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Cooperative pastoral production - reconceptualizing the relationship between pastoral labor and production[1]

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ABSTRACT A review of the literature concerning nomadic pastoralism reveals a prevalent assumption of a positive effect of labor inputs on pastoral production. However, studies that have tried to quantify the relationship between household labor availability and production are characterized by contradictory results where one reason may be related to the fact that nomadic pastoralists cooperate by sharing and exchanging labor. As a consequence, previous quantitative research may have neglected an important level of social organization. The prevalence of cooperative labor investment among pastoralists may indicate the presence of scale-dependent effects of pastoral labor on production. This article aims at developing a conceptual model illustrating this possibility, where the scale dependent effects of labor inputs are conceptualized as changes in the relationship between the costs and benefits of labor at different levels of social organization. [nomadic pastoralism, labor, cooperation, production, modeling].

SAMMENDRAG En gjennomgang av litteraturen om nomadisk pastoralisme, avslører en utbredt forestilling om positiv effekt av arbeidskraft på pastoral produksjon. Til tross for dette har studier søkt å kvantifisere forholdet mellom tilgjengelig arbeidskraft og produksjon, gittmotstridende resultater hvor en årsak kan være at nomadiske pastoralister

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gjennom samarbeid, deler og utveksler arbeidskraft. Med andre ord kan tidligere studier ha oversett et viktig nivå av sosial organisering. Utbredelsen av arbeidsinvestering gjennom samarbeid, synes å antyde tilstedeværelsen av skalaavhengige effekter av pastoral arbeidskraft på produksjon. Artikkelens mål er å utvikle en konseptuell modell som illustrerer denne muligheten, hvor de skalaavhengige effektene av arbeidskraft består av endringer i forholdet mellom kostnader og fordeler ved arbeidsinvestering på forskjellige nivåer av sosial organisering.

INTRODUCTION

While there is a general agreement that labor has a significant effect on agricultural production, the same is not necessarily the case for pastoral production. For example, Helland (1980:15) argues that "[…] once the minimum labour requirements have been met, the productivity of the herd will not increase with the application of more labour." Moreover, it has been observed that a single herder can just as easily herd a flock of 20 sheep as one of 200, indicating that labor inputs are not central to pastoral production (Borgerhoff Mulder and Sellen 1994; Sieff 1997). Nevertheless, a large part of the literature is concerned with discussions on what aspects of pastoral production are sensitive to labor inputs, and Næss (2010) has argued that a prevalent assumption of a positive effect of labor investment on various areas of pastoral production exists. It has been assumed that labor availability influences (1) movement decisions-mobility (e.g. Borgerhoff Mulder and Sellen 1994; Dahl 1981; Sperling 1985; Turner 1999); (2) livestock survival during drought (Hedlund 1979); (3) the efficient tracking of pastures (Reid, et al. 2008); (4) optimal herding (e.g. Ayantunde, et al. 2000; Bonte and Galaty 1991; Dahl and Hjort 1976; Khazanov 1994; Sieff 1997); (5) the number of animals within herds (Barth 1964; Sieff 1997); (6) herd growth (Dahl and Hjort 1976; Sandford 1976); (7) the keeping of multiple species of livestock (Dahl 1981); (8) pastoral risk (Bollig 1997; Bollig and Göbel 1997; Göbel 1997; White 1997), (9) herd management (Paine 1964; Paine 1994), and (10) that labor is an important constraint for pastoral production in general (Bonte, 1991 #432:7, for a review, see Næss 2010:52-54).

Consequently, one should expect that there is a positive relationship between labor input and pastoral production. More specifically, one should expect to find meaningful relationships between labor inputs and (1) herd demography - that is a negative relationship with mortality rates and a positive relationship with reproductive rates, again positively influencing herd size and herd growth. At the same time it is expected that the availability of labor influences (2) herd composition – for example the inclusion of different types of livestock; and (3) optimal herding – splitting up herds into sub-herds according to varying needs and efficient utilization of grazing areas. Nevertheless, Borgerhoff Mulder and Sellen (1994:223) find it "[…] surprising that positive effects of labor supply on herd size and productivity have not yet been demonstrated quantitatively". Moreover, since Bonte and Galaty (1991:8) and Fratkin and Smith (1994:91) argue that pastoral labor is mainly recruited

from households, it is to be expected that households with a larger pool of potential laborers should perform better than households with a smaller pool.

Studies that have tried to quantify this relationship have, however, been characterized by ambiguous results since studies have found both evidence for and against a positive effect of pastoral labor on production. For example, Scoones (1992) found no significant relationship between labor and livestock survival during drought. Similarly, Sieff (1997) found no significant relationship between labor availability, herding strategies and cattle herd dynamics. In terms of keeping of multiple species of livestock, Roth (1990) assumed that the addition of cattle in the Rendille economy represents a diversification strategy from the more traditional keeping of camel, sheep and goats and thus place additional pressure on individual households' labor pools (especially since cattle and camels are adapted to different ecological zones). Nevertheless, Roth (1990) found no significant relationship with labor availability and cattle ownership. In contrast, Turner and Hiernaux (2008) found a significant, but small, effect of labor availability on the probability of herders continuously herding animals. Moreover, Yi et al. (2008) found a strong correlation between labor and herd size. In addition, Berhanu et al. (2007) found a positive relationship between labor and pastoral production, measured as the sum of values of milk and meat off-takes, both marketed and not marketed (for a detailed review of these studies, see Næss 2010). As for the Saami reindeer husbandry in Norway, Næss et al. (2009) found that the number of persons within husbandry units (i.e. household) had a small but significant positive effect on herd size. In essence this implies that detecting pastoral labor related effects is far from straight forward and Næss (2010) has argued that insignificant results may have been influenced by relatively small sample sizes, which is known to have an impact on statistical significance (e.g Johnson 2002). This is especially pertinent if the effect of pastoral labor is marginal as some evidence suggests (e.g. Berhanu, et al. 2007; Næss, et al. 2009; Turner and Hiernaux 2008). Moreover, previous studies have used different measures of pastoral production and as such do not represent clear cut evidence for or against the assumed positive relationship (cf. Næss 2010).

The prevalence of pastoral labor cooperation

More importantly, however, previous quantitative studies have had an explicit bias toward within-household labor availability and have as a consequence neglected an important characteristic of nomadic pastoral social organization – that nomadic pastoralists form cooperative herding groups, consisting of several households, with the explicit aim of sharing and exchanging labor.[1] For the Rendille pastoralists of Kenya, for example, Roth (1996:222) found a pattern of decreasing family size combined with increasing herd size, confirming Roth's (1990) previous findings that labor availability have no effect on pastoral production for the Rendille. Of importance, however, is that Roth (1996) ascribes this to the fact that analyses were undertaken on the basis of livestock ownership, that is households, and not management units were used in the statistical analyses. For the Rendille a management unit consists of several households that share the labor pool: "For the Rendille, the basic management unit is the combined labor pool represented by agnatic and affinal kin termed the "subsistence unit" […]" (see also McCabe 1987; Roth 1990:444; Sato 1980). For example, Rendille camel camps may include up to 600 camels that are tended by 50 herders – which again are split into 2-5 herding groups (Fratkin 1987:300).

The same seems to be the case for the Samburu in Kenya, where labor inputs are rarely delineated by households, but instead extends to settlement-wide cooperation (Sperling 1985:85). Sperling (1985) found that out of 113 potential animal groups (this represents 25 herd owners with 5 different categories of animals: milking cows, small stock, calves, kids/lambs and cattle at dry season grazing camps), 21 percent were managed by households alone, 27 percent were managed by borrowed labor and over 50 percent were managed by the whole settlement, either by everyone in the settlement taking turns or by some households exchanging labor (Sperling 1985:84-5). Sperling (1987a:13), argues that "[…]the pervasiveness of cooperative arrangements creates general labor abundance, whereas households in isolation experience labor scarcity." Similarly, the Ariaal in northern Kenya organize the daily herding by combining herds from several households and form cooperative herding groups that share the responsibilities of labor inputs (Fratkin 1987). For the Ariaal, cattle camps in the highlands are usually shared by many households from the same settlement – each camp consisting of 70-150 cattle that are tended by 6-13 persons (Fratkin 1987:303).

Similarly, since the Gabra in northern Kenya and southern Ethiopia keep cattle, small stock and camels with differing needs, both in terms of pasture and water, herds "[…] must be managed by a system of multiple, mobile and dispersed settlements" (Torry 1977:162). During the dry season the Gabra divide the livestock between main and satellite camps. In general, a camp consists of homesteads, which again are made up of several tents or households with close kinship ties. In a survey of 30 camps, Torry (1977:162) found that each camp consisted of an average of 14 homesteads, ranging from 5 to 34. A homestead then forms the basis for labor cooperatives, as the homestead members live in tents close to each other, keep their livestock in the same enclosures and share labor connected to herding (Torry 1977:162). In general, it may be that African pastoralists have to rely on labor input from close relatives and in-laws, as "[…] many of the independent pastoral units are aggregates of nuclear families who are not able to maintain viability as separate entities" (Dahl 1981:207).

Also, for the Basseri in South Persia, labor requirements for small households are secured through the formation of herding groups, consisting of 2 to 5 tents cooperating in pastoral tasks such as herding (Barth 1964:74). Barth (1964:74) writes: "Families which are short on personnel establish herding cooperation with families with several adolescent sons, thereby securing the additional labour assistance they need."

The same has been observed among pastoralists in the western part of the Tibetan Autonomous Region in the People's Republic of China. Among the Aru nomads, it is common that several households go together and form herding groups, defined as a unit sharing the responsibilities for the daily herding of the members' animals (see Næss 2003 for details). Similarly, Mongolian pastoralists have the 'Khot ail', which Upton (2008:177) describes as "[…] herding camps, usually kinship-based, which achieved increased efficiency and economies of scale in herding through cooperation in basic tasks such as tending livestock, felt and hay-making and seasonal movements."

Along the same lines, Wright et al. (2003) argues that after the collapse of the Soviet Union and the dissolution of state collective farms, pastoralism in Kazakhstan was decollectivized (since the early 1990s). Consequently, pastoral production that was firmly in the hand of the state during the Soviet period was privatized and a new set of livestock owners and management systems emerged. Kerven (2003) has identified three different forms: (1) small-scale private livestock-owners (40 sheep), (2) large-scale private farmers (70

sheep), and (3) cooperatives formed out of ex-collective farms (1000 – 4000 sheep). While during the Soviet period labor was organized by the state collective farms, presently other arrangements have to be implemented. Consequently, informal cooperative labor arrangements have developed where both small-scale private livestock-owners and large-scale private farmers pool both their animals and labor inputs (Kerven 2003).

Cooperative herding is also present among Saami reindeer herders in Northern Norway (see e.g. Bjørklund 1990; Paine 1964; Paine 1994). In this context, the 'siida' group is an important social organization. A siida can be defined as a cooperative unit composed of one or more reindeer families, and is usually organized on the basis of kinship joined together in social and labor communities for keeping control of herds of reindeer through herding (Paine 1994).

A modeling framework

Statistical models based on observational data can only reveal associations or correlations and not casual relationships (Cohen, et al. 2003). Næss et al. (2009:202), for example, argued that it may not be the number of people per husbandry unit that influenced herd size, but rather that the size of livestock holdings positively influenced the number of people per husbandry unit since it has been demonstrated that for the Gabbra pastoralists in northern parts of Kenya, wealth (measured as herd size) is positively correlated with reproductive success (Mace 1996). One way of dealing with such causal difficulties is to develop a conceptual model. Conceptual models are predominantly tools for testing arguments in a formal setting and can be used to test if specific patterns emerge from known processes and mechanisms given a set of more or less realistic assumptions (Kokko 2007). A good model, then, should reveal the conditions that have to be met for us to conclude that we have a logically consistent argument explaining the relevant phenomena (Kokko 2007:10). Following Kohler and Leeuw (2007) a model may be thought of as an imaginary system with useful similarities to the aspect of the target system in the real world. Models and simulations should thus be thought of as thinking aids, or highly simplified representations of reality that can be used to investigate whether the logic behind an argument is correct (Kohler and van der Leeuw 2007; Kokko 2007:10). Following Axelrod (1997), a model does not aim at providing an accurate representation of an empirical phenomenon, but rather to

increase our understanding of fundamental processes underlying a wide variety of phenomena. This necessitates that a model should include a sufficient amount of detail for a particular question while at the same time retaining simplicity so that it can be understood (Gilbert and Troitzsch 2005; Kokko 2007). Moreover, a modeling approach provides the social sciences with a possibility for exploring causal relationships without reverting to actual experimentation which may be impractical/impossible, unethical or even illegal (Gilbert 2008; Gilbert and Troitzsch 2005).

Given the prevalent assumption of a positive effect of labor on pastoral production this paper develops a conceptual model that aims at accounting for both (1) ambiguous results at the household level of social organization and (2) the importance of cooperative herding groups by focusing on the cost and benefits (i.e. production returns) of increased labor inputs. The question investigated is whether cooperation can, in principle, lead to higher production returns for pastoralists. If so, the presence of cooperative herding groups must be given much more weight in the quantitative study of pastoral labor than it previously has been as cooperation may be an important mechanism explaining between-household variation in performance.[2]

THEORETICAL FRAMEWORK

In general terms nomadic pastoralists can be viewed as being in the business of producing animals, and it is assumed that one important strategy for pastoral households is, to some degree, to maximize output, that is production in the form of animals and animal products. Maximizing output can thus be viewed as a strategy for attaining a wide range of pastoral goals that have been described differently in the literature. From the "East African cattle complex", where the prestigious aspect of having large herds was given weight (Herskovits 1926), to nomadic pastoralists seeking reliable food intake (Roe, et al. 1998), and valuing long term household survival (Mace 1993). Moreover, Barth (1964) has argued that nomadic pastoralists maximize herd growth because of the dangers connected with falling below some subsistence threshold where subsistence is no longer possible (Galaty and Johnson 1990; Hjort 1981; Roth 1996) – that is the logic that a 50 percent loss of 100 animals is less severe than a 50 percent loss of 20 (Fratkin and Roth 1990:387; see also Næss and Bårdsen 2010; Templer, et al. 1993) . Moreover, the rationale for accumulating livestock is

summarized by Coughenour et al. (1985:619) as (1) milk requirements demand a large fraction of mature females, giving herds excessive reproductive capability; (2) lactating animals must provide milk to both humans and young animals, leading to a pressure to keep large herds; (3) pastoralists herd 50 to 100 percent more animals than required for subsistence purposes only to secure survival of some animals during droughts, in order to form the basis of a new herd; and (4) individual animals are in general characterized by low productivity, necessitating more animals per person.

In economic terms, production is conceptualized as a function of the factors of production and, for pastoralists, as a function of land (pastures), capital (herd) and labor (e.g. Haaland 1977). Capital, however, in a classical economic sense is usually thought of in terms of man-made products (i.e. something physical) that can be used in and that facilitates the production of other goods or as inputs that last over time (i.e. not easy to change within a short period of time, see Katz and Rosen 1994:246). As such, a herd of animals may not fit the definition. Livestock, however, can be classified as constituting renewable natural capital (Ares 2007:163), that is as "[…] a stock that yields a flow of valuable goods or services into the future" (Costanza and Daly 1992:38). As a consequence a herd of animals can be viewed as capital stock that forms the basis for pastoral production, for example a flow of profit through herd growth which again influences milk, meat, wool, blood and skin production. Consequently, livestock can be considered both as a form of capital investment and as a product (Roth 1996). It is also possible to view knowledge as a form of capital, termed human capital (see e.g. Becker 1962) or cognitive capital (see e.g. Camerer and Hogarth 1999). Human capital can be viewed as a collection of knowledge, know-how and expertise that individual workers have or acquire and use in their productive work and that is different from their ability to perform physical work but nevertheless adds to an income (Nerdrum and Erikson 2001; see Dean and Kretschmer 2007:80 for a critical review of this position). Walker et al. (2002), for example, found that hunting ability among the Ache of Eastern Paraguay was characterized by age-dependency. In other words, hunters at peak age (40 years) had higher hunting returns than hunters at peak strength, indicating that skill acquisition is an important factor in Ache hunting.

Consequently, in a pastoral setting one can think of pastoral production as a function of (1) physical labor inputs (e.g. herding); (2) pastures; (3) capital as knowledge (e.g. herding skills); and (4) capital as herd size. The access to sufficient pasture plays an important role in

the welfare and well-being of livestock, and land is thus an important production factor for pastoralists. Nevertheless, as this paper is mainly interested in the effects of labor, it is assumed that access to grazing areas is fixed for individual households, and as such land as a factor of pastoral production will not be discussed further. Moreover, as the main concern is how production is influenced by the physical inputs of labor, capital in the form of herding skills is disregarded. There are some valid empirical reasons for this, for example Turner and Hiernaux (2008:73) assumed that herder age was a proxy for labor quality, and found age was positively related (curvilinear) to the duration of the grazing itinerary, or the length of time animals were grazed. The overall conclusion, however, was that "[…] no significant difference was found with respect to demographic qualities of labor actually committed to herding (gender and age)" (Turner and Hiernaux 2008:77). Similarly, Sieff (1997) used the ratio of herders to livestock as a proxy measure for the quality of care available for animals (based on the assumption that the fewer animals per herder the better care animals get) but found that it had no effect on cattle herd dynamics.

Animals as a capital stock then form the basis for profit in the form of increased herd size—the larger the stock of animals the larger the profit in terms of added animals and subsidiary products. *Ceteris paribus*, a given household's potential for profit (production) is to a large degree decided by its capital. In other words, a larger herd with more female animals has a larger potential for profit (higher reproduction) than a smaller herd. It is, however, possible that the realized potential is a function of the amount of labor that is invested in the herd, that is, the actual number of surviving offspring (and loss in general) that contributes to an increase in herd size is dependent on the amount of labor invested.

OPTIMAL LABOR INVESTMENT

Assumptions

In general it is assumed that a household at a given time, *t*, has a herd size of female animals, N_t (only female animals are considered in this conceptual model). N_t is designated as the household's capital, forming the basis for future production in terms of reproduction which again forms the basis for a future increase in, for example, milk, meat, and wool production. To maintain a viable herd of animals a household has to invest labor. If this

condition is not met all the animals will be lost (e.g. stolen, or killed by predators), and the household is effectively excluded from the pastoral game.

The starting point for changes in herd size is the BIDE model, which considers birth (B), immigration (I), death (D) and emigration (E) simultaneously (Pulliam 1988). In this model immigration and emigration rates (rates describing, for example, the sale and purchase of livestock by pastoralists) are for simplicity's sake set to zero. Changes in herd size over time is consequently a function of N_t minus deaths from natural causes, both in terms of old age and natural hazards such as climate and illness, and slaughter plus natural reproduction. In general, the changes in herd size from *t* to *t*+1 can be expressed as a difference equation:

$$N_{t+1} = (1 + b - d)N_t \qquad (1.0)$$

where N_{t+1} is the herd size one year from now, N_t is the number now and $1 + b - d$, usually designated as R, is the net discrete (or geometric) per capita rate of growth (Case 2000:2-3). The per capita rate of growth is usually determined on the basis of the number of births per individual per year (*b*, a rate representing the number of surviving offspring per animal) minus the number of deaths per individual per year (*d*, i.e., a rate representing the number of deaths per animal, see e.g. Bernstein 2003).

As it has been argued that labor availability influences the number of animals within herds (Barth 1964; Sieff 1997) and herd growth (Dahl and Hjort 1976), it can be deduced from this basic model of population growth that the herd's growth rate has to be influenced by labor investment if labor is to have an effect on pastoral production. Consequently, one can assume that investing labor has to have an effect on either (1) the number of births per individual per year, (2) the number of deaths per individual per year or (3) both. For simplicity, it is assumed that labor only influences the number of births per individual per year (see below for details), or more to the point, the number of surviving offspring. As a consequence, the herd growth model can be rewritten in terms of investing labor:

$$N_{t+1} = [1 + (b + g) - d]N_t \qquad (1.1)$$

Where *g* indicates the per capita rate of growth as a result of labor investment. Since we are dealing with pastoralists, keeping livestock without any human labor investment may be argued to be meaningless and as such *g* replaces *b* as measurement of the number of surviving offspring per animal for pastoralists. This may be argued to be too simplistic as a

herd of animals without herders may still continue to reproduce and survive (depending on the level of domestication, e.g. it is doubtful that a herd of domesticated sheep would survive long without human input). Nevertheless, whether this is the case or not may be considered a moot point since a herd would not be considered as livestock from a pastoral point of view. For all practical purposes when no labor is invested, the birth rate for a pastoral herd is zero. Thus, equation 1.1. can be rewritten as:

$$N_{t+1} = (1 + g - d)N_t \qquad (1.2)$$

Labor investment, however, carries a cost, usually designated as opportunity costs or the cost of lost opportunity. Opportunity cost implies that "[…] decisions about exploiting items can be assessed by comparing potential gains [benefits] from exploitation with the potential loss of opportunity to do better" (Stephens and Krebs 1986:11). Here, the cost can be thought of as having an effect on the offtake rate – as more and more people from the household are invested in herding, fewer and fewer have the opportunity to generate food elsewhere, for example by hunting, through wage labor or agriculture. As a consequence they have to consume more of the profit in terms of meat directly from the herd, for example, than they could have done if pursuing other food producing activities. Alternatively they have to sell more of the profit to provide necessary food that the herd cannot generate than they could have done if they could allocate members to non-pastoral activities. In short, by only investing in pastoralism they may consume all of the potential benefit they could get from investing more labor into the herd. In the same way as the benefit is conceptualized as a positive effect on the birth rate, the cost can be conceptualized as a negative effect on the same rate, and the herd growth model can be rewritten:

$$N_{t+1} = [1 + (g - c) - d]N_t \qquad (1.3)$$

where *c* indicates the cost expressed as a decrease in the per capita survival for newborns. This conceptualization of the cost of labor may be questioned as pastoralists also slaughter adult animals. Nevertheless, this simplification makes it possible to model the cost and benefit on the same scale, since in general the value of adult female animals is higher than newborns because adult herbivores have both a higher reproductive potential and relatively higher survival probability (e.g. Gaillard, et al. 1998). As such conceptualizing the cost in terms of an increased death rate instead of a reduced birth rate would change the scale of the cost relative to the scale of the benefits. Moreover, due to the higher probability of

survival, labor may have a smaller effect on adult than newborn survival. Consequently, the benefits and costs in terms of death rate would have to be modeled separately from that of the birth rate. While not impossible to do, this represents an unnecessary complicating factor for the argument developed in this paper and as a consequence this aspect of labor related benefits and costs is not considered.

Functional relationships

Following Sieff (1997) and more general economic considerations (Katz and Rosen 1994), a diminishing marginal return of labor on pastoral production is assumed. The law of diminishing marginal returns entails that beyond some point, each additional unit of input, holding all other input factors constant, yields less and less additional output (Katz and Rosen 1994:254). This relationship can be expressed by the equation (adopted from Brown 2007):

$$g = U - Be^{-al} \qquad (1.4)$$

where *g* is the increase in per capita growth as function of labor input (*l*). Note that when $l = 0$, $g_0 = U - B$. As labor input increases (as *l* gets larger), Be^{-al} shrinks to zero in the limit and *g* approaches *U*. Following Brown (2007:25), *g* asymptotically approaches the constant value of *U* as labor increases, that is *g* approaches its limit *U* with smaller and smaller increments, as a functional relationship representing the formal definition of marginal diminishing returns (in other words, the rate of growth (*dg/dl*) for the variable *g* decreases as labor is invested, i.e. the second derivative of *g* is negative. *g* is still growing as *dg/dl* is positive but it grows at a steadily slower rate, see Brown 2007:25). As for the different parameters in the equation, *U* represents the boundary condition that can be conceptualized as the animal species fecundity in terms of females; *a* is a parameter that represents the rate at which actual fertility approaches ideal fecundity; and *e* is the base of the natural logarithm. *B* is a constant whose value determines the value of g_0. As previously argued, keeping livestock without any labor investment may be argued to be meaningless and as such $g_0 = 0$; or when no labor is invested the birth rate is zero. This is fulfilled when $U = B$.

Moreover, labor investment carries a cost, and in the same manner that production can be viewed in term of its marginal physical return to labor, cost can be viewed in terms of

marginal costs. This cost is dependent on the marginal physical return of labor (Katz and Rosen 1994:273-6). When, for example, there are diminishing marginal returns to labor, increasingly large increments of labor are needed to produce additional output, and as a consequence when the marginal physical return of labor diminishes, the marginal physical cost increases (Katz and Rosen 1994:275). This implies that the cost may be thought of as accelerating with the application of labor, which can be expressed as:

$$c = hl^2 \qquad (1.5)$$

where *h* is constant, determining how large the cost in terms of a reduction in per capita growth will be for a given value of *l* (e.g. when *l* = 1, the cost will equal *h*). With these two equations in mind, decisions regarding pastoral labor investment can be reframed as a classical optimality problem.

Herding alone

A hypothetical example can be used to illustrate this point. Two households are herding their animals separately. They have to maintain a minimum level of labor input for regular monitoring of the herds. For simplicity, this can be defined as the optimal level of labor investment for individual households, which is where the difference between the benefit and costs are largest (Fig. 1a). In other words, the optimal labor investment is when pastoralists maximize $g - c$. More specifically this can be defined as when the marginal benefit is equal to the marginal cost ($g' = c'$), that is, when $aBe^{-al} = 2hl$ (Fig. 1b). More correctly, the optimal level of labor investment can be found by $aBe^{-al} - 2hl = 0$ and solving for *l*. However, since the specific value of *l* at the optimal level of labor investment is not as interesting as the question of what theoretically may happen when herding alone vs. cooperatively, the specific solution is not important in this context.

Importantly, when the marginal benefit is equal to the marginal cost there is still some additional benefit that can be gained by investing additional labor since $dg/dl > 0$, but why this does not pay off for households when investing alone is due to the marginal cost of investing additional labor which is larger than the marginal benefit.

Herding cooperatively

According to Axelrod (1984), benefits not easily obtainable by individuals may be available to cooperating groups. Following Smith (2003:402) cooperation can be defined as collective action for mutual benefit, where collective action can be defined as when two or more individuals have to interact so as to achieve a specific goal. Furthermore, the simplest form of cooperation entails some form of coordination, where individuals share preferences so that they always benefit from cooperation (Smith 2003:402).This is usually referred to as mutualism and can be characterized as a broad definition of cooperation (see Bowles and Gintis 2003:429 for a restricted definition of cooperation; Richerson, et al. 2003:358). In terms of cooperative production and cooperative labor investment, Smith (1981), for example, has argued that group formation by hunter-gatherers can potentially benefit individual foraging behavior (see also Smith 1997). The same has also been observed for whale hunters in Indonesia where cooperative whale hunting resulted in greater *per capita* returns than solitary fishing (Alvard and Nolin 2002). By extension, by cooperating and sharing labor, individual pastoral households may reap additional benefits in terms of pastoral production. Assuming a benefit from increasing labor inputs, however small, and that cooperation is based on a sharing and exchange of labor the cost-benefit relationship of pastoral labor investment may change when working cooperatively, where cooperation could be a least-cost combination among a set of feasible labor input combinations incorporating herding alone and herding cooperatively. In terms of benefits, additional labor can for example make it possible to split up the herds into sub-herds that take into account age and sex variation in animal needs, provide better protection from predators, et cetera, and as such increase the birth rate.

Cooperation can for example be viewed as a form of 'going Dutch' where households contribute with a share in a common labor pool, and as such, the cost of adding additional labor is shared between the households in the cooperative group. In this scenario, the cost per household from investing additional labor will increase, but this increase is small in comparison to herding alone because the cost would be devaluated by a fraction of the cost from herding alone. The cost could for example be devaluated by a fraction *k*, and the cost of investing cooperatively could be expressed as:

$$c = khl^2 \qquad (1.6)$$

If $k < 1$, individual households can reap additional benefits by cooperating in terms of an increased birth rate, since the cost of adding additional labor through cooperation is less than the cost of adding additional labor alone (i.e. $khl^2 < hk^2$). As a consequence, the optimal level of labor investment increases when herding cooperatively (see Fig. 1a and b). In other words, the formation of cooperative herding groups can be explained as an attempt at attaining economies of scale, which is an increase in the percentage of output coupled with a reduction in the costs related to the investment of additional labor for individual pastoral households. As such, cooperative herding groups may have as one of its aims to exploit increasing production returns from labor investment.

[INSERT FIGURE 1 HERE]

DISCUSSION

As seen from the earlier optimality analysis it may pay off for pastoralists to cooperate in terms of production (Fig. 1). As such, from this simple theoretical model it could be inferred that there may be scale dependent effects of pastoral labor on production as households nested within extensive cooperative networks should do better than households included in less extensive cooperative networks. Consequently, investigations aimed at investigating the relationship between pastoral labor and production also have to look for effects at levels of social organization above the household level.

In a study on Saami reindeer husbandry in Norway, Næss et al. (2009) investigated : (1) whether labor in general had an effect on production and (2) whether labor related effects were characterized by scale dependency. They found that the number of persons within husbandry units (analogous to households as defined by Dahl 1979) had a significant positive effect on herd size but not on calf body mass (Næss, et al. 2009:Table 1a & 1b). Importantly, the same study also found that the number of husbandry units within reindeer districts, which were assumed to be a proxy for possible labor cooperation, had a significant positive effect on both reindeer density within districts and calf body mass (Næss, et al. 2009:Table 2a & 2b). This provides evidence of both a general effect of pastoral labor and scale-dependent effects of pastoral labor. Moreover, this study confirmed the findings from Berhanu et al. (2007) and Turner & Hieranux (2008) that the effect of pastoral labor is relatively small as an increase in the number of persons by one will increase the predicted

herd size by only 3 percent while increasing the number of husbandry units by one increased calf body mass by only 97 g^3 (Næss, et al. 2009). In another study, Næss et al. (2010) hypothesized that kinship may be an important component in cooperative labor investment. As in the previous study the number of husbandry units within reindeer districts was used as a proxy for possible labor cooperation while kinship (measured as the average coefficient of relatedness within a district) was assumed to be an important prerequisite and facilitator for cooperative labor investment (see e.g. Alvard 2003; Borgerhoff Mulder and Coppolillo 2005). The main finding in this study was that individual husbandry units within districts with both a high degree of relatedness and a large number of husbandry units had larger herd size than husbandry units in districts with a lower degree of relatedness and/or smaller number of husbandry units. This study thus shows that cooperative labor investment, mediated by kin relations, had a positive effect on production in Saami reindeer husbandry (Næss, et al. 2010). Consequently, these two studies indicate that there is empirical support for the presence of scale dependent effects of pastoral labor on production. Nevertheless, Næss et al. (2009) also found a positive effect of within-husbandry unit labor and while this relationship is fraught with interpretative difficulties that are diminished by focusing on between-husbandry unit measurement of labor it may be taken to indicate that the relationship between pastoral labor and production is far from straightforward. To further compound the problem, observational studies, as the two above, have potential problems in relation to confounding factors: variables not included in the analyses may impact both the response and the included variables (e.g. Næss and Bårdsen 2010; Næss, et al. 2010; Næss, et al. 2011; Næss, et al. 2009). Confounding may thus lead to spurious relationships between the included predictor variables and the response (cf. Cohen, et al. 2003; Zuur, et al. 2010). This again stresses the need for further modeling work that can be used to guide future empirical studies.

Furthermore, while the model developed here indicates that cooperation has a positive effect on pastoral production, this may not necessary always be so. There will be an upper limit as to how many households should cooperate, a limit that can be defined in terms of the cost of cooperation. A cost of cooperation can for example be viewed as costs related to higher levels of conflicts or increased grazing pressure which will follow from an increased number of cooperators (more households with separate herds within a limited area will for example increase the total number of animals within the same area). While this

is clearly something that should be investigated, it is not in any way related to why - in the first place - it pays off for individual households to cooperate and share the costs connected with increasing labor inputs. Moreover, a system consisting of a number of cooperators may seem to be sensitive to a possible invasion of "free riders" who only will want the benefits without carrying the costs. Cooperating herding groups, however, are first and foremost small groups consisting of individuals with close kinship ties that maintain face to face communication with each other, that have the possibility of monitoring each other and that can punish individuals that break rules. These are important characteristics that to a large degree favor cooperation and provide a counter to free riding tactics (see e.g. Borgerhoff Mulder and Coppolillo 2005; McGinnis and Ostrom 2008). It seems that herding groups break up and change over time (Bjørklund 1990; Næss 2003; see also Spooner 1971). Their composition, furthermore, may change as a result of exclusion of some by others, or alternatively some households may leave the group and change their cooperative partners because of some transgression of rules connected to the sharing and exchange of labor.

Both the prevalence of cooperative labor investment (see above) and the possible importance of cooperative labor investment may also call for a restriction of the household definition suggested by Fratkin and Johnson (1990:359) who argue that households "[…] may easily include non-relatives who co-reside and cooperate on a regular basis." A household, however, is different from a cooperative unit in at least one fundamental way: cooperative herding of one big herd consisting of animals from several owners does not imply that the cooperative unit as a whole has decision rights over the use of production from the whole herd of livestock (cf. the concept of 'herding' and 'husbandry' in e.g. Paine 1994). From this point of view, households and cooperative herding groups represent different levels of social organization with both overlapping (e.g. decisions related to labor allocation is a concern for both the cooperative unit and the household) and non-overlapping areas of influence (e.g. decisions regarding the use of livestock production, which is done by the household following Dahl (1979:70)).

Moreover, cooperative labor investment may play an important part for the possibility of successful economic diversification. The importance of economic diversification – combining pastoralism with for example wage labor, agriculture and hunting – has been given increasing weight in the literature (see e.g. Bayer and Waters-Bayer 1990; Berhanu, et al. 2007; Berzborn 2007; Hjort 1981; Lesorogol 2008; Little, et al. 2007; Marx 2006; Sperling

1987b; Thornton, et al. 2007). Labor availability, however, is considered as "[…] one of the most important prerequisites for diversification […]" (Berzborn 2007:680; see also de Bruijn and van Dijk 2003:299; Næss 2009). As a consequence, it could be argued that cooperative herding groups may be a significant factor influencing the possibility for successful economic diversification, as cooperative herding may leave more members of individual households free to pursue alternative and beneficial income opportunities than if households are herding alone. As a consequence cooperative herding may increase overall household production efficiency and resilience (see e.g. Swidler 1972:72 for a similar argument). For example, while Berhanu et al. (2007) found that the investment of pastoral labor into livestock production had a positive effect on production, labor invested in livestock had lower marginal returns than the marginal returns from non-pastoral activities. In essence, this implies that the costs of labor investment into livestock production may be high as pastoralist may reap higher marginal returns by investing labor in non-pastoral activities. As such, it could be hypothesized that pastoralists with large cooperative networks may do better both in terms of livestock production and in terms of non-pastoral production than pastoralists with smaller networks. As a consequence, one can expect that cooperative herding groups' importance will vary according to the cost of herding: in contexts were herding is expensive, for example use of costly technology or where other economic adaptations are available, herding groups will be important, but in contexts were herding is cheap or where other economic adaptations are less available, cooperative herding groups may be less important. From this point of view, it could be predicted that the prevalence of cooperative herding groups correlates with dependence on non-pastoral sources of income. Moreover, one could expect that in pastoral societies where cooperating herding groups are important, household members are more involved in non-pastoral production, since livestock labor is not only recruited from within the household. Also, in light of increased modernization and integration into modern national states, cooperative herding groups may become more important. As national states increase their demand of formal education for the children of pastoralists, increased cooperation may become a necessity for pastoralists to continue their way of life. The Tibetan nomadic pastoralist in the western parts of Tibet, for example, are required to send at least one of their children to a school approximately 2 days driving away (Næss 2003). Practices like this will most likely lead to labor investment related problems for individual households. At the same time it may be that the pastoralists

themselves recognize that formal education of their children may be a valuable asset for their future prospects, and as such the cost of labor investment may increase. As a consequence, herding groups may become more and more important for pastoralists experiencing such large scale transitions.

CONCLUDING REMARKS AND FUTURE PROSPECTS

The starting point for the conceptual model developed here is the apparent paradox that while there exists a prevalent assumption of a positive effect of labor investment on various areas of pastoral production, studies that have tried to quantify the effect have been characterized by ambiguous results (see Næss 2010 for a review). This has been argued to be connected to the fact that previous quantitative analyses have neglected that nomadic pastoralists exchange and share herding labor and form cooperative herding groups with other households. Following this line of reasoning, it is possible that labor related effects on pastoral production may also be found on levels of social organization above the household level. As the model shows, it may be that pastoral labor related effects are characterized by scale dependency consisting of trade-offs between the costs and benefits of labor inputs on varying levels of social organization. A possible change in trade-offs between costs and benefits of labor inputs when investing cooperatively may help explain the prevalence of cooperative herding groups among pastoralists as this may make it possible to reap a marginal increase in benefit. In short, it may be expected that a variation in within-household labor may not necessarily lead to a variation in production between different households (but see above). In contrast, variation in the number of cooperating households per cooperative unit can lead to variation in production because this can increase the total amount of labor input per cooperative unit without significantly increasing the cost per household. One should therefore expect that cooperating units consisting of many cooperating households should, on average, perform better than cooperating units consisting of relatively few cooperating households. While difficult to test, preliminary evidence from reindeer husbandry in Norway suggests that this is the case (Næss, et al. 2010; Næss, et al. 2009).

Moreover, if cooperative herding is an important social institution partly aimed at increasing production among nomadic pastoralists, this should have serious implications for

pastoral development and governmental management strategies. Seen in light of the conceptual model presented here, management initiatives aimed at increasing production efficiency through partial or complete privatization of individual households' grazing rights, based on the idea that pastoralism is characterized by 'the tragedy of the commons' in terms of resource management (Hardin 1968), may be at best seem as counterproductive because it can be viewed as increasing coordination problems with respect to extant social institutions that have the potential to increase production efficiency firmly embedded in local cultural practices.

NOTES

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Endnotes

[1] Cooperation as a form of adding labor to households is by no means the only one. Other options are for example (1) the fostering or borrowing of children from extended family or neighboring households, (2) hiring of extra labor, and (3) rich households can distribute their animals to poor households with excess labor (see e.g. Fratkin and Smith 1994; Hedlund 1979; Sieff 1997; Sperling and Galaty 1990). Of concern here, however, is the underlying rationale for the formation of cooperative herding groups that share labor, and the other options of recruiting additional labor will not be discussed in any detail.

[2] It is not implied that previous quantitative studies have been unaware of pastoral labor cooperatives. Scoones (1992:307), for example, argues that it may not be labor at the household level that is critical – instead labor may be shared among clusters of households. Also, Sieff (1997:542) argues that the lack of effects may suggest two things: (1) households

are not limited by labor, or (2) ”[…] they [the Datoga] are circumventing any labor shortages within their households either by borrowing herders from another household, or by having their animals herded in conjunction with the herds of another household.” Furthermore, Turner and Hiernaux (2008:78) argue that the lack of effects - or the prevalence of small effects - of household labor availability on grazing management may suggest that labor sharing among different households is both common and flexible. The point is that cooperative herding groups have previously been used just as an ad hoc explanation for the lack of effects on the household level, rather than as an explicit unit used for statistical analysis.

[3] Body mass is here related to slaughter weight. Live body mass has been found to be 1.92 times carcass weight in reindeer husbandry (Reimers 1983).

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FIGURES

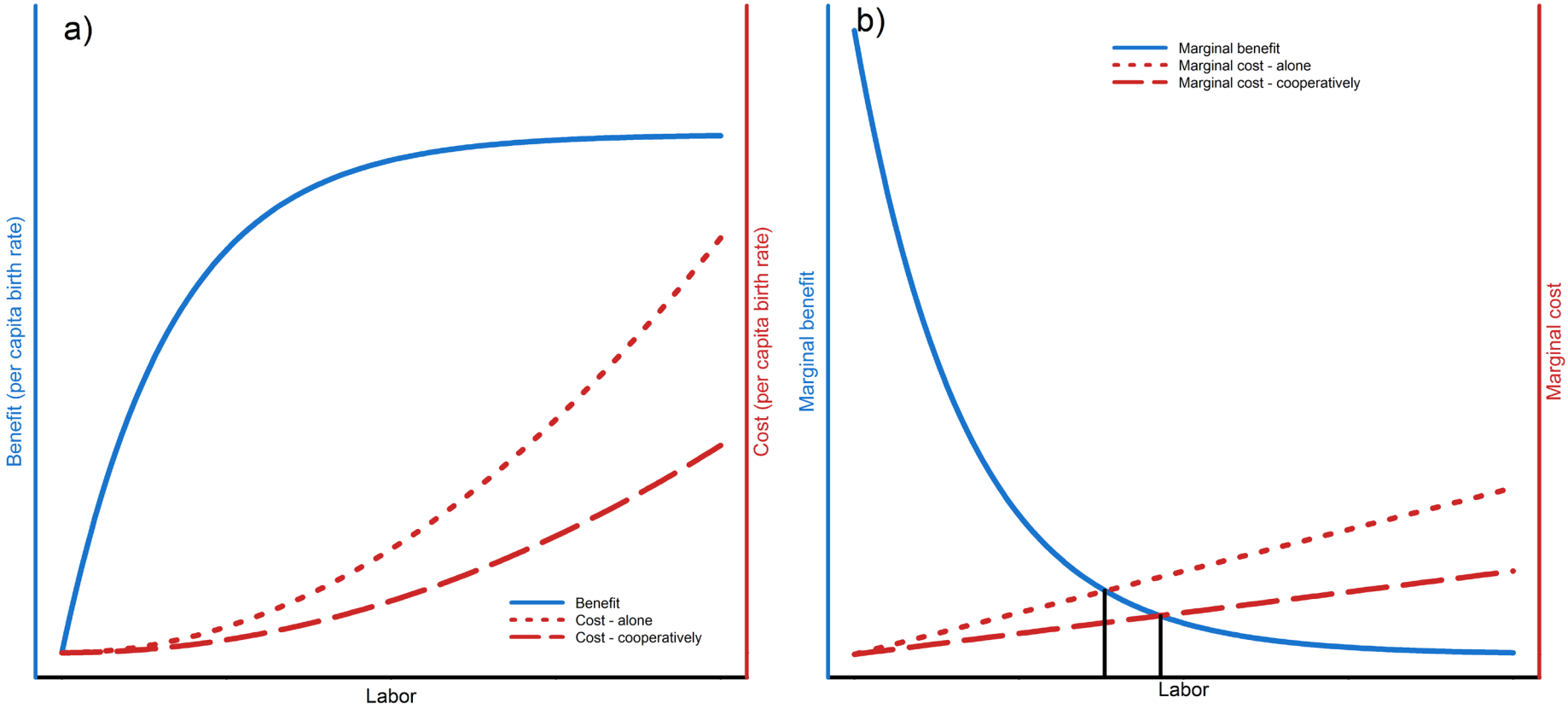

Figure 1. The functional relationships between labor investment and benefit (per capita birth rate, y-axis) and cost (per capita birth rate, z-axis). (a) Showing the benefit and the differential costs associated with investing labor alone and cooperatively. As costs are assumed to be reduced during cooperative labor investment, (b) shows how the optimal level of labor investment (defined as when the marginal benefit is equal to the

marginal cost) is higher when investing cooperatively than alone (optimal level of labor investment is indicated by the solid lines touching the x-axis). As a consequence, cooperation makes it possible to reap additional benefits in terms of birth rate (Figure made with the *R* software environment for statistical computing and graphics, R Development Core Team 2007).