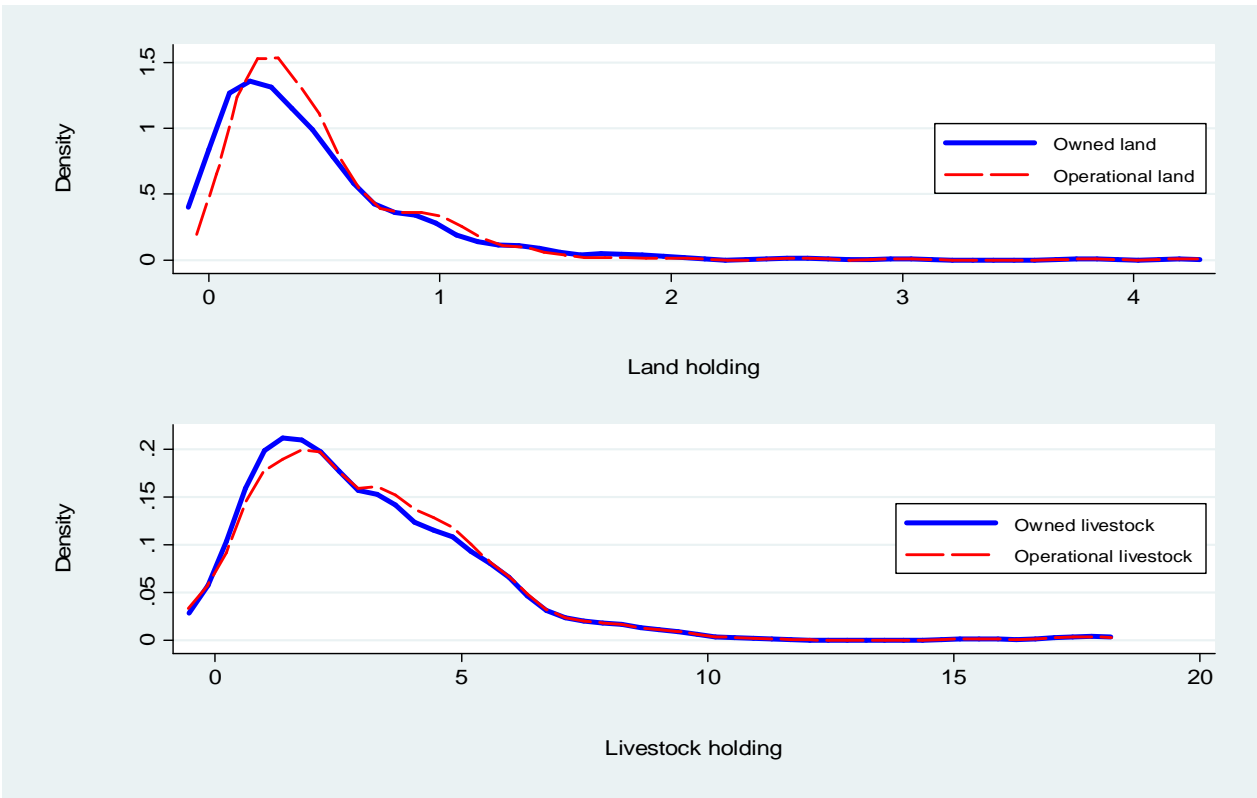


Figure 2 Kernel densities for owned and operational land; and owned and operational livestock holding

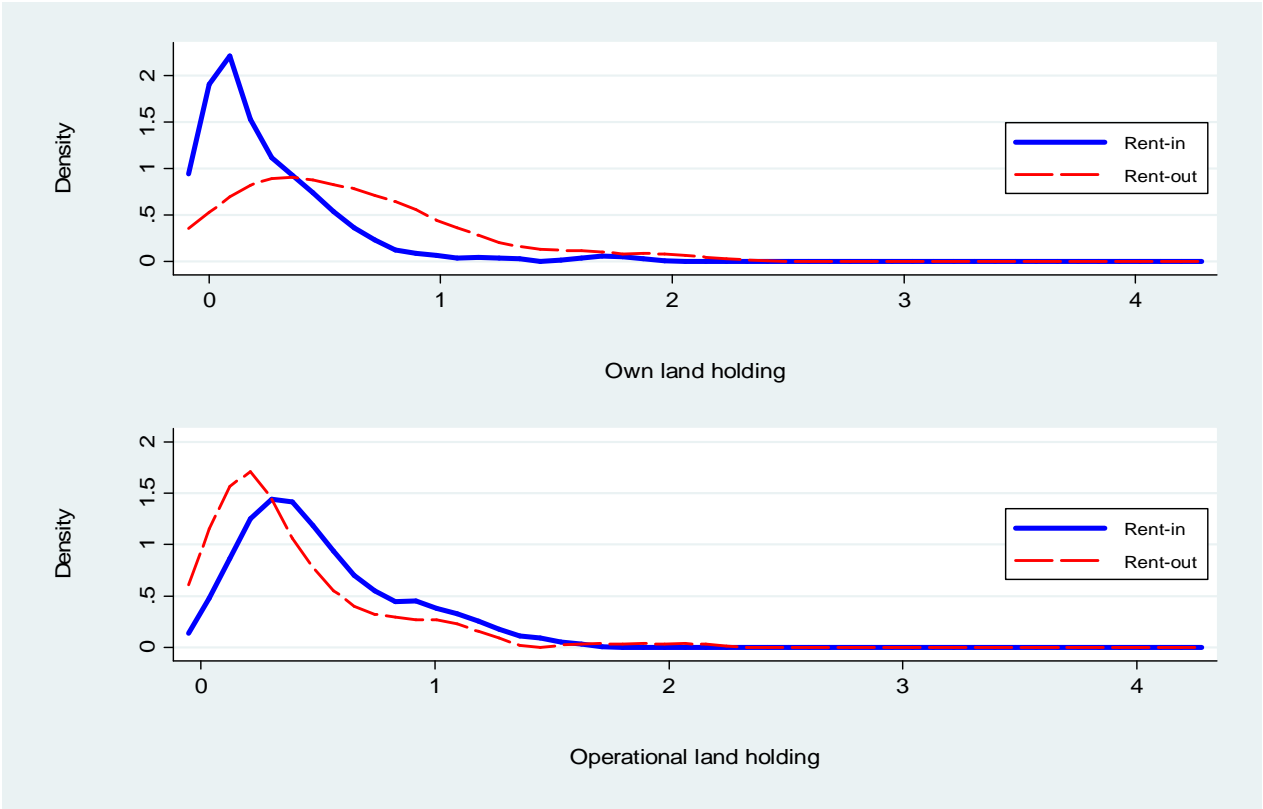


Figure 3 Kernel densities for owned and operated land for households that rent in (out) land.

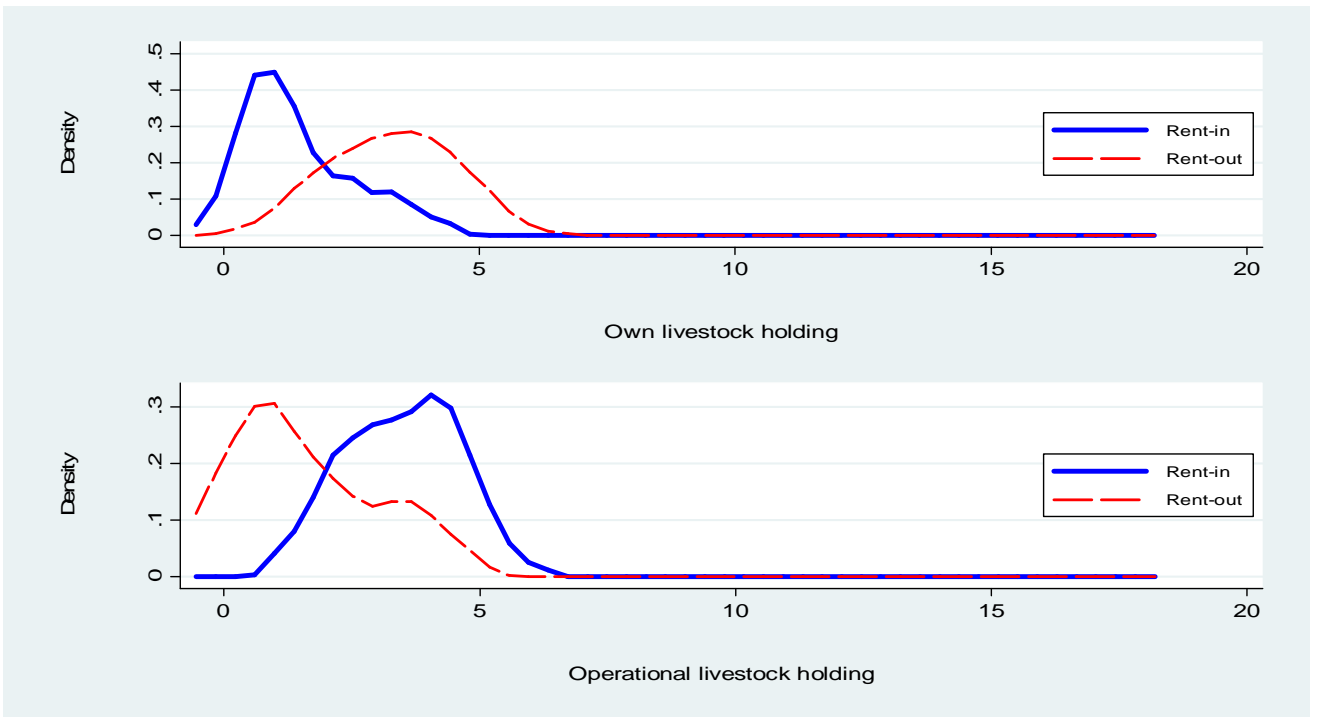


Figure 4 Kernel densities for owned and operated land for households that rent in (out) livestock.