

Livestock and land share contracts in a Hindu society

Jeetendra P. Aryal*, Stein T. Holden

Department of Economics and Resource Management, Norwegian University of Life Sciences (UMB), P.O. Box 5003, N-1432 Aas, Norway

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Abstract

This article examines factors related to a livestock rental market in western Nepal and assesses whether this market is associated with caste differentiation and land rental market participation. Theoretical models for asset-rich (i.e., high-caste) households, rich in land and livestock, and asset-poor (i.e., low-caste families) households are presented to provide logical explanations for the existence of a livestock rental market and the synergy between livestock and land rental markets participation. A combination of double hurdle models and bivariate-ordered probit models were used to test the implications of the models. Consistent with the theoretical models, land- and livestock-rich high-caste households were more likely to rent out land and/or livestock, whereas land- and livestock-poor and credit constrained low-caste households were more likely to rent livestock and land from others. Participation in the two markets was positively correlated, indicating a synergistic relationship that may be due to production and transaction costs reducing benefits. Policies that can enhance the allocative efficiency of livestock and land rental markets can improve equity as well as efficiency of land use in Nepal. Provision of livestock credit to land-poor low-caste households is also crucially dependent on their access to more long-term contracts for land.

JEL classifications: Q12, Q15, Q18

Keywords: Livestock rental market; Land rental market; Share contracts; Asset poverty; Caste; Nepal

1. Introduction

Livestock remains to be an important asset for farm households in rural areas of developing countries. Indeed, livestock acts as a provider of multiple services and commodities, including traction power, manure, productive asset stock, insurance, meat, milk, and wool, thereby making it a major source of income. Livestock is typically considered to be a more liquid asset than land because livestock sales markets are not burdened by the same legal restrictions as land sales; in addition, livestock are mobile in contrast to the immobility of land resources. On the other hand, this has caused land to be favored for collateral purposes, whereas livestock are considered unsuitable for such purposes due to their mobility and fragility (Binswanger and Rosenzweig, 1986). Moreover, land rental markets tend to be

more developed and function better than land sales markets, whereas the opposite is the case for livestock. Binswanger and Rosenzweig (1986) explained the poor development of rental markets for livestock and their services, like plowing services, by highlighting the considerable moral hazard problem associated with such markets and the fragility of animals. Another reason for the poor development of livestock rental markets could be the short season for the demand for such livestock in rain-fed agriculture; yet, more of such rental services could be expected in irrigated agriculture (Holden et al., 2008). This may also explain why there have been many empirical studies of land rental markets, but few studies of livestock rental markets.

Contrary to the current perspectives on livestock rental markets as previously detailed, we found livestock rental transactions to be quite common in our study area in Nepal. Our primary aim is to explain the logic behind this institutional anomaly. Therefore, we question why households choose to participate in livestock rental markets and how this relates to inequalities in asset distribution and the functioning of other input and output markets. In particular, we relate livestock renting to the discriminatory caste system (for details see Section 2), which is of primary importance for asset distribution and market access (Aryal, 2011; Banerjee and Knight, 1985; Ito,

*Corresponding author.

E-mail address: jeetendra.aryal@umb.no (J.P. Aryal).

Data Appendix Available Online

A data appendix to replicate main results is available in the online version of this article. Please note: Wiley-Blackwell, Inc. is not responsible for the content or functionality of any supporting information supplied by the authors. Any queries (other than missing material) should be directed to the corresponding author for the article.

2009) in Nepal. Traditionally, low-caste males have served as plowmen (i.e., *Hali* in Nepali) for high-caste landlords who considered plowing to be inferior work. This system is called *Haliya*. Under the *Haliya* system, low-caste households provided all sorts of manual labor required for farming, including caring for livestock (United Nations Resident and Humanitarian Coordinators Office [UNRHCO], 2011). Consequently, livestock renting can likely be associated with traditional caste differentiations, thereby implying the need to consider the caste system when analyzing livestock rental contracts. Furthermore, low-caste households tend to have little education and poor access to nonagricultural employment; simultaneously they are asset-poor with no or very little land and livestock endowments. Output sharing contracts dominate the livestock and land rental markets where low-caste households typically are tenants. Using farm household data from western Nepal, we investigated how asset distribution, caste association, and labor and credit market access variables are explaining or being associated with participation in the livestock rental and land rental markets. We are not aware of any earlier studies focusing on this particular area.

For the empirical analysis, we used double hurdle and bivariate-ordered probit models. We tested three major hypotheses. Our first hypothesis that livestock- and land-rich high-caste households with better labor market access are more likely to rent out both land and livestock could not be rejected. Our second hypothesis stated that credit-constrained land- and livestock-poor (low caste) households rent in land and livestock. Our empirical analysis revealed that indeed cash constrained asset-poor households obtained access to livestock and land resources through these rental markets. Therefore, the livestock and land rental markets may serve as a means to overcome the capital and credit constraints of poor households. The third major hypothesis we tested was that livestock renting occurs as complementary contract to a land rental contract. Our empirical analysis showed a strong positive correlation for participation on the same side of these two markets; hence, the third hypothesis could not be rejected. This may be explained by the fact that land and livestock are essential complementary inputs in the local farming system, and joint contracts serve as a transaction cost-reducing device for landlords who face moral hazard problems, and search, monitoring, and enforcement costs when renting out their resources. This may explain the otherwise rare institutional phenomenon that livestock renting is.

2. The caste system in Nepal and its implications

The caste system, which originated in the Hindu religion, is a social hierarchy that determines social position at birth based on hereditary membership, thereby preventing movement from one category to another. The major caste classifications include the following: *Brahmins*, *Chhetries*, *Vaishyas*, and *Sudras* (i.e., they are now called Dalits). *Brahmins* have priestly roles and are considered as pure or holy, whereas *Chhetries* are considered

warriors and rulers. *Vaishyas* are regarded as traders, whereas *Sudras* are considered impure or untouchable and are relegated to work as laborers (United Nations Development Programme [UNDP], 2008). Traditionally, the individual caste classification defines the role of each category, thereby determining what an individual can and cannot do. The most severe implication of this system is the division of labor based on the caste classification, which provides a socially acceptable basis for discriminatory treatment. Among several discriminatory practices, the practice of untouchability has severe implications. The practice of untouchability prevents Dalits from participating in religious functions, entering the shops or houses of individuals from other castes, using public wells, and even attending the same school with others (Aryal, 2011; Banerjee and Knight, 1985). This practice has contributed to social ostracism for the Dalits. Although differences can be identified between each of these individual groups, the most dramatic differences can be seen between the Dalits and the non-Dalits (i.e., everyone else). This study, therefore, classified all households under the study into the following two broad groups: Low-caste (i.e., Dalits households only) and High-caste (i.e., all other households).

This caste based hierarchy and division of labor is a long-standing phenomenon in Nepal (Aryal, 2011; Gurung, 1997; Hachhethu, 2003). Although caste discrimination had been practiced for centuries, it was legally accepted by the state in 1854. Specifically, in 1854, Nepal implemented a legal framework that was entirely based on the values of the caste system through the implementation of their first Civil Code. The Civil Code, which was in place and practiced until 1963, accorded differential privileges and obligations to each caste (Bennett, 2005; DFID and World Bank, 2006; Hachhethu, 2003). This resulted in unequal access to resources and even unequal treatment from state institutions.

In 1963, a new Civil Code replaced the Civil Code of 1854. The new Code implemented one important change, specifically the legal abolition of caste discrimination. However, this did not create any substantial changes in practice due to inconsistencies between the existing value system and the new laws (Dahal et al., 2002). Nevertheless, after 1990 when Nepal adopted a multiparty democracy, the constitution of Nepal explicitly declared the equality of all citizens irrespective of their caste. However, this constitutional provision remained ineffective in practice due to the lack of supporting laws and the low level of social awareness among Nepal's citizen (Bhattachan et al., 2002). In reality, the remaining laws and the existing bureaucratic structures facilitated the continuance of caste discrimination in the name of maintaining tradition. In 2007, Nepal became a secular republic nation, and the 2007 Interim Constitution of Nepal assured the legal abolition of caste discrimination. With this, several legal and political changes were implemented in an effort to end caste discrimination, but the overall social transformation necessary to bring these efforts into full effect will take a long time.

Caste discrimination against Dalits creates various implications related to market participation, access to and ownership

of resources, and level of human capital (Aryal, 2011; Banerjee and Knight, 1985; Ito, 2009). Traditionally, Dalits were not allowed to own land (George, 1987) or to receive an education; instead, they were only allowed to do menial jobs (Banerjee and Knight, 1985). A crucial implication of this is the very restricted access to land for Dalits in Nepal because land transfer is most often inter-generational and occurs only among family members despite the existence of a land market (Wily et al., 2008). Moreover, accessing land through the land sales market is nearly impossible for the poor due to credit market imperfections. Consequently, Dalits are far below others in terms of wellbeing indicators, such as literacy, income, life expectancy, and representation in politics (UNDP, 2008). Due to their poverty and illiteracy, Dalits are highly dependent on high-caste households for their survival. In the study area, we observed that even though clusters of Dalits lived separately from other caste groups, the *Haliya* system that linked Dalits as farm workers to high-caste households still existed. Despite the nation-wide abolition of caste discrimination, Dalits still suffer from negative impacts associated with past discrimination, especially in terms of their very limited participation in better paying jobs. Although the traditional caste-based division of labor has weakened over time, the historical patterns of employment still influence their choice of occupation to a large extent. Indeed, past experiences may create lower expectations and ambitions among the Dalits, thereby causing them to accept low-pay and lower status jobs (Banerjee and Knight, 1985). In addition, studies in India, where similar caste based discrimination exists, show that Dalits face significant transaction costs when participating in regular, off-farm employment (Ito, 2009; Madheswaran and Attewell, 2007). A study in Nepal (Hatlebakk et al., 2010) showed an association between caste group and migration; more specifically, the Dalits were less likely to migrate. This study also found a positive effect of the social network on the likelihood of getting jobs at the migration destination.

To summarize, even though caste discrimination has been legally abolished, there exist strong residual effects of the system on the distribution of assets, including human and social capital, and access to markets. Dalits remain the poorest group and the group with least agricultural resources and at the same time being the group most dependent on these resources as the basis for their livelihood.

3. Background on livestock rental markets

Contractual arrangements in agriculture have remained an area of interest for research. However, land tenancy contracts and labor employment contracts have remained the key areas of focus (Otsuka et al., 1992). There are, therefore, little research related to livestock rental markets as compared to land rental markets. The more typical absence of livestock rental markets has been explained by the fragility of animals, moral hazards related to the management of rental animals, the short season for

use of animals as traction power in rain-fed agriculture, and the well-functioning sales markets for animals (Binswanger and Rosenzweig, 1986; Holden et al., 2008). This also raises the question why livestock rental markets exist in some cases, like in our study area.

Livestock plays important roles in many types of farming systems in which land and livestock are inter-related components. In such farming systems where land rental markets are common, major attributes of the land rental market may possibly also affect the plausible existence of a livestock rental market. Furthermore, these markets might represent a response to other factor market imperfections in rural areas, such as imperfect or missing credit and insurance markets where the nonexistence of or access to these markets may be affected by unequal resource distribution.

Land tenancy contracts and the contract production of livestock share many common characteristics (Knoeber, 2000; Knoeber and Thurman, 1995). Knoeber (2000) studied land and livestock contracting in agriculture using the principal-agent perspective. He examined contracts in broiler production and claimed that risk sharing and incentives largely explain such contracts. However, his study concentrated on agriculture production in developed countries, like the USA.

Among the few studies in developing countries, Aspen (1993) found both livestock share contracts and land rental contracts in Ethiopia. In their study in Ethiopia, Tadesse and Holden (2010) examined the determinants of livestock rental contract choices and their impact on poverty. Their study showed that despite the likelihood of moral hazards, livestock rental contracts contributed to overcoming capital constraints in an area with high production risks and imperfect markets. Furthermore, they found a positive effect of the livestock rental contracts on the welfare of livestock tenants.

In developing countries, formal strategies for coping with risk are often costly and thus unattainable (Morduch, 1995); thereby, farm households are forced to rely on informal risk sharing strategies (McPeak, 2006). Studies of risk and insurance in Indian villages using ICRISAT data showed that livestock production is typically the least risky agricultural enterprise while compared to earnings from wages and income from crops produced (Townsend, 2000). Another study using the same data showed that bullocks are sold when households face adverse weather shocks to smooth consumption (Rosenzweig and Wolpin, 2000). Rosenzweig and Wolpin (2000) also found that under a situation in which agriculture suffers from a covariate risk, livestock served as buffer stocks because livestock is a movable form of capital in contrast to the immobility of land. Although livestock is an important source of liquidity, using it as a buffer stock is costly because households may need to sell livestock at low prices when they face shocks under covariate risk (Holden and Shiferaw, 2004).

Several studies have claimed that when production risks exist with no insurance market, sharecropping contracts offer the ability to share risk (Ackerberg and Botticini, 2002; Otsuka, 2007). However, empirical evidence does not always support

the risk-sharing hypothesis as a prime motivation for sharecropping (Allen and Lueck, 1999). Poor households may also use sharecropping to overcome capital constraints, balance their asset portfolios, and enhance cooperation with their relatives and/or neighbors (Bogale and Korf, 2007).

In Nepal, short-term sharecropping, which is known as *Adhiya* in Nepali, is the most common land rental arrangement (Acharya and Ekelund, 1998). The term *Adhiya* is understood as 50% sharing of the produce. However, this varies depending on the supply of inputs by landlords and tenants. In general, the tenant provides the labor and all other inputs, whereas the landlord provides only the land. In practice, not all inputs are shared equally between the landlord and the tenant. Yet, such inputs as chemical fertilizers, irrigation, and improved seeds are often shared (Acharya and Ekelund, 1998). The arrangements may vary depending on the level of dependency and the nature of the relationship between the tenant and the landlord. In the *Gausala* village in Nepal, Acharya and Ekelund (1998) found that none of the landlords shared the costs associated with the inputs in the case of pure tenants, thereby indicating that the contract terms might improve with the increased economic status of the tenants. Their study also showed that 86% of borrowers among the pure share tenants have borrowed from their landlords. Under such cases, landlords possess more power to force the tenants to apply more inputs and may not share all of the inputs equally.

In Nepal, Aryal and Holden (2010) found significant transaction costs in the land rental market, particularly on the demand side of the market. This indicates that many potential tenants find themselves rationed out or have limited, i.e., rationed, access to the land through the land rental market. They also found that low-caste households have higher land productivity compared to high-caste households. Despite this, some high-caste landlords rented out their land to other high-caste tenants that were less productive. This might be due to the tenure insecurity that is created by the land-to-the-tiller policy in Nepal. In general, the research conclusion was in line with the claim made by Otsuka (2007); i.e., the inefficiency of share tenancy might not be due to the inherent difficulty of the contractual arrangement of the share tenancy but more due to policy distortions. This may be the reason for the dominance of short-term, informal sharecropping contracts in our study area, which is similar to what Acharya and Ekelund (1998) had observed.

A study by CSRC (2007) showed that almost 300,000 Dalit households work as *Haliya* in Nepal. Among the *Haliya* workers, 97% belong to the Dalits (UNRHCO, 2011). Because plowing land with oxen was traditionally assumed to be a job that is beneath the dignity of high-caste households, they relied mostly on low-caste males to accomplish this task (Adhikari, 1992). Adhikari (1992) also noticed that in the case of a high-caste landlord and a low-caste tenant, an interlinked contract requiring the tenant to work as a plowman and an agricultural laborer on the land of the landlord may also exist. In South Asia, most of the permanent agricultural laborers belong to the low-caste and their employers to the high-caste (Otsuka

et al., 1992). In addition, *Hali* and his family members were often required to assist their respective patrons in other activities related to farming and caring for livestock (UNRHCO, 2011).

By tradition, Dalits were assigned manual jobs, which in turn also lowered their general expectations regarding their access to jobs (Banerjee and Knight, 1985). However, the strict norms created interdependence and synergy between the caste groups, and a form of trust developed, which reduced the moral hazard problems associated with rental contracts. Furthermore, households within villages are closely connected. As a result, transaction costs related to livestock rental can possibly be reduced. In addition, most of the livestock tenants belonging to low-caste households have worked as agricultural laborers, livestock attendants, or *Hali* for the landlord. This has increased their level of trust and helps reduce monitoring costs for the landlord. Our data revealed that land and livestock contracts are mostly integrated. Of the sample tenant households that rented livestock from others, almost 60% have also rented land. Under such a contract, the landlord can monitor the use of livestock as well as the use of land in the same visit. In many cases, not only landlords but also their close relatives can engage in these monitoring activities. If the tenant resides nearby close relatives of the landlord, the landlord can get information about the use and care of the livestock that he/she has rented out. The following two types of livestock rental contracts were observed in our study area: i) the livestock lord owns or covers the initial payment for purchasing the livestock and ii) the livestock lord and tenant share the costs associated with the initial purchase. In the first case, the livestock tenant has to cover most of the other costs, including labor, shed for the animal, feed, water, and also medicine. Sharing of output depends on the type of livestock that is covered in the contract. In case of cows and buffaloes, the livestock tenant has to share 30–50% of the revenue obtained from selling milk and milk products, usually *Ghee* (i.e., a kind of butter), or give a certain amount of cash to the livestock lord at the onset of each lactation. In this case, the tenant has no right to the offspring or the revenue obtained from selling the animal. In the case of oxen, tenants are required to provide traction services to the livestock lord; thus, most of the households renting in oxen belong to the low-caste. However, in the case of medical expenses, the tenant can share some of the costs with the livestock lord if the information is provided in a timely fashion. In the case of the unexpected death of an animal, the tenant has to provide evidence to the livestock lord or any person assigned by him that the death of the animal was natural and unpreventable. In the second type of contract, both the livestock lord and the tenant share the initial purchase costs as well as the benefits. This contract is often used in the case of small ruminants, especially goats. Because goats are a popular source of meat in this society, goat meat has a high selling value throughout the year but more so during festivals. Despite these noted differences, contract choice is not the major focus of this article due to the limited sample size available for some contract types.

4. Model and empirical strategy

4.1. Theoretical framework

A farm household has initial endowments of land \bar{A} and livestock \bar{N} . Assume that both of these are associated with caste of the household, C . The land and livestock resources, A_j and N_j , respectively, are transacted in the land and livestock rental markets. Consider that the labor endowment of the household L depends on migration M , which in turn depends on the caste as high-caste households usually contain more migrated members partly because they have better access to regular off-farm employment due to better family networks and higher levels of education. This results in a reduction in the male labor endowment of high-caste households with migrated members. The production function, q , is then given by

$$q = q(N, A; L(M(C)));$$

where

$$\begin{aligned} \frac{\partial q}{\partial N}, \frac{\partial q}{\partial A}, \frac{\partial q}{\partial L}, \frac{\partial^2 q}{\partial N \partial A}, \frac{\partial^2 q}{\partial N \partial L}, \frac{\partial^2 q}{\partial A \partial L} &> 0; \\ \frac{\partial^2 q}{\partial N^2}, \frac{\partial^2 q}{\partial A^2}, \frac{\partial^2 q}{\partial L^2} &< 0 \end{aligned} \tag{1}$$

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

where N and A refer to the operational holding of livestock and land resources, respectively. According to our production function assumptions, livestock, land, and labor are complementary factors of production (i.e., have positive cross-derivatives); indeed, this is plausible in our context. Note that both caste and migration are categorical variables.

In our study area, most land and livestock rental contracts are share contracts where the owner gets a share of the output from the crop and livestock production, respectively. However, a household can decide whether or not to participate as a lord in the rental markets for land and livestock, whereas potential tenants may be rationed in their access to land and livestock through the rental market. This is due to the presence of moral

4.1.1. General model for asset-rich household

Households will rent out surplus land and livestock that they do not want to sell but cannot manage with their limited labor resources. They can rent out the land and livestock separately or jointly. We have assumed that land and livestock are complementary inputs in crop and livestock production. In addition, transaction costs are associated with establishing, monitoring, and enforcing rental contracts; however, a joint contract may increase returns and reduce such transaction costs. This requires the identification of a tenant partner that is trustworthy and in need of both land and livestock. If a productive potential tenant with limited land and livestock endowments is trustworthy but capital and credit-constrained, renting both land and livestock to this tenant may be optimal. This assertion is formalized subsequently.

Assume that the production function on rented land looks like this: $q_A^{ro}(A^{ro}, N^{ro}; l_A^t, A^t, N^t)$, with $\frac{\partial q_A^{ro}}{\partial A^{ro}} > 0$, $\frac{\partial q_A^{ro}}{\partial N^{ro}} \geq 0$, $\frac{\partial^2 q_A^{ro}}{\partial A^{ro} \partial N^{ro}} \geq 0$, with potential synergies involved in joint contracts and similarly in livestock contracts. Superscript t refers to the tenant. Assume that transaction costs related to land and livestock renting are nondecreasing (i.e., concave) functions of the amount of land and livestock that are rented out, and a joint contract reduces total transaction costs. This means

$$l_N^{ro} = l_N^{ro}(A^{ro}, N^{ro}); \quad l_A^{ro} = l_A^{ro}(A^{ro}, N^{ro})$$

and

$$\begin{aligned} \frac{\partial l_N^{ro}}{\partial N^{ro}} &\geq 0; \quad \frac{\partial l_A^{ro}}{\partial A^{ro}} \geq 0; \quad \frac{\partial^2 (l_N^{ro} + l_A^{ro})}{\partial A^{ro} \partial N^{ro}} < 0; \\ \frac{\partial l_N^{ro}}{\partial A^{ro}} &< 0; \quad \frac{\partial l_A^{ro}}{\partial N^{ro}} < 0, \end{aligned}$$

where l_N^{ro} and l_A^{ro} are transaction costs in the form of family labor related to renting out livestock and land. In all cases, superscripts ro, ri, and o refer to rent out, rent in, and own components of the corresponding variable, whereas the subscripts N and A refer to livestock and land, respectively.

Therefore, the general income maximization problem of the asset rich household is

$$\text{Max}_{\left\{ \begin{matrix} A^{ro}, N^{ro}, \\ l_A^{ro}, l_N^{ro}, \\ l_A^t, l_N^t \end{matrix} \right\}} Y = \left\{ \begin{aligned} &[P_A q_A(l_A^o, \bar{A} - A^{ro}, \bar{N} - N^{ro}) + (1 - \alpha) P_A q_A^{ro}(A^{ro}, N^{ro}; l_A^t, N^t, A^t) - w l_A^{ro}(A^{ro}, N^{ro})] \\ &+ [(P_N q_N(l_N^o, \bar{N} - N^{ro}, \bar{A} - A^{ro}) + (1 - \beta) P_N q_N^{ro}(N^{ro}, A^{ro}; l_N^t, N^t, A^t)) - w l_N^{ro}(N^{ro}, A^{ro})] \\ &- w(l_A^o + l_N^o) \end{aligned} \right\}, \tag{2}$$

hazards, monitoring, and supervision costs, and the predominance of share contracts (Bell and Sussangkarn, 1988; Dutta et al., 1989; Singh, 1989). Therefore, we will present two general models, i.e., one for a household that is wealthy in land and livestock (i.e., a high-caste household) and likely to rent out part of these endowments and one for a household that is poor in land and livestock endowments (i.e., low-caste household) and that may access these through the rental markets.

where $A^{ro} \geq 0$, $N^{ro} \geq 0$, $l_A^{ro} \geq 0$ and l_N^{ro} . Symbol α represents the output share of the tenant in the land rental market, and β represents the output share of the tenant in the livestock rental market. Variable P is the price of output, and w refers to the wages of labor.

The first-order conditions with respect to land and livestock rented out for a household that rents out both land and livestock are

$$-P_A \frac{\partial q_A}{\partial N^o} - P_N \frac{\partial q_N}{\partial N^o} + (1 - \alpha)P_A \frac{\partial q_A^{ro}}{\partial N^{ro}} + (1 - \beta)P_N \frac{\partial q_N^{ro}}{\partial N^{ro}} - w \left(\frac{\partial l_A^{ro}}{\partial N^{ro}} + \frac{\partial l_N^{ro}}{\partial N^{ro}} \right) \leq 0; \quad \perp N^{ro} \geq 0, \quad (2.1)$$

$$-P_A \frac{\partial q_A}{\partial A^o} - P_N \frac{\partial q_N}{\partial A^o} + (1 - \alpha)P_A \frac{\partial q_A^{ro}}{\partial A^{ro}} q_A^{ro} + (1 - \beta)P_N \frac{\partial q_N^{ro}}{\partial A^{ro}} - w \left(\frac{\partial l_A^{ro}}{\partial A^{ro}} + \frac{\partial l_N^{ro}}{\partial A^{ro}} \right) \leq 0; \quad \perp A^{ro} \geq 0. \quad (2.2)$$

These conditions demonstrate that in the case of interior solutions, more land and livestock are rented out as the marginal returns decrease for those under their own management, as the marginal productivities increase under rental management, as the shares of the output that the lord gets increase, and as the marginal transactions costs related to the rental contracts decrease. The cross derivatives, $\frac{\partial q_A^{ro}}{\partial N^{ro}}$ and $\frac{\partial q_N^{ro}}{\partial A^{ro}}$, are positive if the land and livestock are rented out to the same tenant who is poor in land and livestock; otherwise, they are zero. This favors renting both the land and livestock to the same tenant. The cross derivatives for the transaction costs, $\frac{\partial l_A^{ro}}{\partial N^{ro}}$ and $\frac{\partial l_N^{ro}}{\partial A^{ro}}$, are negative if the contracts are linked to the same tenant; otherwise, they are zero. This also favors joint contracts to reduce transaction costs.

4.2.2. General model for asset poor household

The tenants are offered incentive contracts based on sharing output. To further enhance their incentives, their contracts may be renewed after good performance, whereas bad performance can have long-term rationing out effects. This serves to prevent shirking and reduce or eliminate Marshallian disincentive effects due to output sharing. Assuming that the contract renewal in the second period depends on the performance in the first period, the income maximization problem for the asset poor household can be expressed as follows:

$$\text{Max}_{l_{A1}^o, l_{A1}^{ri}, l_{N1}^o, l_{N1}^{ri}} \text{EU}(Y) = \left\{ \text{EU}_1 \left[P_{A1}q_{A1}(l_{A1}^o, \bar{A}^o, \bar{N}^o) + \alpha P_{A1}q_{A1}^{ri}(l_{A1}^{ri}, \bar{A}^{ri}, \bar{N}^{ri}) + P_{N1}q_{N1}(l_{N1}^o, \bar{A}^o, \bar{N}^o) + \beta P_{N1}q_{N1}^{ri}(l_{N1}^{ri}, \bar{A}^{ri}, \bar{N}^{ri}) - wL \right] + \rho \{ \eta_A(q_{A1}^{ri})\text{EU}_2[\bar{A}^{ri}] - \eta_N(q_{N1}^{ri})\text{EU}_2[\bar{N}^{ri}] \} \right\}, \quad (3)$$

where $L = l_{A1}^o + l_{A1}^{ri} + l_{N1}^o + l_{N1}^{ri}$, $\bar{A}^{ri} \geq 0$, $\bar{N}^{ri} \geq 0$, $l_{A1}^{ri} \geq 0$, $l_{N1}^{ri} \geq 0$.

Subscripts 1 and 2 refer to period one and two, respectively. ρ refers to the discount factor given by $\rho = \frac{1}{1+\delta}$, and δ is the discount rate. Symbol η represents the probability of contract renewal for land and/or livestock contracts in period two and depends on the amount of output produced in period one, thereby creating incentives for tenants to be more efficient to counteract the disincentive effect of output sharing. Therefore, $\eta = \eta(q_{A1}^{ri}, q_{N1}^{ri})$; $\frac{\partial \eta}{\partial q_{A1}^{ri}} > 0$, $\frac{\partial \eta}{\partial q_{N1}^{ri}} > 0$.

This is demonstrated by inspecting the Kuhn–Tucker first-order conditions for tenants that rent in land, or livestock, or both

$$\frac{\partial q_{A1}^o}{\partial l_{A1}^o} - w = 0, \quad (3.1)$$

$$\frac{\partial q_{N1}^o}{\partial l_{N1}^o} - w = 0, \quad (3.2)$$

$$\frac{\partial \text{EU}_1}{\partial Y} \left(\frac{\partial q_{A1}^{ri}}{\partial l_{A1}^{ri}} - w \right) + \rho \left\{ \frac{\partial \eta_{A2}}{\partial q_{A1}^{ri}} \frac{\partial q_{A1}^{ri}}{\partial l_{A1}^{ri}} \text{EU}_2[\bar{A}^{ri}] \right\} \leq 0 \perp l_{A1}^{ri} \geq 0, \quad (3.3)$$

$$\frac{\partial \text{EU}_1}{\partial Y} \left(\frac{\partial q_{N1}^{ri}}{\partial l_{N1}^{ri}} - w \right) + \rho \left\{ \frac{\partial \eta_{N2}}{\partial q_{N1}^{ri}} \frac{\partial q_{N1}^{ri}}{\partial l_{N1}^{ri}} \text{EU}_2[\bar{N}^{ri}] \right\} \leq 0 \perp l_{N1}^{ri} \geq 0. \quad (3.4)$$

Equations (3.3) and (3.4) demonstrate that by working harder to increase their output from rented land and livestock, the tenants increase the probability of contract renewal. Tenants with sufficient labor to do this will prefer to do so. For this to be an efficient incentive device for landlords, tenants must have sufficient labor endowments and are rationed in their access to land and livestock. Kassie and Holden (2007) have demonstrated the relevance of the threat of eviction as an incentive device in land rental contracts.

Based on these analyses, the following hypotheses are derived:

- H1. Livestock- and land-rich high-caste households with better labor market access are more likely to rent out livestock (and land).
- H1a. Labor-poor households are more likely to rent out their livestock (+rent out more) and less likely to rent in livestock (+rent in less) than labor-rich households.

- H1b. Migration is positively correlated with renting out livestock (+rent out more) and negatively correlated with renting in livestock (+rent in less).

- H2. Land- and livestock-poor (low-caste) households rent in livestock.
- H2a. Credit constrained, low-caste households are more likely to rent in livestock (because they cannot afford to buy).
- H2b. Labor-rich, low-caste households are more likely to rent in livestock.

- H3. Livestock renting occurs as a complementary contract to a land rental contract.

4.2. Methods

Double hurdle models were chosen to identify the factors that influence the probability and level of participation in the livestock rental market by farm households. First, we tested censored Tobit models versus the double hurdle (i.e., Cragg) models for our data. The censored Tobit model assumes that the same mechanism determines the zeros, the positives, and the amount of the variable in question, given that the variable is positive (Cameron and Trivedi, 2009; Wooldridge, 2002). Therefore, in the censored Tobit model, a variable that increases or decreases the probability of participation in the livestock rental market also increases or decreases, respectively, the amount of livestock rented in or 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 the Cragg model, the first part corresponds to the household choice of whether to participate in the livestock rental market or not (i.e., probit model) and the second part corresponds to the extent of participation in the market given that the household has decided to participate (i.e., truncated regression model).

For comparison, we applied the likelihood ratio test because the Cragg model nests the censored Tobit model (Fin and Schmidt, 1984; Greene, 2003). The test led us to reject the censored Tobit model in favor of the Cragg model for both sides of the market. Empirical analyses also showed substantial differences between the variables affecting the likelihood to participate and the level of participation on each side of the market, thereby indicating the relevance of the double hurdle model. We then tested the Cragg model versus the Wooldridge model by using a Vong test as these two models are non-nested to each other (Vong, 1989). The Vong test is given by:

$$V = n^{-\frac{1}{2}} LR_n(\hat{\theta}_n, \hat{\gamma}_n) / \hat{\omega}_n \xrightarrow{D} N(0, 1),$$

where n refers to the number of observations, $LR_n(\hat{\theta}_n, \hat{\gamma}_n) \equiv L_n^f(\hat{\theta}_n) - L_n^g(\hat{\gamma}_n)$, is the likelihood ratio statistic for the model F_θ (i.e., for the Cragg model) against the model G_γ (i.e., for the Wooldridge model), and $\hat{\omega}_n^2 \equiv \frac{1}{n} \sum_{i=1}^n [\log \frac{f(Y_i|Z_i; \hat{\theta}_n)}{g(Y_i|Z_i; \hat{\gamma}_n)}]^2 - [\frac{1}{n} \sum_{i=1}^n \log \frac{f(Y_i|Z_i; \hat{\theta}_n)}{g(Y_i|Z_i; \hat{\gamma}_n)}]^2$. To select a model, we choose a critical value c from the standard normal distribution for a specified significance level, such as 2.58 (i.e., for 1%) and 1.96 (i.e., for 5%). If $V > c$, we reject the null hypothesis that the models are equivalent in favor of F_θ being better than G_γ . If $V < (-c)$, we reject the null hypothesis in favor of G_γ being better than F_θ . If $|V| \leq c$, then we cannot discriminate between the two competing models for this data (Vong, 1989).

In our analysis, the Vong test favored the Cragg model over the Wooldridge model for the demand side of the livestock rental market, but it did not discriminate between these two models for the supply side of the market. Therefore, we only present the results from the Cragg model. The log-likelihood for the Cragg model is

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

In addition to these models, we also tested for possible selection bias using the control function approach. For this method, we need a variable that determines participation but does not affect the degree of participation. We used the variable “number of adult males” in our case because this variable was found to affect participation decisions in the rental market but not in the degree of participation according to the Cragg model. We did not find any significant selection bias.

A bivariate-ordered probit model was used to test any possible association between livestock and land rental market participation. Both dependent variables, i.e., net livestock leased-in ($nlsli$) and net land leased-in (nli), were ordinal and offer three alternatives. In each rental market, a household can either rent-out, remain autarkic, 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

$$y_{1i}^* = \mathbf{x}'_{1i} \beta_1 + \varepsilon_{1i}$$

$$y_{2i}^* = \mathbf{x}'_{2i} \beta_2 + \gamma y_{1i}^* + \varepsilon_{2i},$$

where β_1 and β_2 are vectors of unknown parameters, γ is an unknown scalar, ε_1 and ε_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

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

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

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 the case of the 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 ε_{1i} and ε_{2i} are distributed normally, the system of equations is estimated by full-information maximum likelihood (Sajaia, 2008).

When estimating the econometric models stated previously, we included migration as if it were an exogenous variable. However, most economic models treat migration as an endogenous variable. Therefore, we looked for the possibility to overcome this problem of endogeneity by instrumenting for migration. However, we were not able to find any good instrument for it due to the limitations of the data. We considered using caste as an instrument, but caste also has other direct and indirect effects that made it unsuitable as an instrument; moreover, caste could not be left out in the second stage of the regressions. The caste variable was of primary interest in our analysis due to its effects on labor market participation and asset distribution, and therefore, also participation in other factor markets, such as the livestock and land rental markets. The same issue is of concern for the credit constraint variable, which was assumed to be important for poor low-caste households. In the absence of suitable instruments, we resorted to running the models with and without the credit constraint dummy variable.

5. Study area and data

Data for this study was collected in the western hills of Nepal in 2003. A total of 500 households from three villages (i.e., Lahachok, Rivan, and Lwang-Ghalel) were surveyed. This article utilizes, however, the information from 489 households because 11 households were dropped from the analysis due to some inconsistencies in their information. The settlements in the study area are located 15–45 km from the main city. Due to the poor roads and transportation networks, the area is not accessible by road during the rainy season, but a rough road links the central plain area called Khoramukh during the dry season. Because many of the settlements are on the hills, the people of these settlements have to walk two–six hours to reach the village market center at Khoramukh. Human labor is the common mode of transporting agricultural products to the market. Hills and mountains higher than 1,200 m are the major topographical feature of this region (Thapa and Weber, 1995).

Agriculture is the main economic activity in the study area. The integration of crop and livestock farming is a main characteristic of the farming system because livestock is essential not only for traction power but also for sustainable crop production through the use of their manure as fertilizer. This is one of the possible reasons that explain the integration of the land and livestock rental market decisions. Almost all of the households in the study area own livestock (Annapurna Conservation Area Project [ACAP], 1999). Buffaloes, cows, and oxen are the major large livestock found on these farms, whereas goats and sheep are the main small ruminants owned in this area. In addition, unlike the other types of livestock, oxen and cows are not sold for the purpose of meat consumption in Hindu society; therefore, the market for cows and oxen is limited outside the rural areas where agriculture is not the major activity. Resource poor farmers who cannot invest in cattle and buffalo usually prefer to engage sheep and goat husbandry.

Table 1
Major household characteristic by caste

Household characteristics variables	High caste	Low caste	All sample	Test
Male head dummy (%)	20	65	30	82.72***
Literate head (%)	35	19	31	10.40***
Age of household head (in year)	49	49	49	0.09
Ownership holding (in ha)	0.64	0.17	0.54	9.02***
Operational holding (in ha)	0.62	0.34	0.56	5.93***
Owned livestock (in TLU)	3.54	1.52	3.09	8.15***
Operated livestock (in TLU)	3.32	2.41	3.12	3.49***
Standard labor unit	3.81	3.98	3.85	0.85
Standard consumer unit	4.93	5.2	4.99	1.09
Farm income (in Rs.)	32,035	15,312	28,376	6.44***
Remittance income (in Rs.)	20,127	3,449	16,478	4.42***
Total income (in Rs.)	72,360	30,929	63,295	8.15***
Value of asset (in Rs.)	38,581	15,360	33,500	8.22***
Agricultural wage labor (unskilled) (%)	12.3	69.8	24.9	7.16***
Nonagricultural wage employment (unskilled) (%)	34.2	25.6	32.3	3.78***
Regular salary jobs (at least one member) (%)	41.3	9.2	26.6	5.71***
At least one member earning pension (%)	26.7	5.6	22.1	3.96***
At least one adult member migrated (%)	43	28	31	2.57***
Credit constrained (%)	38.7	74.5	47	43.58***
Number of sample households	382	107	489	

Notes: Test shows the difference between high-caste and low-caste households; *t*-test is used for continuous variables and chi-square test for categorical variables. Regular salary jobs include the jobs both in and outside the country. Livestock is measured as Tropical Livestock Unit (TLU). Significance levels: ***: 1% level.

Table 1 presents the major household characteristics according to caste. The differences between high-caste and low-caste households are highly significant in terms of income and major assets, such as land, livestock, and other household assets. Likewise, at least one member has migrated for 43% of the high-caste households, whereas only 28% of the low-caste households had any type of migration by its members. Furthermore, 41% of the high-caste households as compared to only 9% of the low-caste households have a member who is employed at a regular job.

Nearly 13% of the total sample households rented in livestock from others, whereas 11% rented out livestock. Cows, oxen, and buffaloes are the major livestock involved in rental transactions. Out of the total households that rented out livestock, 76% reported that they have rented out oxen to low-caste households, which is also related to labor contracts for plowing. Some high-caste households also have shared ownership of oxen because they need a pair of oxen to plow the land. Non-participation in the livestock rental market is higher than that of the land rental market, which possibly implies that there are larger transaction costs in the livestock rental market as compared to the land rental market (Binswanger and Rosenzweig, 1986). This is also depicted in a separate ranking of all sample

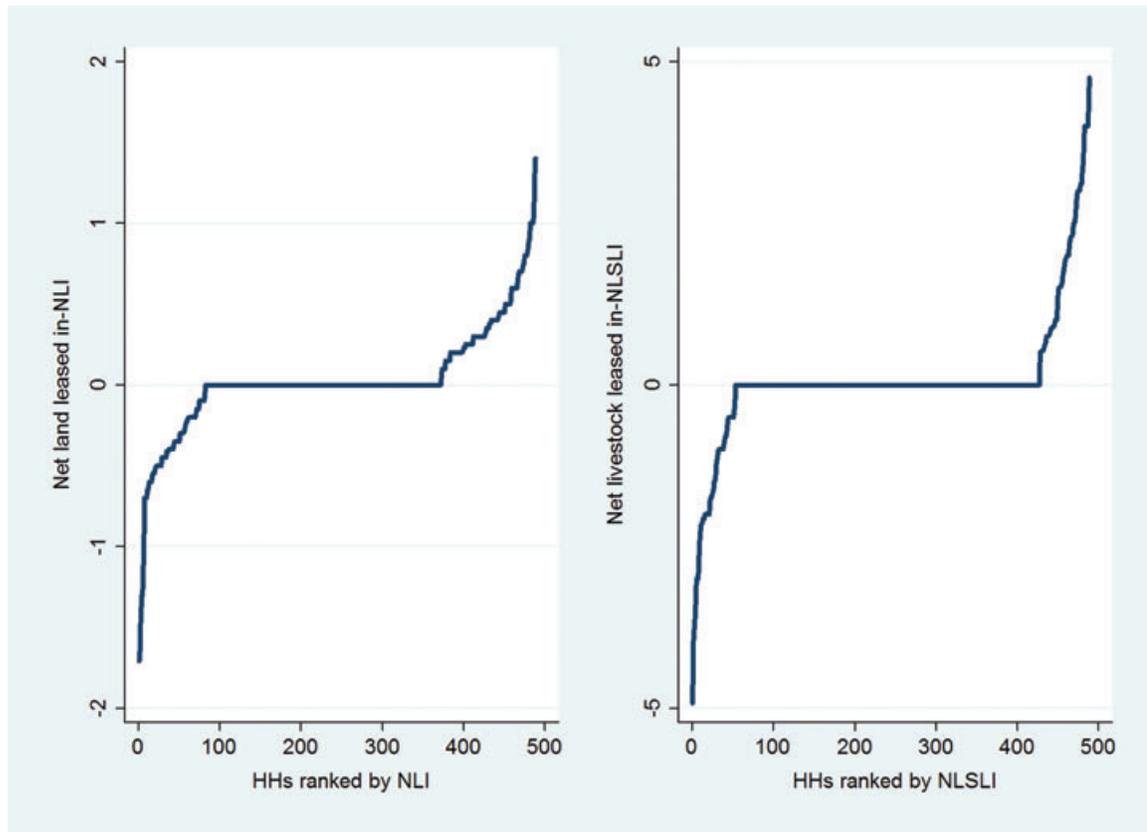


Fig. 1. Households ranked by net land leased in and net livestock leased in.

households on the basis of net land leased-in and net livestock leased-in (see Fig. 1).

Table 2 summarizes the livestock and land rental market participation for the sample households according to caste. According to Table 2, 31% of the households that rented in land have also rented in livestock. Likewise, 36% of the households that rented out land have also rented out livestock. None of the households that have rented out land were found to rent in livestock; similarly, none of the households that have rented in land were found to rent out livestock. Interestingly, 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, thereby supporting our first hypothesis. Out of the 30 households that rent out both land and livestock, 28 belong to high-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. Of the total households that rented in livestock, only 19% have at least one adult member who has migrated as compared to 89% for those households that rented out. A similar difference is observed between the households that are renting in and renting out land. Of the total households that rented in livestock,

66% were low-caste households, whereas only 7% of the low-caste households have rented out livestock. Differences with regard to male headship, caste, and migration are highly significant for the households that participated on each side of these markets. Likewise, differences in land ownership, operational land holdings, and family labor endowments were also significant across both markets. The average land ownership holding of the households that rent out livestock was 0.96 ha against 0.25 ha for those that rent in. Similarly, the differences in livestock ownership holdings were also significant; specifically, households renting out livestock owned 3.3 tropical livestock units (TLUs) versus 1.5 TLUs for those that rented in. Both the family labor endowment as measured in standard labor units and the labor endowment per unit land ownership holdings were significantly higher among the households that rented in land and those that rented in livestock, thereby indicating that much land and livestock has been transferred to farmers with larger family labor endowments. Of the total households that rented in both livestock and land, 63.4% have rented in from the same household.

In the case of land, the Gini coefficient for ownership holding was 0.46 as compared to 0.37 for operational holding. Similarly, for livestock, the Gini coefficient for ownership holding was 0.40 as compared to 0.38 for operational holding. Therefore, the rental markets for land and livestock contributed

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

Land	Livestock												Total
	Rent in				Owner operated				Rent out				
	High caste		Low caste		High caste		Low caste		High caste		Low caste		
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
Rent in	11	9	26	22	53	45	27	23	0	0	0	0	117
Owner operated	10	3	15	5	208	72	31	11	24	8	2	0.7	290
Rent out	0	0	0	0	48	59	4	5	28	34	2	2	82
Total	21	34	41	66	305	83	62	17	52	93	4	7	489

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

Variables	Land			Livestock		
	Rent in	Rent out	Test	Rent in	Rent out	Test
Male head (%)	39.4	25.6	4.1**	43.6	28.6	2.9*
Literate (%)	26.5	35.4	1.8	22.6	33.9	1.9
Low caste (%)	45.3	7.3	33.3***	66.2	7.1	43.4***
At least one adult member migrated (%)	26.5	71.9	40.2***	19.4	89.3	57.7***
Age of household head (years)	49	51	1.1	48	50	0.99
Owned land (ha)	0.21	1.04	16.8***	0.25	0.96	8.1***
Family labor endowment	5	3.6	5.1***	4.2	3.5	2.1**
Family labor endowment/Owned land	24.8	3.6	10.6***	18.2	4.3	7.2***
Operated land (ha)	0.6	0.59	0.13	0.48	0.73	2.9**
Family labor endowment/Operated land	10.2	8.4	2.14**	11.9	6.8	2.6***
Family labor endowment/Own livestock	4.6	1.4	3.14***	5.6	1.2	3.1***
Family labor endowment/Operated livestock	3.1	3.3	0.36	1.3	8.9	4.4***
Own livestock (in TLU)	2.4	3.8	4.4***	1.5	3.3	8.8***
Own livestock/Owned land	11.4	3.9	5.3***	5.4	3.9	2.5***
Own livestock/Operated land	4.9	9.2	4.1***	3.9	6.2	3.1***
Operated livestock (in TLU)	3.1	3.1	0.96	3.4	1.2	10.7***
Operated livestock/Owned land	15.6	3.3	7.7***	15.4	1.4	9.1***
Operated livestock/Operated land	6.9	7.9	0.94	11.1	2.2	7.5***
Number of observations	117	82		62	56	

Note: Test for significance of difference between those renting in and renting out land and livestock (*t*-test for continuous variables and chi-square test for categorical variables). Family labor endowment is measured as Standard labor units (SLU). Livestock is measured in Tropical Livestock Unit (TLU).

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

to a more egalitarian distribution of these resources across households.

6. Results and discussions

6.1. Participation in the livestock rental market

Table 4 presents the results of the double hurdle models for both sides of the livestock rental market. Hypothesis H1 claimed that livestock and land-rich, high-caste households with better market access are more likely to rent out both land and livestock. To test this hypothesis empirically, we put forth two sub-hypotheses. Our results show that hypothesis H1a, which stated that labor-poor households are more likely to rent out livestock (+rent out more) and less likely to rent in livestock (+rent in less), cannot be rejected because households with a higher male labor endowment were found to be less likely

to rent out and more likely to rent in. Similarly, households with a higher female labor endowment rented out less livestock. Land ownership holding was positively associated with the likelihood of renting out livestock, but this negatively affected the amount rented out. This indicates a complementary relationship between land and livestock inputs in rural farming (i.e., less labor-intensive feeding regimes may be feasible when there is more land). Based on the results, hypothesis H1b (i.e., migration is positively correlated with renting out livestock (+rent out more) and negatively correlated with renting in livestock (+rent in less) cannot be rejected because the migration dummy variable was highly significant for both sides of the livestock rental market. Migration was found to have positive effect on the likelihood to rent out livestock and the amount rented out, whereas a negative association was observed between migration and the likelihood to rent in livestock as well as the amount rented in. The caste dummy variable was not found to have a significant additional effect on the probability

Table 4
Analysis of livestock rental market participation

	Renting in (Yes = 1)		Renting out (Yes = 1)	
	Probit	Truncreg	Probit	Truncreg
Caste dummy: low(1)	1.045*** (0.252)	0.863** (0.391)	−0.381 (0.370)	−0.857* (0.488)
Value of Asset (In Rs.)	0.007 (0.004)	0.002 (0.007)	−0.010** (0.004)	0.012** (0.006)
Owned livestock (in TLU)	−0.227*** (0.071)	−0.374** (0.156)	−0.046 (0.047)	0.511*** (0.092)
Owned land holding (ha)	0.357 (0.292)	0.445 (0.545)	1.000*** (0.192)	−0.483** (0.190)
Age of hh head (years)	−0.006 (0.009)	0.021* (0.011)	0.011 (0.009)	−0.005 (0.011)
Sex head dummy: male(1)	−0.154 (0.233)	−0.209 (0.255)	0.003 (0.229)	−0.066 (0.286)
Number of adult males	0.189** (0.083)	0.109 (0.108)	−0.212** (0.100)	−0.056 (0.114)
Number of adult females	−0.154 (0.104)	−0.126 (0.139)	−0.032 (0.104)	−0.315** (0.147)
Migration dummy: 1 (yes)	−0.406* (0.222)	−0.652** (0.300)	1.731*** (0.252)	1.048*** (0.366)
Credit constrained: Yes(1)	1.235*** (0.271)	0.411 (0.590)		
Constant	−1.842*** (0.554)	0.602 (1.073)	−2.410*** (0.518)	0.478 (0.649)
Sigma Constant		0.844*** (0.076)		0.756*** (0.071)
Wald Chi-square	114.36	57.13	105.321	57.010
Number of observations	433	62	427	56
Test	Renting in		Renting out	
LR test (Cragg vs. Tobit model)	LR chi2 = 22.3 Prob > chi2 = 0.0014 Cragg is preferred to Tobit		LR chi2 = 55.53 Prob > chi2 = 0.000 Cragg is preferred to Tobit	
Young test (Wooldridge vs. Tobit model)	V = 3.13; c = 2.58 V > c → Wooldridge is Preferred to Tobit		V = 3.03; c = 2.58 V > c → Wooldridge is Preferred to Tobit	
Young test (Cragg vs. Wooldridge model)	V = 2.68; c = 2.58 V > c → Cragg is Preferred to Wooldridge		V = 1.94; c = 2.58 V > c → not discriminate between two models	

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

to rent out livestock, thereby implying that inequality in asset endowments and market access, which are closely associated with caste in our case, determine the participation in the supply side of the livestock rental market rather than more direct and separate caste effects.

Given that low-caste households are often discriminated against in the regular nonagricultural job market, they rely more on the agricultural sector for employment. Furthermore, high-caste households consider plowing the land with oxen as an inferior job; consequently, such caste-related labor restrictions might have favored low-caste households in terms of renting livestock and land. This might indicate why caste membership remains highly significant even after controlling for possible factors that represent inequalities in resource endowments and market access between these two groups, such as land, livestock, family labor endowments, migration, and credit constraints.

However, the inclusion of the migration dummy variable in the empirical analysis does not fully control for labor market access. The caste dummy variable may also capture other omitted variables correlated with caste.

Hypothesis H2 stated that land and livestock-poor (low-caste) households rent in livestock (and land). Our empirical analysis as illustrated in Table 4 does not allow us to reject this hypothesis because low-caste households were significantly more likely to rent in livestock and rented in more as compared to high-caste households. Likewise, credit constrained households were found to have significantly higher likelihood of renting in livestock, thereby implying that hypothesis H2a (i.e., credit constrained low-caste households are more likely to rent in livestock) cannot be rejected. Hypothesis H2b cannot be rejected partially because the male labor endowment was significantly positively correlated with the likelihood to rent in livestock.

Finally, low-caste households were significantly more likely to rent in livestock and rented in significantly more livestock than high-caste households after controlling for differences in asset endowments. These results might also be associated with the practice of the *Haliya* (i.e., bonded labor) system as nearly 74% of the low-caste households have worked as permanently attached *Haliya* labor. Such manual labor with livestock may still be perceived as inferior by high-caste households. This could be one of the possible reasons that explain why low-caste households are more likely to rent in livestock. In addition, less access to credit, poverty, and liquidity constraints created incentives to rent in livestock, which is a lumpy asset, thereby making renting a good option to reduce the up-front costs associated with accessing livestock.

6.2. Association between livestock and land rental market participation

Table 5 provides the results of the analysis of the association between participation in both the livestock and land rental markets. In the absence of good instruments to measure access to credit, we estimated the models with and without the credit constraint dummy variable.

Table 5
Analysis of association between land and livestock rental markets participation

Market participation ¹	Bivariate ordered probit models			
	Without credit constraint		With credit constraint	
	Livestock	Land	Livestock	Land
Caste dummy: low(1)	0.908*** (0.207)	0.267 (0.200)	0.910*** (0.207)	0.252 (0.198)
Value of Assets (In Rs.)	0.005** (0.002)	0.003 (0.003)	0.008*** (0.003)	0.004 (0.003)
Owned livestock (In TLU)	-0.052** (0.021)	-0.045* (0.026)	-0.029 (0.023)	-0.034 (0.026)
Owned land holding (ha)	-0.719*** (0.128)	-1.367*** (0.302)	-0.449*** (0.146)	-1.233*** (0.307)
Age of household head (years)	-0.008 (0.006)	-0.011** (0.005)	-0.009 (0.006)	-0.012** (0.005)
Sex head dummy: male(1)	-0.040 (0.154)	0.234 (0.143)	-0.047 (0.158)	0.233 (0.144)
Number of adult male	0.169*** (0.055)	0.403*** (0.057)	0.177*** (0.056)	0.406*** (0.057)
Number of adult female	-0.060 (0.061)	-0.017 (0.062)	-0.060 (0.064)	-0.015 (0.063)
Migration dummy: 1 (yes)	-1.070*** (0.157)	-0.809*** (0.125)	-0.985*** (0.160)	-0.736*** (0.129)
Credit constrained: 1 (yes)			0.996*** (0.192)	0.406** (0.158)
Constant (<i>Athrho</i>) ²		0.373*** (0.077)		0.338*** (0.081)
Wald Chi-square		145.24***		136.25***
Wald test of independence of equations		23.68***		17.53***
Number of observations		489		489

1. Dependent variable: Rent out = 1; Nonparticipation = 2, and Rent in = 3.

2. $Athrho = \frac{1}{2} \ln\left(\frac{1+\rho}{1-\rho}\right)$, where $\rho = \text{corr}(u_1, u_2)$; $u_1 \xrightarrow{D} N(0, \sigma)$ and $u_2 \xrightarrow{D} N(0, 1)$.
Significance levels: *: 10% level, **: 5% level, ***: 1% level.

Hypothesis H3 (i.e., livestock renting occurs as a complementary contract to a land rental contract) was tested by assessing the correlation between the decisions to participate in the land and livestock rental markets after controlling for differences in endowments and caste. The variable *Athrho* in Table 5 indicates a highly significant positive correlation between the errors in the two ordered probit models, and this high level of significance did not change when we controlled for access to credit. Therefore, hypothesis H3 cannot be rejected. This implies that a household that is renting in land is also more likely to rent in livestock and vice versa; in addition, a household that rents out land is also more likely to rent out livestock and vice versa. Hence, the rental decisions are positively inter-related. This is consistent with the theory of production complementarities and the transaction cost reducing effects of joint contracts. A Wald test of the independence of equations in Table 5 also supported that these decisions are interrelated as the test cannot accept the null hypothesis that the decisions are independent.

Results show that low-caste households were significantly more likely to rent in livestock as compared to high-caste households after controlling for other differences in endowments, but this was not the case for land rental. One possible reason for the observation of no significant effect of caste on renting out

land could be tenure insecurity caused by the land-to-the-tiller policy, which may cause some high-caste households to prefer to rent out their land to other high-caste households even though these households are less productive (Aryal and Holden, 2010). Male labor endowment, young head of household, less migration, and asset poverty (i.e., land and livestock) were found to be important variables that are positively related to the decisions to rent in and negatively related to renting out livestock and land. The inclusion of the credit constraint dummy variable did not affect the results much but indicated that credit constrained households were more likely to be on the renting in side and less likely to be on the renting out side of the rental markets for livestock and land.

7. Conclusions

Although rental markets are the only market for labor due to the national prohibition of slavery and a very common form of market for land, they are uncommon for livestock due to the fragility and mobility of livestock. Therefore, we examined the rationale for the existence of a livestock rental market in western Nepal with a focus on the predominant caste differentiation in that area.

The positive association between household decisions to participate in the land rental and livestock rental markets were indicative of the complementarities between these factors of production in hill agriculture; thus, policies targeted to enhance land productivity should also consider livestock management as a crucial issue. As most of the households that rented in land and livestock did so from the same landlord, this indicates that these sorts of interlinked contracts may emerge as a strategy to reduce transaction costs for the households in both markets.

The results from the analysis have several important policy implications. Firstly, credit-constrained land- and livestock-poor low-caste households are able to access additional land and livestock resources through these rental markets, which therefore help them overcome their financial constraints. Aryal and Holden (2011) have shown that low-caste households in Nepal have higher land productivity than high-caste households and although sharecropping is the dominant contract form they did not find any significant Marshallian inefficiency associated with the sharecropping contracts of low-caste households. Therefore these rental contracts both enhance equity and efficiency in a setting where the traditional land-to-the-tiller policy has not been very successful in redistributing land to the land-poor. They also found that land-poor low-caste households were severely constrained (rationed) in their access to land in the land rental market. This is a likely effect of the land-to-the-tiller policy which has enhanced the tenure insecurity of land owners. A removal of the land-to-the-tiller policy could improve the functioning of land and livestock rental markets and this could be a more efficient policy to enhance both equity and efficiency of land use by making land owners less reluctant to rent out their land. A land bank that provides credit to land-poor house-

holds for purchase of land and livestock may be a better policy for land-poor low-caste households to obtain land from willing sellers. Credit services for livestock may also be helpful for credit-constrained poor households. Such a credit program is not likely to materialize and become sustainable unless low-caste households can obtain longer-term land rental contracts or are able to buy their own land.

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