Pastoralist Economic Behavior: Empirical Results from Reindeer Herders in Northern Sweden

Göran Bostedt

This paper presents a model of pastoralists, as illustrated by reindeer herders, together with an analysis based on a cross-sectional data set on Swedish reindeer-herding Saami. The intrinsic utility of being an active reindeer herder plays an important role in determining supply. Results show this can lead to unconventional supply responses among pastoralists, and suggest that the probability of a backward-bending supply response increases with stock size. Further analyses confirm that reindeer herders with backward-bending supply curves have significantly larger herds than herders with conventional supply responses. Relaxed externalities from forestry would cause most herders to increase their slaughter.

Key words: backward-bending supply, externalities, pastoralist, reindeer husbandry

Introduction

Pastoralism can be defined as a subsistence system in which a group of people make their living by tending herds of large herbivores, found in various parts of the world (O'Neil, 2002). Pastoralists are usually distinguished from (for example) cattle farmers by certain features, all of which may not be present for certain pastoralists. These characteristics include:

- *Natural Pastures.* This feature is perhaps the most important (Salzman, 1996), and implies that pastoralists usually have access to free and natural grazing resources, although the abundance is limited and generally difficult to control. Pastoralism is therefore often an adaptation to natural conditions, which for certain reasons (such as arid or cold climates) may not be suitable for farming (Barfield, 1997). Consequently, one simply does not observe high-density, sedentary populations of pastoralists, since any land capable of supporting these animal herds is devoted to agriculture.

- *Subsistence.* This term indicates that many pastoralists raise their animals both for direct consumption as well as for exchange value, although the level of interaction with the market economy varies.

■ *Indigenous Peoples.* Pastoralism is mainly practiced by people who are regarded as indigenous because of their descent from the populations who inhabited the country (or a geographical region to which the country belongs) at the time of conquest or colonization or the establishment of present state boundaries. Pastoralists usually also retain some or all of their own social, economic, cultural, and political institutions, irrespective of their legal status. Well-known pastoralist societies include the Maasai and the Bedouins in Africa, the Mongols and ethnic Tibetans in Asia, and the Saami in northern Scandinavia and Russia (O'Neil, 2002).

Despite low profitability, many pastoralists are reluctant to give up animal herding altogether, due to the cultural identity connected with the activity. The close relationship with their animals is actually an important characteristic of pastoralists. The identity of pastoralists is in many cases based on the close association with their livestock that forms a key component of their social and ritual life—suggesting most pastoralists have other objectives beyond profit or income maximization. This feature, in combination with the limited and sensitive grazing resources and other special circumstances surrounding the pastoralist way of life, makes modeling and empirical analyses of the pastoralist economic behavior an interesting challenge. Yet, few economic studies focusing exclusively on pastoralists have been conducted. Among the exceptions are the theoretical papers by Livingstone (1986), who addresses the common property problem, and Skonhoft (1999), who compares a standard profit-maximization model with a stock-maximizing model. Scarpa et al. (2003) conducted one of the few empirical studies, using choice experiments and hedonic data to compare value estimates for cattle attributes among the Maasai in Kenya. Although interesting in their own right, these studies provide no empirical data on the individual behavior and preferences of the pastoralist.

The Saami, northern Scandinavia's and Russia's indigenous people, practice a form of transhumance pastoralism[1] (e.g., Borgerhoff Mulder and Sellen, 1994), involving the reindeer (*Rangifer tarandus*). In Sweden, reindeer husbandry is an exclusive right for the Saami, and the reindeer has been domesticated by the Saami for at least as long as there is written evidence (the oldest documents date from about 880 AD). As of 2001, there were approximately 220,000 reindeer in Sweden, owned by about 4,500 reindeer herders,[2] all of whom belong to one of the 51 Swedish Saami villages (Swedish National Board of Agriculture, 2002). Although the reindeer herders of today use modern equipment such as snowmobiles and mobile slaughterhouses, the basics of reindeer husbandry have changed fairly little over the centuries. The reindeer are allowed, with some exceptions, to follow their yearly cycle and search for natural grazing grounds, permitting grazing grounds to replenish themselves as the reindeer move from the high mountains to the coast and back again. Thus, reindeer husbandry requires large areas. In Sweden, the Reindeer Husbandry Act gives the Saami the right to let their reindeer graze on, for instance, private forestland. In total, the Saami have grazing rights on about 40% of the Swedish land area.

---

[1] Transhumance pastoralists follow a cyclical pattern of migrations that usually take them from cooler, high altitude areas in the summer to warmer lowland areas in the winter. Because transhumance pastoralists generally depend somewhat less on their animals for food than nomadic pastoralists, they are thus more likely to sell the offtake in the market.

[2] This number includes approximately 1,000 concession reindeer herders who, by special government permit, practice reindeer husbandry outside the traditional reindeer herding area.

Approximately 75% of the forest area in the three northernmost counties in Sweden is used for winter grazing of reindeer (Eriksson, Sandewall, and Wilhelmsson, 1987). The primary food source during winter is lichen, which mainly grows on the ground (e.g., *Cladina rangiferina*), and on trees (e.g., *Alectoria sarmentosa* and *Bryoria fuscescens*). Because other food sources are scarce, lichen availability in winter is a critical factor for reindeer survival (Gustavsson, 1989; Skogland, 1986; Virtala, 1992). In winter, ground lichen in a clearcut area may be completely inaccessible due to snow cover, leaving tree lichen as the only means of sustenance for the herds. However, as reported by Essen, Renhorn, and Pettersson (1996), spruce trees must be older than 80–100 years to support high tree lichen mass. A forest in northern Sweden is typically clearcut after 80–120 years, creating a scarcity of older forest stands (Bernes, 1996). Thus, by affecting winter grazing resources, harvesting older stands for timber production imposes a negative unidirectional externality on reindeer husbandry.

Even if only a minority of the approximately 20,000 Swedish Saami (the total number depends on how the ethnic group is defined) today are active reindeer herders, the importance of reindeer husbandry for the Saami culture can hardly be overemphasized (Riksdagens Revisorer, 1996). Most Saami have family members or other relatives who are reindeer owners, making the reindeer an integral part of the Saami way of life. The Swedish government, both in official statements and through different types of subsidies and compensations, has also emphasized the importance of reindeer husbandry as a cornerstone in the Saami culture.

Using a developed version of the dynamic economic model of a pastoralist (as presented in Bostedt, 2001), the objective of this study is to empirically analyze a unique cross-sectional data set on the preferences of the Swedish reindeer herding Saami community. The remainder of the paper proceeds as follows. In the theoretical section, a dynamic model is presented for a reindeer herder who might have other objectives in addition to profit maximization, leading to testable hypotheses about the reindeer herder's supply of slaughtered reindeer. Here, the intrinsic utility of being an active reindeer herder plays an important role in determining supply. An analysis of the cross-sectional data set is then provided in the empirical section. This data set is based on a survey of Swedish reindeer herders by Statistics Sweden, and the analysis is conducted with a focus on supply effects of changes in prices and externalities from forestry. Some concluding remarks are offered in the final section.

The Pastoralist Model

The Utility Maximization Problem

The theoretical model presented here draws on the model developed by Bostedt (2001), which in turn has connections to other models of agricultural households (e.g., Singh, Squire, and Strauss, 1986), as well as models of self-employed forest owners (e.g., Johansson and Löfgren, 1985, chapter 7). The basis for the analysis is a utility-maximizing pastoralist, such as a reindeer herder, who decides upon private consumption (C), the size of his/her herd of livestock, e.g., reindeer in the case of the Saami (R), and the time devoted to work unrelated to the livestock (l_2).

Assume that the pastoralist maximizes a utility function of the form $U[C, R]$, where $\partial U/\partial R > 0$ can be seen as an expression of the pleasure derived from being an active

reindeer herder (which is increasing in R). The livestock argument is included in the utility function to represent the notion that the herd of livestock provides an intrinsic utility of its own for an active pastoralist. Several government reports in Sweden (e.g., Riksdagens Revisorer, 1996; Swedish Ministry of Finance, 1998) have noted the low profitability among Swedish reindeer herding companies. Yet, these companies persist despite the financial disadvantages—emphasizing the point discussed earlier that the cultural importance of reindeer husbandry clearly extends beyond its value as merely a source of income.

Essentially, the utility function states that the pastoralist values private consumption and being an active herder, as represented by the size of the herd. This formulation can be regarded as a form of middle-ground between a pure profit-maximization model, which ignores the intrinsic utility provided by the herd, and the likewise extreme stock-maximization model suggested by Skonhoft (1999), which does not include consumption as a maximand. Means for private consumption (C) come from two sources: profits from herding, $\pi(h, R)$, and labor income from work unrelated to the livestock, l_2, which is paid with the wage rate, w. Specifically:

$$(1) \qquad C = \pi(h, R) + wl_2,$$

where h is the number of slaughtered animals.[3] Since most reindeer herding companies are small, price-taking behavior is a reasonable assumption. The formulation in (1) implicitly assumes some market exchange in meat, so that when slaughtered animals are retained for personal consumption they are withheld from this market, and thus "sold" to the herder's family.

The pastoralist's livestock not only entails management costs, it also takes time. One basis for the pastoralist model is that pastoralists can obtain all, or part, of their income from the livestock they own. Using Swedish reindeer herders as an example, the Swedish National Board of Agriculture (1998) states that a reindeer herding family company requires more than 400 reindeer for the family to be able to receive its livelihood completely from its reindeer husbandry. With about 220,000 reindeer and 915 reindeer herding companies in 2001 (Swedish National Board of Agriculture, 2002), the average number of reindeer per company is only 240 animals. Furthermore, according to an income survey in a report prepared for the Swedish Parliament Auditors (Riksdagens Revisorer, 1996), the average reindeer-herder household received only 19% of its income from reindeer herding. This means that alternative sources of income are important for most reindeer herders and influence how much time should be devoted to the reindeer herding company. This holds true for other types of pastoralists as well, as evidenced by the fact that the Maasai are increasingly engaged in the tourism industry in Kenya and Tanzania, while the Bedouin often are recruited into the armed forces of their countries where they are especially valued as scouts and trackers. A large livestock herd takes a great deal of time to manage (rounding up the animals for branding or slaughter, moving them from winter to summer grazing grounds, etc.). However, high prices on meat make the tradeoff between the pastoralist lifestyle and other occupational alternatives more advantageous for the former.

---

[3] This formulation does not distinguish between adult animals and calves; i.e., h represents a standardized animal, assuming a constant share of calves.

Time used for work unrelated to the livestock (l_2) is defined as total time minus time allocated to work managing the livestock herd (including rounding up animals, branding, and slaughtering), i.e.:

$$(2) \qquad\qquad l_2 = \overline{T} - l_1(R),$$

where $\overline{T}$ is total time (leisure time is assumed to be fixed and already excluded), and $l_1(R)$ is a function determining the time to manage the livestock as a function of the herd size. The reason why time allocated to managing the livestock herd is a function of the herd size is that a large reindeer herd takes a great deal of time to manage; thus, it would be unreasonable to assume a reindeer herder with a large herd would not allocate this time. However, economies of scale are assumed to exist, so that $\partial l_1(R)/\partial R > 0$, while $\partial^2 l_1(R)/\partial R^2 < 0$. The question of empirical verification of this assumption will be addressed in a later section.

Consequently, based on preferences for consumption and the intrinsic utility of being an active pastoralist (represented by the stock of reindeer), the reindeer herder simultaneously decides upon whether to work outside of reindeer husbandry (and if so, how much) and how many reindeer to slaughter—which in turn affects consumption, the livestock, and the time that must be allocated to livestock management. Inserting (1) and (2) into the utility function gives:

$$(3) \qquad\qquad U = U\left[\left(\pi(h, R) + w(\overline{T} - l_1(R))\right), R\right].$$

Livestock growth is assumed to be a continuous function of the stock (R) and the grazing resource, i.e., lichen (L) in the case of reindeer, minus the number of slaughtered animals (h):

$$(4) \qquad\qquad \dot{R} = f(R, L) - h,$$

where $f(R, L)$ is the natural growth function for the livestock stock. This function is assumed to have the usual features of a compensatory growth function, i.e., $f(R, L) = 0$ when $R = 0$ and at the carrying capacity. The derivative with respect to the stock is written as $\partial f(R, L)/\partial R = f_R = 0$ at some maximum sustainable yield stock, while the second derivative is specified as $\partial^2 f(R, L)/\partial R^2 = f_{RR} < 0$ (see Clark, 1990). The size of the carrying capacity stock is assumed to depend on available grazing resources, such as lichen in the case of reindeer. Lichen is not fixed, but is regarded as exogenous in the growth function from the perspective of the individual reindeer herder. This is due partly to the fact that we are considering one representative reindeer herder with a negligible effect on the communal grazing resource, and partly due to the important negative externalities caused by forestry (e.g., Parks, Bostedt, and Kriström, 2002; Bostedt, Parks, and Boman, 2003). Thus, the individual reindeer herder does not exercise control of the lichen resource.

Maximizing the present value of an infinite[4] stream of utilities with respect to the two controls $(h$ and $l_2)$, and where r is the discount rate, subject to the restriction given by (4), gives the following current-valued Hamiltonian:

---

[4] Maximizing to infinity is strictly speaking not correct, but is used for convenience. A more precise objective would involve maximizing over expected life and including a bequest value for heirs. Such an objective function would complicate the analysis and provide limited additional analytical insights.

(5)
$$H = U\big[\big(\pi(h, R) + w(\overline{T} - l_1(R))\big), R\big] + \lambda\big[f(R, L) - h\big].$$

First-Order Conditions

The optimum levels of h and l_2 and the steady-state equilibrium may be determined from the necessary conditions of the Hamiltonian in (5):

(6a)
$$\frac{\partial H}{\partial h} = \frac{\partial U}{\partial C}\frac{\partial C}{\partial \pi}\frac{\partial \pi}{\partial h} - \lambda = 0$$

and

(6b)
$$-\frac{\partial H}{\partial R} = \dot{\lambda} - r\lambda = -\frac{\partial U}{\partial C}\frac{\partial C}{\partial \pi}\frac{\partial \pi}{\partial R} + \frac{\partial U}{\partial C}w\frac{\partial l_1}{\partial R} - \frac{\partial U}{\partial R} - \lambda\frac{\partial f(R, L)}{\partial R}.$$

The partial derivative with respect to the harvest states that the marginal benefit of harvest (which increases private consumption in the utility function) must be weighed against the effects of harvest on the stock through the shadow price on the growth constraint, λ. The co-state equation in (6b) can perhaps be more easily interpreted if rewritten as $r - \dot{\lambda}/\lambda = f_R + U_R/\lambda$. Here, the left-hand side can be described as the "own rate" of interest for the stock R, a rate which is not observable in the marketplace (Hartwick, 2001), and which must be equal to the marginal rate of growth on this stock plus the marginal utility of increasing the stock divided by the shadow price on the growth constraint.

Steady-State Solution

To analyze the solution to the optimal harvesting problem, we must determine the properties of the steady-state solution. To do this, set $\dot{\lambda} = 0$ and $\dot{R} = 0$. Using (6a) to cancel out λ gives a steady-state solution, which is defined by:

(7)
$$r\left[\frac{\partial U}{\partial C}\frac{\partial C}{\partial \pi}\frac{\partial \pi}{\partial h}\right] = \frac{\partial U}{\partial C}\frac{\partial C}{\partial \pi}\frac{\partial \pi}{\partial R} - \left[\frac{\partial U}{\partial C}w\right]\frac{\partial l_1}{\partial R} + \frac{\partial U}{\partial R} + \left[\frac{\partial U}{\partial C}\frac{\partial C}{\partial \pi}\frac{\partial \pi}{\partial h}\right]\frac{\partial f}{\partial R}.$$

Dividing through with the marginal utility of consumption $\partial U/\partial C$ gives:

(8)
$$r\left[\frac{\partial C}{\partial \pi}\frac{\partial \pi}{\partial h}\right] = \frac{\partial C}{\partial \pi}\frac{\partial \pi}{\partial R} - w\frac{\partial l_1}{\partial R} + \frac{\partial U/\partial R}{\partial U/\partial C} + \left[\frac{\partial C}{\partial \pi}\frac{\partial \pi}{\partial h}\right]\frac{\partial f}{\partial R}.$$

Since from (1), $\partial C/\partial \pi = 1$, we have the equilibrium condition:

(9)
$$F = \left(r - \frac{\partial f}{\partial R}\right)\frac{\partial \pi}{\partial h} - \frac{\partial \pi}{\partial R} + w\frac{\partial l_1}{\partial R} - \frac{\partial U/\partial R}{\partial U/\partial C} = 0.$$

Functional Forms

To obtain more unequivocal results, assume the following specific functional forms:

(10)
$$U = C^\alpha R^{1-\alpha},$$

where $0 < \alpha < 1$. This Cobb-Douglas functional form makes R an essential good, reflecting the actual situation (refer to table 2, presented later). The parameter α is a taste parameter representing the individual taste for private consumption. Furthermore, it is assumed:

$$\text{(11)} \qquad \pi(h, R) = ph - c_R(R),$$

where p is the price per slaughtered animal net of slaughtering cost, and where the management cost for reindeer, $c_R(R)$ is increasing in R.

From (10) and (11), we obtain:

$$\text{(12)} \qquad \frac{\partial \pi}{\partial h} = p,$$

$$\text{(13)} \qquad \frac{\partial \pi}{\partial R} = -\frac{\partial c_R(R)}{\partial R},$$

$$\text{(14)} \qquad \frac{\partial U/\partial R}{\partial U/\partial C} = \frac{1 - \alpha}{\alpha R}\left(ph - c_R(R) + wl_2\right),$$

giving the following specific form of (9):

$$\text{(15)} \qquad F = \left(r - \frac{\partial f}{\partial R}\right)p + \frac{\partial c_R(R)}{\partial R} + w\frac{\partial l_1}{\partial R} - \frac{1 - \alpha}{\alpha R}\left(ph - c_R(R) + wl_2\right) = 0.$$

Comparative Statics

The steady-state solution (15) has four exogenous variables: p, w, L, and r. It is reasonable to assume regional and even individual variation in the first three, since prices of reindeer meat may vary, wages in alternative occupations may depend on the labor market situation as well as on individual skills, and the lichen density may vary due to natural geographical conditions and regional variation in the intensity of forestry. Marginal changes in harvesting can now be analyzed from marginal changes in these exogenous variables.

We first derive the following partial derivatives of (15):

$$\text{(16)} \qquad \frac{\partial F}{\partial h} = -p\frac{1 - \alpha}{\alpha R},$$

$$\text{(17)} \qquad \frac{\partial F}{\partial p} = r - \frac{\partial f(R, L)}{\partial R} - h\frac{1 - \alpha}{\alpha R},$$

$$\text{(18)} \qquad \frac{\partial F}{\partial L} = -p\frac{\partial^2 f(R, L)}{\partial R \partial L},$$

$$\text{(19)} \qquad \frac{\partial F}{\partial w} = \frac{\partial l_1}{\partial R} - l_2\frac{1 - \alpha}{\alpha R}.$$

Using (16) and (17), together with the fact that $f(R, L) = h$ in steady-state, and totally differentiating gives:

$$(20) \qquad \frac{dh}{dp} = -\frac{\partial F/\partial p}{\partial F/\partial h} = \frac{1}{p}\left[R\frac{\alpha}{1-\alpha}\left(r - \frac{\partial f(R,L)}{\partial R}\right) - f(R,L)\right].$$

This derivative is quite difficult to sign. However, if $\partial f/\partial R > r$, then $dh/dp < 0$, which means the supply curve will be backward-bending. The inequality $\partial f/\partial R > r$ will hold for most values of $R < R_{MSY}$, i.e., if the reindeer stock is lower than the stock associated with maximum sustainable yield (*MSY*). If $r > \partial f/\partial R$, the sign of dh/dp may still be negative for $R > R_{MSY}$ if $1 - \alpha$ is large relative to α—i.e., if the intrinsic utility of being an active reindeer herder is important relative to private consumption. This means that the phenomenon of backward-bending supply is consistent with the theoretical model. Generally, we can expect to find herders with both positive and negative supply responses, depending on the size of their herd, what discount rate they use, and their private marginal intrinsic utility of being an active herder. However, it is reasonable to assume that herders for whom $1 - \alpha$ is large will also have large herds.

To illustrate the above reasoning, assume the growth function has the following specific logistic form: $f(R, L) = \gamma R(1 - (R/L))$, where γ is the intrinsic growth rate. If $\gamma = 0.254$ (as suggested by Virtala, 1996), carrying capacity is arbitrarily set to 100, and $\alpha = 0.1$ (i.e., the intrinsic utility of being an active reindeer herder is important relative to private consumption), then $dh/dp > 0$ if $R > 89$. In contrast, if $\alpha = 0.9$, then $dh/dp > 0$ if $R > 46$. Therefore, herders with a strong intrinsic utility of being active herders are more likely to exhibit a negative supply response. Backward-bending supply responses have been described earlier in the context of common property resources (see Copes, 1970; Berck and Perloff, 1985; Clark, 1990).

Using (16) and (18), and totally differentiating gives:

$$(21) \qquad \frac{dh}{dL} = -\frac{\partial F/\partial L}{\partial F/\partial h} = -R\frac{\alpha}{1-\alpha}\frac{\partial^2 f(R,L)}{\partial R\,\partial L}.$$

Since the availability of lichen is largely determined by intensity of forestry, this derivative is primarily an analysis of the supply effects of the forestry externality on reindeer husbandry. This supply effect can be signed by noting that $\partial^2 f(R, L)/\partial R\,\partial L > 0$; marginal growth rates for reindeer will increase if lichen becomes more abundant, so (21) will have a negative sign. Put another way, the lichen increase will make reindeer husbandry more profitable relative to other work, resulting in a higher equilibrium stock of reindeer. If harvest is equal to growth, then in combination with the negative sign on $\partial h/\partial L$, this must imply that equilibrium stocks are higher than R_{MSY}. Conversely, harvest will increase if lichen becomes less abundant, due to the negative effect a reduction in lichen stock has on the carrying capacity of the reindeer. Thus, reducing lichen stocks by harvesting older stands for timber production imposes a negative unidirectional externality on reindeer husbandry.

Using (16) and (19), and totally differentiating gives:

$$(22) \qquad \frac{dh}{dw} = -\frac{\partial F/\partial w}{\partial F/\partial h} = \frac{1}{p}\left[R\frac{\alpha}{1-\alpha}\frac{\partial l_1}{\partial R} - l_2\right].$$

The sign of this derivative depends on the size of R. If R is small, then l_2 will be large, indicating that a negative sign on (22) will be more likely. On the other hand, if R is so large that $l_2 = 0$ (i.e., the herder receives all income from reindeer husbandry), then a

positive sign on (22) is ensured. This is intuitive; the attraction of an alternative employ-
ment increases if w increases, making it more expensive on the margin to keep the herd,
which will drive the reindeer stock down. For a reindeer herder with a herd size above
R_{MSY}, this stock reduction will generate a larger harvest.

Empirical Analysis

The Data

In 1999, a mail survey of Swedish reindeer herders was conducted by Statistics Sweden
(SCB) in collaboration with the National Association of the Swedish Saami (Svenska
Samers Riksförbund, SSR) and the Swedish University of Agricultural Sciences. The
survey was sent to a random sample of the Swedish national register of reindeer herding
companies, and 316 completely or partially answered questionnaires were returned for
a response rate of 63%. The survey, which focused on attitudes and preferences, resulted
in a unique cross-sectional data set on the preferences of a typical transhumance pastor-
alist community, the Swedish reindeer herding Saami.[5] For purposes of this paper, only
responses to selected questions are analyzed. To illustrate the representativness of the
sample, some general characteristics of the sample may be compared with the national
counterparts in table 1. Relevant portions of the questionnaire can be found in the
appendix.

As evident from table 1, the sample is skewed in the sense that reindeer herding
companies with more than 200 reindeer are considerably overrepresented. Similarly,
when examining geographical distribution, reindeer herding companies in Västerbotten
and Jämtland counties are somewhat overrepresented. Consequently, mean values from
the sample are less likely to be representative for Swedish reindeer herding companies,
but the skewness plays a less important role when the analysis controls for group size.[6]

Empirical Results

An empirical motivation for the formulation of the utility function in the previous
section can be found in the responses to the question, "How important is it for you to be
a reindeer herder?"—detailed in table 2. As clearly illustrated in table 2, the intrinsic
utility of being an active reindeer herder is an essential argument in the utility function.
There are no significant differences in reindeer herd size between respondents in the
four different response categories.

To gain some insight into the empirical justification for the formulation of the
consumption function in (1), it is useful to study the responses to the question, "How
important are the economic revenues of each year's slaughter?" (table 3). More than 60%
of the respondents chose response alternatives 1 or 2, and the mean reindeer stocks for
those who chose those alternatives are larger than the mean stock for alternative 3. The
mean reindeer stock for those who chose alternative 3 is in turn larger than the
corresponding mean stock for alternative 4. These findings are logical, and suggest that

---

[5] Some results from the study are presented in a publication by the Swedish National Board of Agriculture (1998).

[6] Note that respondents gave information on reindeer herd size in six different reindeer group sizes: 0–99, 100–199,
200–299, 300–399, 400–499, and more than 500.

Table 1. Descriptive Statistics for Respondents to Survey of Swedish Reindeer Herding Companies

Variable	Description	Survey Sample (%)	Swedish Average (%)[a]
Reindeer herding companies by size group	0–99 reindeer	11.7	34.6
	100–199 reindeer	15.5	21.5
	200–299 reindeer	27.2	16.0
	300–399 reindeer	16.4	8.9
	> 400 reindeer	29.1	18.8
Reindeer herding companies by county	Norrbotten	70.2	76.5
	Västerbotten	15.8	12.8
	Jämtland	13.9	10.7

[a] Source: National Register of Reindeer Herding Companies.

Table 2. Responses to the Question: *"How important is it for you to be a reindeer herder?"*

Response Alternative	No. of Responses	Percent (%)
1. "I will quit as a reindeer herder if I can find an occupation that will provide the same income."	2	0.7
2. "I will quit as a reindeer herder if I can find an occupation that will provide a better income."	21	6.9
3. "I will not personally quit as a reindeer herder."	113	37.3
4. "I will not personally quit as a reindeer herder, and it is important to me that the next generation continues in the occupation."	167	55.1
Total Responses:	303	

Table 3. Responses to the Question: *"How important are the economic revenues of each year's slaughter?"*

Response Alternative	No. and Percent of Responses	Mean Reindeer Stock [Confidence Interval]
1. "The slaughter revenues determine if I can continue as a reindeer herder or not."	91 (29.5%)	393.9 [362.9–425.0]
2. "The slaughter revenues are important for my livelihood, but it is the combination of revenues from slaughter, hunting, and fishing that determine if I can continue as a reindeer herder."	98 (31.8%)	316.3 [287.1–345.5]
3. "Slaughter revenues are important, but I can supplement them with income from other occupations.	62 (20.1%)	282.2 [247.3–317.2]
4. "Slaughter revenues only give a small contribution to my livelihood."	45 (14.6%)	187.8 [147.6–227.9]
5. "Slaughter revenues are not important for my livelihood."	12 (3.9%)	183.3 [80.8–285.9]
Total Responses:	308	

possibilities to find reasonably well-paid alternative occupations greatly influence reindeer stock size. This result is in turn connected to the time constraint in (2), where an increasing stock increases the number of working hours in the reindeer enterprise, albeit at a decreasing rate. The concavity of $l_1(R)$ in R can be verified from questions in the survey related to the number of working hours in the reindeer enterprise. Fitting the regression equation $l_1 = \beta_0 + \beta_1 * Ln(R)$ to the survey responses yields a t-value of 2.97 on β_1 (with 100 degrees of freedom).

To further examine the pastoralist's supply responses to changes in price, two questions were asked. Each respondent was first asked whether he/she would change the number of slaughtered reindeer per year if the present price of reindeer meat per kilogram was doubled. The choice alternatives to this question were: "I would reduce slaughter," "No change in slaughter," "I would increase slaughter," and "Don't know." The second question was similar, but requested a response to a halving of the price. The question format did not specify whether these price changes were temporary or permanent, leaving the respondent to form his/her own opinion about the duration of the price change (see appendix).

On the basis of the responses to these questions, two ordered probit regressions (cf. Zavoina and McElvey, 1975) were then conducted to determine whether reindeer stock size influences the probability of an increase in slaughter. In the first case, the dependent variable is the response to the question whether the respondent would change the slaughter following a 100% price increase, while in the second case, the dependent variable is the response to the question whether the respondent would change the slaughter following a 50% price decrease. Formally, we can define the vector of choices available for the respondent in the first question as y_1 = slaughter decrease, y_2 = no change, and y_3 = slaughter increase. The log-likelihood function for the ordered probit regression on the first (price increase) question can then be defined as:

$$\ln L = \sum_i \ln \left\{ \Phi\left[\mu_j - \beta'x_i\right] - \Phi\left[\mu_{j-1} - \beta'x_i\right] \right\},$$

where $\mu = \mu_{j-1}, ..., \mu_J$ is the vector of threshold parameters associated with the choices available for the respondent, and x_i denotes the data on the independent variables for respondent i. The log-likehood function for the second (price decrease) question can be defined in a similar manner. Results are reported in table 4.

As observed from table 4, estimates for case 1 indicate that the reindeer herd size has a negative effect on the probability of increasing slaughter after a 100% price increase, although this variable is not significant at the 5% level. For case 2, estimates reveal that the reindeer herd size significantly contributes to predicting the responses to a 50% price decrease. These results confirm the backward-bending supply response predicted in the theoretical model. That herders with large herds seem to be more likely to exhibit this supply response may depend on a high private marginal intrinsic utility of being an active herder [represented by a high value of $1 - \alpha$ in equation (20)]. Indeed, strong preferences for reindeer herding may be the very reason some herders have large herds. In these cases, a high utility may be connected to having a large herd. A price increase then allows a herder to slaughter fewer animals and still obtain the same level of income from reindeer husbandry.

Combining the responses to the price increase/decrease questions enables a closer examination, as presented in table 5. As many as 16% of the respondents answered response combinations indicating a backward-bending supply response (i.e., combinations

Table 4. Results from Ordered Probit Regressions of Responses to Questions Concerning Change in Slaughter After Price Increase/Decrease

	CASE 1		CASE 2	
	Dependent Variable: Prob. of increase in slaughter after 100% price increase		Dependent Variable: Prob. of increase in slaughter after 50% price decrease	
Description	Coefficient	t-Value	Coefficient	t-Value
Constant	1.926	9.56	0.578	3.31
Reindeer Stock	−0.899	−1.81	0.128	2.59
No. of observations	291		265	
Log likelihood	−175.01		−196.78	
Correctly predicted observations	80%		73%	

Note: Responses were coded as follows: 0 = slaughter decrease, 1 = no change, and 2 = slaughter increase. All "don't know" answers were removed.

Table 5. Number of Respondents (n), Mean ($\bar{x}$), and Standard Deviation of Reindeer Herd Sizes, Distributed According to Responses to Questions Concerning Change in Slaughter After Price Increase/Decrease

		Response to 100% Price Increase		
Response to 50% Price Decrease		Slaughter Decrease	No Change	Slaughter Increase
	Slaughter Decrease	[A] $n = 3$, $\bar{x} = 317$ Std. Dev. = 145	[B] $n = 39$, $\bar{x} = 242$ Std. Dev. = 23	[C] $n = 33$, $\bar{x} = 295$ Std. Dev. = 28
	No Change	[D] $n = 7$, $\bar{x} = 421$ Std. Dev. = 52	[E] $n = 119$, $\bar{x} = 323$ Std. Dev. = 16	[F] $n = 25$, $\bar{x} = 234$ Std. Dev. = 29
	Slaughter Increase	[G] $n = 10$, $\bar{x} = 370$ Std. Dev. = 51	[H] $n = 25$, $\bar{x} = 390$ Std. Dev. = 28	[I] $n = 2$, $\bar{x} = 250$ Std. Dev. = 0

Note: Total number of respondents to both the increase and decrease questions = 263.

D, G, and H), whereas 37% answered combinations indicating a conventional, forward-bending supply response (i.e., combinations B, C, and F). As many as 45% of the herders would not change their slaughter irrespective of a price increase or decrease, indicating that for many reindeer herders the supply curve is nearly vertical at a slaughter level mainly determined by nonprice-related variables.

A visual inspection of table 5 suggests that respondents with response combinations indicating backward-bending supply (D, G, and H) have larger herds than their counterparts with response combinations indicating a conventional supply response (B, C, and F). This result can be confirmed statistically by merging combinations D, G, and H into one group, and joining combinations B, C, and F to form another. The mean reindeer herd sizes for these two groups are then significantly separated at the 95% level. This finding supports the theoretical result that backward-bending supply is more likely to occur among herders with large herds.

Table 6. Number of Respondents (*n*), Mean (x̄), and Standard Deviation of Reindeer Herd Sizes, Distributed According to Responses to Questions Concerning Change in Profitability and Slaughter After Reduction in Clearcuts

		Change in Slaughter from 50% Reduction in Clearcut Volume		
		Slaughter Decrease	No Change	Slaughter Increase
Change in Profitability from 50% Reduction in Clearcut Volume	Profitability Decrease	[A] $n = 9$, x̄ = 261 Std. Dev. = 68	[B] $n = 4$, x̄ = 150 Std. Dev. = 71	[C] $n = 5$, x̄ = 330 Std. Dev. = 80
	No Change	[D] $n = 0$	[E] $n = 5$, x̄ = 270 Std. Dev. = 73	[F] $n = 0$
	Profitability Increase	[G] $n = 4$, x̄ = 150 Std. Dev. = 41	[H] $n = 34$, x̄ = 329 Std. Dev. = 27	[I] $n = 163$, x̄ = 321 Std. Dev. = 13

Note: Total number of respondents to both questions = 224.

Responses from reindeer herders to relaxed externalities were studied with two questions. The first asked if profitability would increase as a result of a 50% reduction in the clearcut volume of timber in the area where the respondent conducts his/her reindeer husbandry. Such reductions in clearcuts are assumed to increase the volume of lichen for winter grazing. The second question asked how the respondent would change his/her slaughter of reindeer in response to such a reduction in clearcut volume (see appendix). Table 6 reports the results from responses to these two questions.

Approximately 90% of the respondents stated that the profitability of their reindeer herding company would increase as a result of a 50% reduction in clearcuts. This finding clearly confirms that forestry causes a significant externality on reindeer husbandry. Of the respondents who would benefit from a reduction in clearcut volume, about 80% would increase their slaughter. Even so, as many as 25% of the respondents would not change, or even decrease, the slaughter as a result of a reduction in clearcut volume.

Concluding Remarks

A dynamic economic model of a pastoralist is used to empirically analyze a unique cross-sectional data set on the preferences of the Swedish reindeer herding Saami community. It is found that the intrinsic utility of being an active reindeer herder plays an important role in determining the supply of reindeer meat. Empirical results from a survey of Swedish reindeer herders suggest this can lead to backward-bending supply responses among pastoralists, as expected from the theoretical model. Results indicate that the probability of an increase in the slaughter following a price decrease (i.e., a backward-bending supply response) increases with the stock size. Further analyses confirm that reindeer herders with some form of backward-bending supply curve have significantly larger herds than their counterparts with conventional supply responses. Based on responses to questions about relaxed externalities from forestry, this would cause most herders to increase their slaughter.

As a pastoralist society in industrialized countries such as Sweden, Norway, and Finland, the Saami face, to a certain extent, different challenges than pastoralist societies in other parts of the world. For instance, the choices among alternative sources of income may be more plentiful for most reindeer herders than for pastoralists in developing countries. Despite the intrinsic utility of being an active reindeer herder, alternative, better paid occupations may still wield a power of attraction that is difficult to resist. Such differences limit the possibilities for drawing inferences from the results presented in this paper. Furthermore, because this study is an analysis of a transhumance pastoralist society, the results do not immediately carry over to nomadic pastoralist societies.

Future research should pay closer attention to the economic situation of the pastoralist societies. Many of these societies are under considerable stress caused by the small margins for livelihood on the often arid lands they inhabit as well as externalities from other resource users. Estimation of the opportunity costs created by these externalities remains an important task, as well as further analysis of the economic behavior of pastoralist herders.

[*Received June 2004; final revision received June 2005.*]

References

Barfield, T. "Pastoral Nomads." In *The Dictionary of Anthropology*, ed., T. Barfield. Oxford, UK: Blackwell, 1997.

Berck, P., and J. M. Perloff. "A Dynamic Analysis of Marketing Orders, Voting, and Welfare." *Amer. J. Agr. Econ.* 67(1985):487–496.

Bernes, C. "Jordbruk, renskötsel—och överbetning." ["Agriculture, Reindeer Husbandry—and Overgrazing."] In *Arktisk miljö i Norden—Orörd, oexploaterad, förorenad? [Arctic Environments in the Nordic Countries—Untouched, Unexploitated, Polluted?*], ed., C. Bernes. Monitor No. 15. Copenhagen: Nordic Council of Ministers, 1996.

Borgerhoff Mulder, M., and D. W. Sellen. "Pastoralist Decisionmaking: A Behavioral Ecological Perspective." In *African Pastoralist Systems: An Integrated Approach*, eds., E. Fratkin, K. A. Glavin, and E. A. Roth. Boulder, CO: Lynne Rienner Publishers, 1994.

Bostedt, G. "Reindeer Husbandry, the Swedish Market for Reindeer Meat, and the Chernobyl Effects." *Agr. Econ.* 26(2001):217–226.

Bostedt, G., P. J. Parks, and M. Boman. "Integrated Natural Resource Management in Northern Sweden: An Application to Forestry and Reindeer Husbandry." *Land Econ.* 79(2003):149–159.

Clark, C. W. *Mathematical Bioeconomics: The Optimal Management of Renewable Resources.* New York: Wiley-Interscience, 1990.

Copes, P. "The Backward-Bending Supply Curve of the Fishing Industry." *Scottish J. Polit. Econ.* 17(1970):69–77.

Eriksson, O., M. Sandewall, and E. Wilhelmsson. "A Model for Analyzing Influence of Timber Production on Lichens for Reindeer Grazing." *Rangifer* 7(1987):15–32.

Essen, P.-A., K.-E. Renhorn, and R. B. Pettersson. "Epiphytic Lichen Biomass in Managed and Old-Growth Boreal Forests: Effect of Branch Quality." *Ecological Applications* 6(1996):228–238.

Gustavsson, K. *Rennäringen—En presentation för skogsfolk. [Reindeer Husbandry—A Presentation for Foresters.]* Jönköping, Sweden: Skogsstyrelsen, 1989.

Hartwick, J. M. "National Accounting with Natural and Other Types of Capital." *Environ. and Resour. Econ.* 19(2001):329–341.

Johansson, P.-O., and K.-G. Löfgren. *The Economics of Forestry and Natural Resources.* Oxford, UK: Blackwell, 1985.

Livingstone, I. "The Common Property Problem and Pastoralist Economic Behaviour." *J. Develop. Studies* 23(1986):5–19.

O'Neil, D. "Patterns of Subsistence: Classification of Cultures Based on the Sources and Techniques of Acquiring Food and Other Necessities." Cultural Anthropology Tutorials No. 3, Behavioral Sciences Dept., Palomar College, San Marcos, CA, 2002.

Parks, P. J., G. Bostedt, and B. Kriström. "An Integrated System for Management and Policy Analysis: Theoretical Results for Forestry and Reindeer Husbandry in Sweden." *Environ. and Resour. Econ.* 21(2002):203–220.

Riksdagens Revisorer. "Stödet till rennäringen." ["The Financial Support to the Reindeer Husbandry."] Report No. 1995/96:8 to the Swedish Parliament Auditors, Stockholm, 1996.

Salzman, P. C. "Pastoralism." In *Encyclopedia of Cultural Anthropology*, eds., D. Levinson and M. Ember. New York: Henry Holt and Co., 1996.

Scarpa, R., E. S. K. Ruto, P. Kristjanson, M. Radeny, A. G. Drucker, and J. E. O. Rege. "Valuing Indigenous Cattle Breeds in Kenya: An Empirical Comparison of Stated and Revealed Preference Value Estimates." *Ecological Econ.* 45(2003):409–426.

Singh, I., L. Squire, and J. Strauss. *Agricultural Household Models: Extensions, Applications, and Policy.* Baltimore, MD: Johns Hopkins University Press, 1986.

Skogland, T. "Density-Dependent Food Limitation and Maximal Production in Wild Reindeer Herds." *J. Wildlife Mgmt.* 50(1986):314–319.

Skonhoft, A. "Exploitation of an Unmanaged Local Common: On the Problems of Overgrazing, Regulation, and Distribution." *Natural Resour. Modelling* 12(1999):461–479.

Swedish Ministry of Finance. "Vad kostar en ren? En ekonomisk och politisk analys." ["How Much Does a Reindeer Cost? An Economic and Political Analysis."] Report No. Ds-1998:8 to the Expert Group for Studies in Public Economics, Swedish Ministry of Finance, Stockholm, 1998.

Swedish National Board of Agriculture [Jordbruksverket]. "Rennäringen i Sverige." ["The Reindeer Husbandry in Sweden."] Jönköping, Sweden, 1998.

———. *Jordbruksstatistisk Årsbok. [Statistical Yearbook of Agriculture.]* Halmstad, Sweden: Bulls, 2002.

Virtala, M. "Optimal Harvesting of a Plant-Herbivore System: Lichen and Reindeer in Northern Finland." *Ecological Modelling* 60(1992):233–255.

———. "Harvesting a Lichen-Reindeer System in an Uncertain Environment." *Ecological Modelling* 89(1996):209–224.

Zavoina, R., and W. McElvey. "A Statistical Model for the Analysis of Ordinal Level Dependent Variables." *J. Mathematical Sociology* (Summer 1975):103–120.

Appendix:
English Version of Selected Questions from the 1999 Statistics Sweden Mail Survey of Swedish Reindeer Herders

(The complete, original questionnaire was in Swedish and contained 29 questions.)

■ Question 11. *How important is it for you to be a reindeer herder?* [check one alternative]

    [ ]   I will quit as a reindeer herder if I can find an occupation that will provide the same income.

    [ ]   I will quit as a reindeer herder if I can find an occupation that will provide a better income.

    [ ]   I will not personally quit as a reindeer herder.

    [ ]   I will not personally quit as a reindeer herder, and it is important to me that the next generation continues in the occupation.

■ Question 13. *How important are the economic revenues of each year's slaughter?*
[check one alternative]

[ ] The slaughter revenues determine if I can continue as a reindeer herder or not.

[ ] The slaughter revenues are important for my livelihood, but it is the combination of revenues from slaughter, hunting, and fishing that determine if I can continue as a reindeer herder.

[ ] Slaughter revenues are important, but I can supplement them with income from other occupations.

[ ] Slaughter revenues only give a small contribution to my livelihood.

[ ] Slaughter revenues are not important for my livelihood.

■ Question 21a. *How would the yearly total profitability for your reindeer herding company change if the clearcut area were reduced by 50% within the region where you conduct reindeer husbandry?*
[check one alternative]

Profitability would be affected . . .

[ ] very negatively   [ ] somewhat positively

[ ] somewhat negatively   [ ] very positively

[ ] not at all   [ ] don't know

Note: In the analysis for question 21a, no distinction was made between "very" and "somewhat," i.e., the two negative categories were merged into one. Accordingly, the two positive categories were also merged into one.

■ Question 21b. *If you answered that profitability would be changed in Question 21a, then how would you change your slaughter of reindeer?* [check one alternative]

My slaughter would be . . .

[ ] decreased very much   [ ] increased somewhat

[ ] decreased somewhat   [ ] increased very much

[ ] not changed at all   [ ] don't know

Note: In the analysis for question 21b, no distinction was made between "very" and "somewhat," i.e., the two decrease categories were merged into one. Accordingly, the two increase categories were also merged into one.

■ Question 22. *How would you as a reindeer owner change your slaughter (of reindeer per year) if the present price per kilogram was changed in the following ways?*

(a) *The present price per kilogram on reindeer meat was **doubled**?* [check one alternative]

[ ] I would DECREASE my slaughter   [ ] I would INCREASE my slaughter

[ ] I would NOT CHANGE my slaughter   [ ] I don't know

(b) *The present price per kilogram on reindeer meat was **halved**?* [check one alternative]

[ ] I would DECREASE my slaughter   [ ] I would INCREASE my slaughter

[ ] I would NOT CHANGE my slaughter   [ ] I don't know