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Original Article

Sending children to school: rural livelihoods and parental investment in education in northern Tanzania☆

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ABSTRACT

Evolutionary and economic models of the demographic transition argue that economic development incentivizes low-fertility, high-investment parental strategies, and that such strategies emerge first in relatively wealthy families within populations undergoing 'modernization'. However, most research focuses on fertility reduction rather than shifting parental investment, and few studies consider how parental decisions regarding educational investment vary in relation to alternative rural livelihoods. Using data from 19 villages and 1,719 children (7–19 years), we investigate the effects of diversifying livelihoods, wealth and child characteristics on multiple measures of educational investment in rural Tanzania. Children in (predominantly Maasai) pastoralist households were the least likely to attend school, while neighboring farmers and business owners invested more in education. Household wealth, as measured by asset ownership, was also independently positively associated with educational investment for all livelihood types. These results are consistent with lower opportunity costs and greater perceived economic pay-offs to education for relatively labor market-integrated and wealthy households. However, among pastoralists wealth held in livestock was not associated with educational investment. This result may reflect elevated opportunity costs related to the child labor demands of livestock herding. We find a marginal female advantage in education, which is surprising because qualitative research and numerous development projects in the region emphasize the disadvantages facing girls. We also find suggestive evidence of a later-born disadvantage (i.e. borderline statistically significant) consistent with the predicted consequences of sequential household resource dilution. Female advantage and later-born disadvantage were particularly evident in the wealthiest households. Greater reliability in the returns to education for wealthy households may favor preferential treatment of children with higher perceived long-term payoffs, while equal but lower-level investment in all children in relatively poor families may reflect a bet-hedging strategy. We discuss our results in light of parental investment theory and the wider literature on the demographic transition.

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1. Introduction

1.1. Parental investment in schooling, rural livelihoods and economic development

Human life history is characterized by high levels of parental investment, an extended period of juvenile dependency, and a reliance on complex skills acquired through social learning (Hill & Kaplan, 1999; Kaplan, Hill, Lancaster, & Hurtado, 2000; Mace, 2000). In many societies, the demands of costly parental investment are to some extent offset by the labor contributions of children, which subsidize their parents' continued reproduction (Kramer, 2011; Lee & Kramer, 2002; Turke, 1988). Optimal levels of fertility, parental investment and offspring time allocation are thus predicted to vary by socioecological factors, including the opportunities for both child and adult labor dictated by local livelihoods. Evolutionary and economic models of the demographic transition argue that shifts from subsistence to market economies increase dependency on skills acquired through formal education, devalue child labor, and strengthen the link between parental investment and offspring outcomes, incentivizing both fertility limitation and the further extension of juvenile dependency (Kaplan, 1996). Many researchers have suggested that such shifts may be adaptive in terms of long-term genetic fitness, provided substantial economic rewards are bestowed on descendants (e.g. Boone & Kessler, 1999; Mace, 1998). However, multigenerational studies suggest that modern below-

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replacement low fertility rates are unlikely to be fitness maximizing. Goodman, Koupil, and Lawson (2012), for example, demonstrate that across four generations of Swedish families, low fertility was associated with improved school results, higher levels of educational attainment and increased household incomes for descendants, but did not improve long-term descendant survival, marital or reproductive success (see also Borgerhoff Mulder, 1998a; Kaplan, Lancaster, Johnson, & Bock, 1995). Consequently, transitions to modern low fertility appear best understood as parental decisions to enhance self and offspring embodied capital in order to enhance economic and social success. However, in contexts where opportunities for skill and resource acquisition conflict with childbearing, and where the likelihood of offspring survival and reproduction is only weakly contingent on accumulated wealth, parental investment is decoupled from offspring reproductive success and decisions to invest in embodied capital appear not to maximize fitness (Goodman et al., 2012; Kaplan et al., 1995). While high investment in education and economic success may not be adaptive in post-transition environments, changes in parental investment decisions are undoubtedly central to our understanding of the demographic transition.

This viewpoint draws our attention directly to education, a fundamental component of parental investment that is believed to enhance a child's wellbeing and success worldwide. Trivers (1972: 139) defined parental investment as "*any investment by the parent in the offspring that increases the offspring's chance of survival (and hence reproductive success) at the cost of the parent's ability to invest in other offspring*". Parental investment can also enhance offspring reproductive success by improving close proxies such as economic success and social status. As communities undergo demographic and subsistence transitions, formal schooling replaces more traditional forms of learning as an important aspect of embodied capital acquisition. Schooling is costly to parents, both directly, through expenditure on school fees and supplies, and indirectly, because it reduces children's ability to offset their costs through economic contributions to their household. Here, we propose to shift evolutionary analyses of demographic transition from their traditional focus on fertility reduction to the variability in parental investment in education (see also Gibson & Lawson, 2011; Gibson & Sear, 2010).

In addition we address a broader need for studies of educational investment from specific rural communities undergoing economic change. As indicated by the inclusion of universal, equitable education in both the Millennium Development Goals (United Nations, 2015a) and their replacements the Sustainable Development Goals (United Nations, 2015b), investment in education is a key focus of development initiatives, yet much of what we know about investment in child health and education in the developing world comes from large-scale, highly aggregated national surveys, such as the Demographic and Health Surveys (e.g. Eloundou-Enyegue & Williams, 2006). While valuable in identifying broad trends, such surveys are inadequate for exploring patterns within communities, and typically lack appropriate data to consider the role of alternative rural livelihoods, such as differences between pastoralists and agriculturalists (Lawson & Uggla, 2014; Lawson et al., 2015). Livelihood variation is likely to be an important determinant of parental investment patterns, because reliance on child labor alters the opportunity costs of school attendance, and because the value of formal education in conferring skills relevant to the realities of adult livelihoods may differ.

In this paper, we explore patterns of child education in a region of northern Tanzania that has undergone rapid and recent uptake of education, but remains predominantly characterized by different degrees of reliance on subsistence-level farming and pastoralism and different access to education. Our data come from 19 villages sampled from one region as part of the Whole Village Project (Borgerhoff Mulder et al., 2010), selected in order to provide a snap-shot of recently diversified livelihoods. Three main ethnic groups occupy these villages: the Maasai, the Arusha and the Meru. While primarily pastoralist, in recent decades Maasai livelihoods have diversified, with increased levels of settlement and cultivation (Coast, 2002; Spear & Waller, 1993). The Arusha were originally Maasai pastoralists, who settled and became farmers two centuries ago, though cattle remain a key aspect of their livelihood strategy and they retain cultural similarities to the Maasai (Spear, 1997: 35). Finally, the Meru have traditionally been farmers, and were early adopters of cash crops such as coffee (Spear, 1997: 154). Compared to other ethnic groups in the region the Meru are relatively wealthy (Lawson et al., 2014). This sample thus encapsulates a broad range of livelihood strategies, from predominant reliance on pastoralism, through increasing degrees of subsistence agropastoralism, to commercial agriculture and business ownership, reflecting the development and accompanying subsistence transitions that have occurred in this area over the past century.

1.2. Predictions and prior literature

We derive a number of predictions regarding parental investment in child education in this setting concerning both parental and child characteristics. First, we consider variation in child education by livelihood type. There are a number of reasons to suspect that pastoralists generally face greater direct and indirect costs, and lower returns to children's education, compared to other livelihood groups. East African pastoralism is labor-intensive, requiring many workers to allow for flexible and specialized labor allocation, with households traditionally recruiting children from the ages of 6 or 7 (Sperling & Galaty, 1990). Herding also requires an all-day commitment, especially when grazing or water is far from households (Coppolillo, 2001), making herding largely incompatible with school attendance, in contrast to farm work, which can be done before or after school hours. This dependence on child labor, as well as long journeys to school, increases the opportunity costs of attending school for pastoralists compared to households relying on cultivation (Bishop, 2007; Heffernan, Misturelli, & Nielsen, 2001; Holland, 1996). Maasai pastoralists tend to be poorer than neighboring farming populations, at least when wealth is assessed in terms of material assets (e.g. Lawson et al., 2014), suggesting that pastoralists are also less able to meet the direct costs of schooling. Poor child health, and so presumably higher child mortality rates, associated with poverty among pastoralist populations may also reduce the certainty of the long-term returns on investment in education (Lawson et al., 2014). These higher costs and lower returns to education are evidenced by the perception of formal education as 'practically irrelevant' to a pastoralist way of life (Bishop, 2007). These perceptions are compounded by the difficulties faced by pastoralist children in accessing education, including stigmatization by teachers and peers, language barriers, and the lack of viable employment alternatives in rural areas (Bishop, 2007; Dyer, 2010). By contrast, parents with salaried jobs or small businesses may perceive skills taught in school to be more relevant and useful for their children's futures, and may be more likely, or better able, to take advantage of the job opportunities made available by formal education. This leads to the prediction that (1) *educational investment will be lower for children in pastoralist households, intermediate for those in farming households, and highest for those in business-owning households.*

Taking advantage of within-village variation in livelihoods, we use a multilevel framework to test this prediction, effectively contrasting households by occupation within the same local socioecological context, using random effects for village. While it is recognized that pastoralists are often disadvantaged in access to education, the extent to which this is attributable to their livelihood strategy independently of their relative poverty is unclear. By adjusting for household wealth, we aim to determine the extent to which livelihood strategy, insofar as it shifts the costs and possibly the benefits of education, influences educational investment over and above household economic status.

Second, we consider how variation in household wealth influences school enrolment within communities. Wealthier households are better able to meet the direct costs of schooling, and are more certain of investment returns due to lower mortality rates (Kaplan, 1996; Kaplan, Lancaster, Tucker, & Anderson, 2002). Additionally they have lower opportunity costs through being less reliant on child labor, as they are able

to hire extra workers, or recruit from client households if needed (Borgerhoff Mulder & Sellen, 1994). In historic European demographic transitions, there is evidence that the wealthiest were the first to adopt fertility limitation (Clark & Cummins, 2009; Coale & Treadway, 1986), and the first to invest in education for their children (Lesthaeghe & Wilson, 1986). We explore the evidence for this pattern in our sample, but also consider whether or not household wealth has the same consequences for education outcomes among both farmers and pastoralists. Studies of pastoralist groups have documented large differences in household wealth, but little effect of wealth on child growth and nutrition (Grandin, 1988; Sellen, 2003). It has been suggested that this may be due to wealth, food and labor transfers between households leveling inter-household differences, or different priorities within households leading to excess wealth being invested into extra cattle or wives for men, rather than extra investment in existing children (Sellen, 2003; Sieff, 1997). While decisions about educational investment are likely to involve different considerations, Bishop (2007) did observe that the proportion of children enrolled in school did not differ significantly according to wealth in a small-scale study of Tanzanian Maasai pastoralists. Wealthier pastoralist households typically have larger herds and therefore greater labor requirements than poorer households, so despite being better able to meet the direct costs of schooling, they may face greater opportunity costs due to their greater need for child herding labor (Bishop, 2007; Sellen, 2003). It is therefore predicted that (2) *educational investment will increase with household wealth but to a lesser extent among pastoralists than among farmers or business-owners.*

Third, we examine evidence for biased parental investment in terms of child sex and birth order. Evolutionary and economic models lead to a general prediction that parents will strategically focus investment into children with the greatest (perceived) returns in the long-term. In evolutionary models payoffs are ultimately measured as reproductive success, but outcomes such as mating or economic competition may serve as more salient proxies guiding behavior. Many factors may influence the pay-offs to investing preferentially in sons or daughters (Borgerhoff Mulder, 1998b; Sear, 2011), and evolutionary anthropologists have been instrumental in documenting cases of both son and daughter-bias in parental investment in rural East African populations (Borgerhoff Mulder, 1998b; Cronk, 1989; Gibson & Lawson, 2011; Gibson & Sear, 2010; Mace & Sear, 1997). Recently the Trivers and Willard (1973) hypothesis has been applied to educational investment in western populations (Hopcroft & Martin, 2014). The Trivers–Willard hypothesis stipulates that investment will be biased towards the sex with the greater variance in reproductive success, so long as reproductive success is influenced by parental investment. Under such conditions, which may occur for example in polygynous contexts where men can accumulate multiple wives, the fitness returns to producing a daughter will be higher for relatively poor parents while the returns to producing a son will be higher for relatively rich parents. There is some support for Trivers–Willard effects on sex-ratio biasing at birth in humans (e.g. Gibson & Mace, 2003). However, whether or not post-natal investment is predicted to follow a Trivers–Willard pattern is a point of some confusion in the literature (Hartung, 1997; Keller, Nesse, & Hofferth, 2001). This is because the comparative fitness value of producing a son versus a daughter can vary independently of the marginal fitness returns of investing in current offspring of either sex. Indeed if male reproductive (and economic) success is more closely predicted by parental investment, then post-natal investment, at least when not closely linked to survival, is predicted to favor males across the population independent of parental wealth (Keller et al., 2001). Furthermore, in patrilocal societies not just offspring, but also parents are more likely to benefit from investing in sons' over daughters economic success, because the benefits of daughters' education are perceived to accrue to her husband's family (Grogan, 2007). In sub-Saharan Africa as a whole, gender bias in education is evident, with girls being less likely to be enrolled in school than boys, particularly for secondary education (United Nations, 2013).

Where birth order has been shown to matter, later-born children are most often disadvantaged, with numerous studies reporting detrimental effects of older siblings on indicators of both reproductive and economic success (e.g. Borgerhoff Mulder, 1998b; Gibson & Lawson, 2011; Gibson & Sear, 2010; Mace, 1996). With regard to parental investments during childhood, such bias may simply reflect household resource dilution; finite resources must be shared between all living children, and early-born children experience more time in a household with fewer competitors, prior to the birth of subsequent siblings (Hertwig, Davis, & Sulloway, 2002). On the other hand, older siblings may also work to provide assistance towards the education of younger children, and diminishing returns to additional labor may decrease the opportunity costs of younger children's schooling (Borgerhoff Mulder, 1998b; see Chernichovsky, 1985 for evidence from Botswana; Gomes, 1984 for Kenya). Bias towards early-born offspring is also predicted by some theoretical models because first-borns are typically of higher reproductive value than later borns at any one point in time when parental investment decisions are being made. This is both because older children are closer to beginning their own reproduction, and because child mortality rates tend to decrease with increasing age (Clutton-Brock, 1991). In light of these considerations we predict that (3) *educational investment will be lower in daughters and later-born children.*

Finally, we consider whether variation in wealth influences patterns of gender and birth order-biased parental investment. This research question is perhaps particularly interesting in the face of contrasting predictions and seemingly contrary findings at alternative scales of analysis in the existing literature. At a national level, economic development is generally associated with a closing gender gap in education, with literature emphasizing changing social norms and a relaxation of the resource constraints that lead to biased investment (United Nations, 2013). As such wealthier households within communities might be anticipated to abandon strategies of biased parental investment in parallel with macro-level trends. Yet, recent studies examining parental investment in education *within* developing rural communities have reported that patterns of biased investment are exaggerated in the wealthiest households. Gibson and Sear (2010) for example found in a study of rural communities in Ethiopia and Malawi that educational investment (measured as any education and total years of education respectively) was higher for early-born sons and daughters respectively, and that these birth order biases were most pronounced among the wealthiest households (Gibson & Sear, 2010). In Ethiopia, villages with recently installed water taps, where child mortality had substantially decreased, were found to have higher overall levels of school enrolment. However, villages with taps also showed greater discrimination by birth order, with later-borns receiving less education than their older siblings (Gibson & Lawson, 2011). These findings have been interpreted as an indication of the emergence of high parental investment strategies in contexts of increasing perceived returns to education, but where fertility remains relatively high and resources too scarce to enable high investment in all children. In such circumstances, parents may choose to invest preferentially in specific children rather than spread investments equally across all children. In contrast relatively poor families face higher levels of extrinsic risk and uncertainty over the returns to investment, making it harder for parents to predict which offspring will have the most favorable prospects, and favoring a 'bet-hedging' strategy of low, but relatively equal investment in all offspring (Liddell, Barrett, & Henzi, 2003). Here we seek to replicate these findings predicting (4) *biases in educational investment by gender and birth order will be more pronounced in wealthier households.*

2. Materials and methods

2.1. The Whole Village Project

This study uses data from the Whole Village Project (WVP), a research project conducted by the Tanzanian non-governmental

organization (NGO) Savannas Forever Tanzania (SFTZ) in collaboration with the University of Minnesota and the National Institute of Medical Research (NIMR). The WVP collects data from 56 villages in Northern Tanzania, in order to support the evaluation of development projects in the region, and to provide a source of data about rural Tanzania. Villages were sampled partly according to the needs of development agency partners, but efforts were made to randomize selection and to ensure a wide geographic spread of villages. Within villages, 60–75 households were randomly sampled from a list provided by village administrators. For a general description of the WVP, see Borgerhoff Mulder et al. (2010), or the SFTZ website (www.sftz.org). The WVP received ethical approval from the University of Minnesota (Institutional Review Board code number: 0905S65241) and from the National Health Research Ethics Review Committee at NIMR.

The current study utilizes data on 19 WVP villages in the Arusha region, a subsample selected to allow for the comparison of different livelihood strategies within the same administrative context and geographic area, giving a working sample of 1,215 households used in our analysis (with an additional 74 households excluded due to incomplete data on household wealth, livelihood or ethnicity). Table 1 contains information on the demographic and socioeconomic characteristics of the households in this sample.

2.2. Wealth and livelihood measures

For each household, several wealth and livelihood measures were recorded, including asset ownership, food insecurity, livestock ownership, and the amount of land cultivated. Livelihood was determined by the main occupation stated by the household head. Those who stated 'Other' activities were included as 'Farmers', as the majority reported cultivating land and had similar patterns of asset ownership. A continuous household wealth index was calculated on the basis of a principal component analysis (PCA). The PCA was applied to a total of 37 dichotomous variables representing ownership of assets and characteristics of assets at the household level (for more information see the online supplementary material to Lawson et al., 2014). The household wealth index ranged in value from 0.14 to 17.8 (mean = 3.52, standard deviation (SD) = 2.85). Livestock ownership was not included in the assets used to create the index, and so this measure should be interpreted as a 'non-livestock wealth index'.

Anthropological studies often use livestock ownership as the most salient indicator of wealth for pastoralist communities, where ownership of consumer durables may be rare and incompatible with a nomadic lifestyle (e.g. Borgerhoff Mulder, 1998b; Mace, 1996; Sellen, 2003; Sieff, 1997). In this dataset, ownership of large livestock (cattle, horses, donkeys and mules) was converted into Tropical Livestock Units (TLUs) using the conversion factors listed in Jahnke, Tacher, Keil, and Rojat (1988). As the distribution of TLUs was highly skewed, with many households having few livestock and a few having very large herds, a log transformation was used. Food insecurity was measured using the Household Food Insecurity Access Scale (HFIAS), which assesses the extent to which households experienced problems accessing food during the last 30 days (Coates, Swindale, & Bilinsky, 2007). Among pastoralists, TLUs are correlated with increased wealth ($r = 0.18$, $p < 0.001$), but there is no correlation between TLUs and wealth index for farmers or business owners ($r = -0.01$, $p = 0.797$), suggesting that TLUs do not serve as an appropriate indicator of wealth across the whole sample. Bishop (2007) conducted qualitative wealth ranking exercises among Maasai men in Arusha, and found that they did emphasize material assets such as modern housing, as well as livestock, as an indicator of wealth. The asset-derived wealth index is therefore used as the principal proxy of economic status in this analysis, though models were also run substituting the log transformation of the TLU variable for the wealth index variable for pastoralists only.

2.3. Measuring 'educational investment': enrolment, progression and years of education

Education in Tanzania is compulsory between the ages of 7 and 14. The education system includes seven years of primary education (i.e. the compulsory component), four years of 'ordinary-level' secondary education, and two years of 'advanced-level' secondary education. Primary schools are free (although there are costs like uniform, shoes and miscellaneous requests for school funds that can be quite significant for the poorest households), and the language of instruction is in the national language Swahili. Fees must be paid for secondary school, and the language of instruction changes to English, although Swahili may often be used in practice (UNESCO, 2011). Net primary school enrolment has increased dramatically, from 49% in 1999 to 83% in 2013, though there has been a decline from 97% in 2008 (World Bank, 2015). Gender equality in access to education has improved at primary level, but girls are underrepresented at secondary and higher level (UNESCO, 2011). Less than 60% of boys and girls progress to secondary school, and there are concerns over the low quality of schooling available, and the failure to attract well-qualified teachers, especially to rural areas (United Nations, 2015c; World Bank, 2015).

We use three measures of educational investment for children identified as the biological child of the household head ($n = 1{,}803$). These measures were generated from a household survey question asking "What is the highest level of education reached by this person?", for all household members above the age of 5, which provided valid responses for 1,719 (95.3%) cases. Those with 'none' or 'nursery' listed as their highest level of education were assumed never to have attended school. Those answering Form 1 (first year of secondary school education) or above were assumed to have completed primary education and progressed to secondary school. Two binary variables were therefore generated; (i) *Ever educated*, indicating whether an individual had ever attended school, and (ii) *Progressed*, indicating whether an individual aged 14 or over had progressed to secondary school. A third variable, *Edyears*, was generated from the highest level reached as an indicator of the total years of education, for example an individual who had reached Standard 1 (first year of school) was assumed to have one year of education.

2.4. Child characteristics

Child age, gender and a proxy for birth order were included in our analysis. The birth order proxy was generated by ordering biological children within the same household by age and assigning them a rank, with the oldest child being first. This measure is thus a reflection of 'social birth order', rather than biological birth order, indicating an individual's age rank relative to other school-aged children within the same household. This proxy is used because data were only collected for individuals resident within the household, rather than complete birth histories. This means that children in our sample may have older siblings who have left the household. Therefore, a child may be the oldest within a household, but is not necessarily their parents' first biological child. While this is a limitation of the measure, social birth order provides a measure of the availability of substitute labor within the household, a key factor affecting the opportunity costs of children's school attendance. Following this definition, birth order ranged from 1 to 9, and was categorized into three groups for analysis, consisting of first or second-born children ($n = 1{,}049$), third or fourth-born children ($n = 529$) and fifth or later-born children ($n = 141$).

2.5. Data analysis

We used multilevel logistic and linear regression to evaluate the evidence behind each of our predictions. All models were fit using maximum likelihood estimation in Stata version 13.1. The commands 'xtmelogit' and 'mixed' were used to account for the clustering of

Table 1
Household characteristics by livelihood (stated primary occupation of household head).

Livelihood	Pastoralists	Farmers	Business	Total
N	380	751	84	1215
Ethnic group (%)				
Maasai	92.1	23.3	25.0	44.9
Arusha	5.0	23.4	20.2	17.4
Meru	1.8	34.1	33.3	24.0
Other	1.1	19.2	21.4	13.7
Household head education (%)				
None / nursery	71.8	33.8	24.3	45.1
Primary	25.7	59.7	52.7	48.6
Secondary or above	2.4	6.5	23.0	6.3
Wealth index (mean score)	1.6	3.9	5.7	3.3
Food insecurity score (mean score)	16.0	10.2	8.2	11.9
Acres cultivated (mean acres)	1.7	2.6	2.5	2.3
Livestock owned (mean TLU)	6.4	2.4	2.8	3.7
Household size (mean number of people)	5.4	5.3	5.0	5.3

children (Level 1, n = 1719) within villages (Level 2, n = 19) using random intercepts. Failure to adjust estimates for the effect of non-independent sampling increases the risk of Type I error, and can obscure trends within communities masked when data are analyzed at aggregate levels (e.g. Lawson et al., 2015). An intermediate random effect for household is not included because there were only 1.7, 1.5 and 2.3 children per household for *Ever educated*, *Progressed* and *Edyears* respectively, and when clusters (i.e. households) are unbalanced and sparsely populated, there is the risk that both fixed and random effects may be overestimated (Clarke, 2008). All models included child age in years. Separate models were run for each outcome: (i) for the sample of 7–13 year olds, with *Ever educated* as the outcome, (ii) for the sample of 14–19 year olds with *Progressed* as the outcome, and (iii) for all school-aged individuals with *Edyears* as the outcome. A first set of models was run without interactions to assess the main effects of livelihood, wealth, gender, and birth order. A second set of models added in interactions between livelihood and wealth, livelihood and gender, wealth and gender, and wealth and birth order, keeping interactions found to be significant in the final models.

3. Results

3.1. Descriptive statistics

Table 1 shows various household characteristics by livelihood category. Just over half of the sample classify themselves as farmers, with only a small proportion of households being engaged primarily in business or a professional job. However, the data on land use and livestock ownership indicate that households maintain a certain degree of diversity in livelihood, with 66% of households both cultivating land and owning livestock. A large overlap between livelihood and ethnic group can be seen, with 92% of pastoralists being Maasai. Pastoralists experienced a greater degree of food insecurity, and were poorer than farmers and business owners on average, and household heads had a lower level of education (see also Lawson et al., 2014).

At age 13, 90% of children (n = 129) had at least some education, indicating that the majority of children do at least enroll in primary school. Fewer children progress to secondary school, with 48% of those aged 19 (n = 86) having progressed. At age 13, individuals have on average 5.0 (SD = 2.1) years of education, increasing to an average of 7.5 (SD = 3.5) years of education at age 19. It therefore appears that most children attend and progress through primary school, but a much lower proportion progress to secondary school, and very few get more than one or two years of secondary education.

3.2. How do education outcomes vary by livelihood?

Our first prediction was that educational investment would be lower for children in pastoralist households, intermediate for those in farming households, and highest for those in business/professional households. The results in Table 2 demonstrate that children in pastoralist households are disadvantaged compared to farming and business households in all three education outcomes. Even after adjustment for differences in household wealth, children in farming households have 1.9 (95% confidence interval (CI): 1.2–3.1, $p = 0.011$) times the odds of having ever been in school, and 2.4 (95% CI: 1.2–5.0, $p = 0.013$) times the odds of progressing to secondary school, compared with children in pastoralist households. Those in business households have 3.7 (95% CI: 1.4–9.6, $p = 0.009$) times the odds of having ever been in school, and 5.8 (95% CI: 2.0–16.7, $p = 0.001$) times the odds of progressing to secondary school. That these effects remain after adjusting for household wealth indicates that lower educational investment by pastoralist households is not solely due to their relative poverty. Fig. 1 shows the mean years of education by age for each livelihood group, demonstrating that pastoralist children have fewer years of education at all ages compared with children in farming or business households. The effect of livelihood on years of education increases with age, with less differentiation between livelihoods at younger ages.

3.3. Socioeconomic gradients in education outcomes across livelihoods

Our second prediction was that educational investment would increase with household wealth, but to a lesser extent among pastoralists than among farmers or business-owners. Wealth did have a significant effect on all educational outcomes, with each unit increase in wealth giving 1.3 (95% CI: 1.2–1.4, $p < 0.001$) times the odds of ever having been in school and 1.2 (95% CI: 1.1–1.3, $p < 0.001$) times the odds of progressing to secondary school, and on average 0.2 (95% CI: 0.1–0.2, $p < 0.001$) more years of education (Table 2). An interaction between wealth and livelihood (see Table S2 in supplementary material, available on the journal's website at www.ehbonline.org), was not found to be significant, indicating that the effect of wealth on education outcomes is similar in all three livelihood groups. However, when wealth is measured in terms of livestock (TLU) for pastoralists, there is no significant effect of wealth on education outcomes (Table 3).

3.4. Education outcomes by gender and birth order

Our third prediction was that educational investment would be lower in daughters and later-born children. Gender was not found to be a predictor of having ever been in school for those aged 7 to 13, but daughters aged 14 to 19 had 3.5 (95% CI: 2.3–5.4, $p < 0.001$) times the odds of progressing to secondary school compared to sons (Table 2). Daughters also had an advantage over sons in total years of education, having on average 0.4 years more for their age (95% CI: 0.2–0.6, $p < 0.001$). Thus the female advantage appears to be driven by daughters being more likely to progress to secondary school than sons. An interaction between gender and livelihood was not significant (see Table S2 in supplementary material, available on the journal's website at www.ehbonline.org), though the direction of effect suggests that daughters aged 7 to 13 may be less advantaged among pastoralists than among farmers or business-owning households.

While the main effect of social birth order was not significant at the $p < 0.05$ level for any outcome (see Table 2), there is a marginal trend ($p < 0.1$) towards children with more older siblings in their household having fewer years of education for their age compared to earlier-born children.

Table 2
Multilevel logistic and linear regression models for effect of livelihood, wealth, gender and social birth order on education outcomes. For each outcome, the left-hand model shows the basic effects of each predictor, while the right-hand model includes interactions between wealth and gender, and wealth and social birth order.

	Ever educated (age 7 to 13)		Progressed to secondary school (age 14 to 19)		Years of education (age 7 to 19)	
	Odds ratios				β coefficients	
Observations	1112		607		1719	
Mean-centered age (years)[a]	1.49**	1.50**	1.43**	1.44**	0.55**	0.55**
	[1.35, 1.63]	[1.37, 1.65]	[1.27, 1.62]	[1.27, 1.63]	[0.52, 0.58]	[0.52, 0.58]
Livelihood (reference = pastoralists)						
Farmers	1.88*	1.83*	2.44*	2.41*	0.65**	0.66**
	[1.16, 3.05]	[1.12, 2.97]	[1.19, 4.99]	[1.18, 4.94]	[0.35, 0.96]	[0.36, 0.97]
Business	3.65**	3.59*	5.83**	5.49**	0.99**	1.02**
	[1.39, 9.60]	[1.36, 9.50]	[2.04, 16.69]	[1.91, 15.82]	[0.54, 1.45]	[0.57, 1.47]
Household wealth index	1.30**	1.59**	1.20**	1.27**	0.16**	0.16**
	[1.17, 1.45]	[1.30, 1.94]	[1.11, 1.31]	[1.10, 1.45]	[0.12, 0.20]	[0.09, 0.22]
Gender (reference = male)						
Female	1.00	0.75	3.50**	4.40**	0.40**	0.14
	[0.71, 1.40]	[0.44, 1.29]	[2.28, 5.36]	[2.06, 9.38]	[0.21, 0.59]	[−0.17, 0.44]
Social birth order (reference = 1–2)						
3–4	0.86	1.97*	1.19	1.52	0.00	0.31+
	[0.60, 1.24]	[1.08, 3.60]	[0.72, 1.96]	[0.64, 3.59]	[−0.21, 0.21]	[−0.03, 0.64]
5+	0.95	2.76*	1.43	0.98	−0.35+	−0.27
	[0.55, 1.63]	[1.17, 6.53]	[0.46, 4.45]	[0.09, 11.28]	[−0.71, 0.01]	[−0.85, 0.30]
Wealth # gender interaction						
Wealth # female		1.14		0.94		0.07*
		[0.95, 1.36]		[0.81, 1.10]		[0.00, 0.14]
Wealth # social birth order interaction						
Wealth # 3–4		0.69**		0.94		−0.08*
		[0.56, 0.86]		[0.80, 1.11]		[−0.16, −0.01]
Wealth # 5+		0.62**		1.07		−0.02
		[0.47, 0.83]		[0.71, 1.62]		[−0.15, 0.10]
Constant	1.77+	1.19	0.04**	0.04**	2.84**	2.85**
	[0.95, 3.31]	[0.58, 2.41]	[0.02, 0.10]	[0.01, 0.09]	[2.44, 3.23]	[2.43, 3.27]
Between village variance	0.83	0.82	0.77	0.77	0.37**	0.37**
	[0.54, 1.28]	[0.53, 1.28]	[0.47, 1.27]	[0.47, 1.26]	[0.18, 0.77]	[0.18, 0.77]
Within village variance					3.90**	3.88**
					[3.65, 4.17]	[3.62, 4.15]

95% confidence intervals in brackets.
[a] Age was centered at the mean age for each outcome.
+ $p < 0.1$.
* $p < 0.05$.
** $p < 0.01$.

3.5. Does increasing wealth alter parental investment biases?

There is mixed evidence for our final prediction that biases by gender and birth order would be more pronounced in wealthier households. Supporting our predictions, there are statistically significant interactions between wealth and gender and between wealth and social birth order in models predicting the total number of years educated for children between 7 and 19 years (Table 2). These interactions are graphically represented as predicted years of education in Fig. 2. With regard to gender, we estimate that the relative advantage for daughters is larger in the wealthiest households (Fig. 2 panel a). For social birth

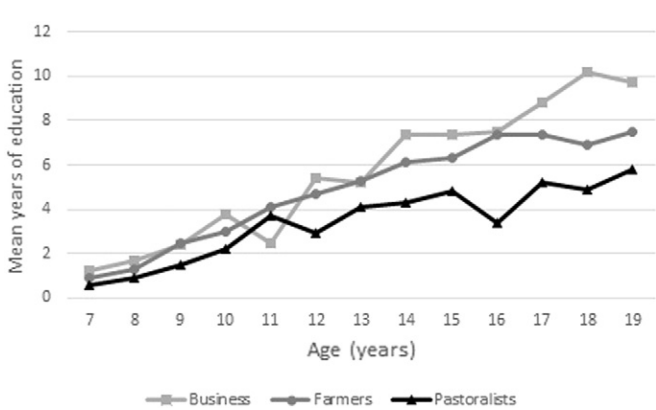

Fig. 1. Years of education by livelihood. Children in pastoralist households have fewer years of education than children in farming and business owning households, and this difference increases with age.

Table 3
Multilevel logistic and linear regression models for effect of Tropical Livestock Unit (TLU) ownership on educational outcomes.

	Ever educated (age 7 to 13)	Progression to secondary school (age 14 to 19)	Years of education (age 7 to 19)
	Odds ratios		β coefficients
Observations	340	147	487
Mean-centered age (years)[a]	1.39**	1.85**	0.43**
	[1.22, 1.57]	[1.33, 2.57]	[0.37, 0.49]
Log TLU large	0.91	1.1	0.18
	[0.69, 1.20]	[0.65, 1.86]	[−0.07, 0.42]
Constant	2.41*	0.12**	2.90**
	[1.17, 4.99]	[0.05, 0.31]	[2.23, 3.58]
Between village variation	0.73	0.00[b]	2.93**
	[0.36, 1.50]	[0.00, .]	[2.26, 3.61]
Within village variation			0.85**
			[0.78, 0.91]

95% confidence intervals in brackets.
[a] Age was centered at the mean age for each outcome.
[b] Between village variation was not significant but multilevel results are presented for consistency.
* $p < 0.05$.
** $p < 0.01$.

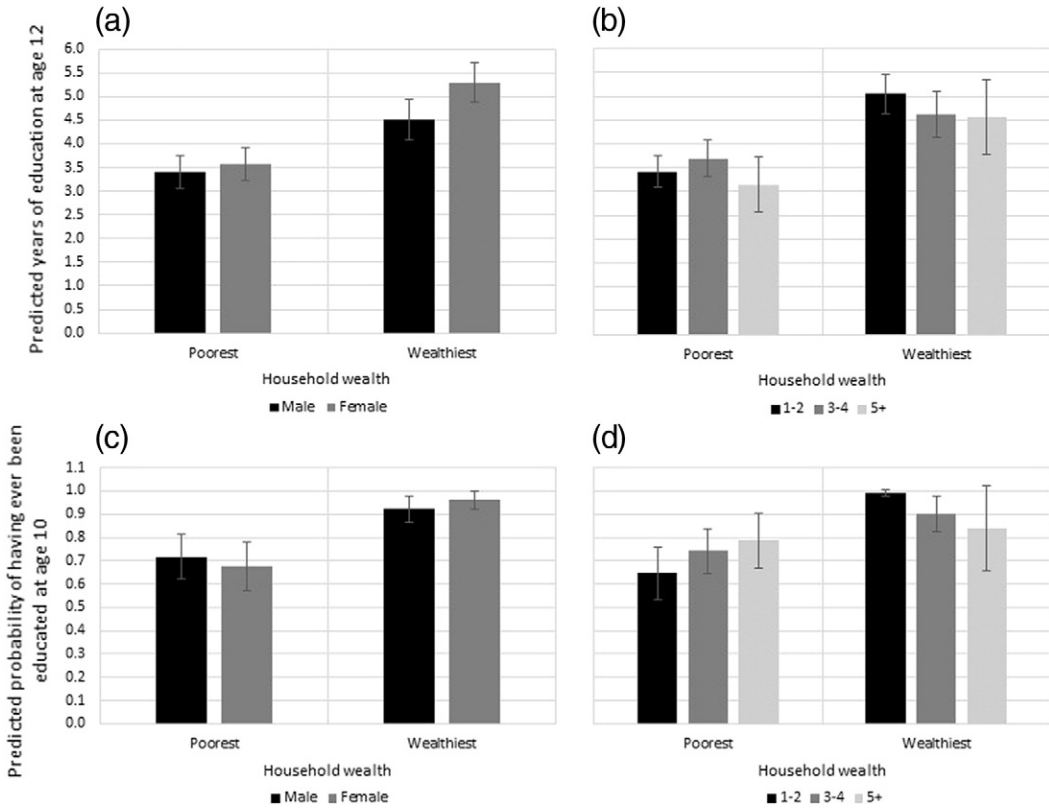

Fig. 2. Predicted years of education at age 12, by (a) household wealth and gender and (b) household wealth and birth order, and predicted probability of having ever been educated at age 10 by (c) household wealth and gender and (d) household wealth and birth order. Daughters receive more years of education than sons in wealthy households, but not in the poorest households. Greater household wealth increased the probability of ever going to school for all children with no significant interaction with gender. In terms of both years of education and the probability of ever attending school, significant interactions between birth order and household wealth indicate that a modest advantage to earlier-born children is apparent in wealthy households. See Table 2 for effect estimates. Values for household wealth: 'Poorest' = 5% centile, and 'Wealthiest' = 95% centile.

order, predicted values suggest that earlier-born children are only likely to be advantaged among wealthier households (Fig. 2 panel b). Fig. 2 also plots estimated interactions between wealth and gender and wealth and birth order for the predicted probabilities of ever attending school for children between 7 and 13 years (converting from the odds ratios in Table 2). The estimated interaction between wealth and gender for this outcome is non-significant (Table 2). However, there is a significant interaction between wealth and social birth order, suggesting that increasing household wealth is most likely to be channeled into earlier-born children within the household. Interactions between wealth and gender or wealth and birth order were non-significant for the odds of secondary school progression.

4. Discussion

4.1. Rural livelihoods and educational investment

The international development sector strongly emphasizes the benefits of education, including improved prospects on the adult labor market, access to information and the empowerment to better pursue individual goals that ultimately advance human capital at both individual and aggregate levels. Yet, whether or not to send children to school presents a dilemma for parents living in developing rural communities, even when resources are available. On the one hand, education holds the promise of white-collar jobs and improved economic and social status. However, for many, the poor quality of available schooling and the lack of viable labor markets make educational investment a risky gamble. This will be particularly the case when formal schooling restricts opportunities for children to contribute back to the household economy they in turn rely upon for future investment. Moreover, children's work at home can present its own, potentially more valuable, opportunities to learn skills specific to local subsistence, which for some families may be more useful and relevant to their future wellbeing. These cautionary points follow clearly from evolutionary anthropological scholarship on human life history which has, for example, emphasized that high fertility rates are sustainable partly because older children are recruited as 'helpers at the nest' (Kramer, 2011), and the importance of childhood as a period for acquiring the skills necessary for competent adult functioning (Kaplan, 1996; Kaplan & Bock, 2001). As such, we must interpret educational investment as a form of parental investment that can be explained through consideration of its benefits and costs to parents and children, which will vary according to socioeconomic context, and by child characteristics such as gender.

Supporting our predictions, children in households identifying as pastoralists (predominantly Maasai households in this context) had the lowest levels of education across all three outcomes. Our findings are consistent with qualitative studies that have documented the barriers to education faced by Maasai pastoralists (Bishop, 2007; Coast, 2002; Holland, 1996). That this educational 'disadvantage' remains after the inclusion of random effects for village and statistical adjustments for wealth between households, suggests that such differences cannot simply be accounted for by differences in poverty, or by differential access to schools, which we presume is similar for pastoralists, farmers and business owners living in the same villages (although we acknowledge pastoralist households may often reside further from village centers). Instead it seems likely that, over and above these factors, pastoralists perceive lower benefits and higher opportunity costs to formally educating children. Thus we emphasize the role of demand, rather than simply supply, in explaining patterns of educational attainment. Low perceived benefits may stem from the fact that, as a marginalized population subgroup, the Maasai are often most distant from viable labor markets dependent on formal education. High perceived

opportunity costs on the other hand may be the product of a 'damaging trade-off' (Siele, Swift, & Kratli, 2013: 206) parents face between sending children to school, or engaging children in specialist work and learning at home to support vulnerable homesteads. Such trade-offs are not unique to pastoralists, but responsibilities of herding and caring for livestock typically begin at a very young age (6–7 years) and herding activities are generally difficult to combine with education because they occupy children for most of the day and may involve taking livestock far outside of villages (Sperling & Galaty, 1990). Children supporting farming or business-owning households may be better able to combine work and school because work does not necessarily involve leaving the village. Interestingly we observe greater differentiation by livelihood at the progression to secondary education compared to early education. This may reflect growing responsibilities with age, as well as the greater distances to secondary schools, and relaxed external pressure to enroll children, as only primary education is officially mandatory in Tanzania.

We also found evidence for our prediction that wealthier households would invest more in educational attainment. Increasing household wealth is expected to improve educational outcomes as wealthier parents are better able to bear the costs of schooling, and may also perceive greater benefits to education following higher certainty in the returns to investment (i.e. lower extrinsic risk) and the ability to capitalize on education and employment opportunities. This pattern was seen during the European demographic transition, when wealthier parents were the first to adopt a more quality-focused strategy, investing in education and reducing their fertility (Coale & Treadway, 1986; Lesthaeghe & Wilson, 1986). The effect of wealth in our study increased with age, which may reflect the increasing direct costs of education, as primary education is free but fees must be paid for secondary school. It may also reflect the higher opportunity costs of education at older ages, as teenagers in poorer households may be required to contribute labor or income to the household.

Household wealth measured through the asset index appeared to have similar effects on educational outcomes among all livelihoods, contrary to the prediction that outcomes would be similar for pastoralist children regardless of household wealth. However, little effect of household livestock ownership on educational outcomes among pastoralists was found. This supports Bishop's (2007) finding of little differentiation by livestock wealth in education, which she attributed to the greater labor requirements in households with larger herds increasing the opportunity costs of schooling. The differing effects of the two types of wealth (material assets and livestock) may reflect the diversification of pastoralist livelihoods in this area; in recent years material wealth and education have become more important status symbols, and educated individuals often prefer to only keep a small herd (Bishop, 2007; Heffernan et al., 2001). Thus we may be observing a pattern of more 'modern' households accruing material wealth and investing in education for their children, and more 'traditional' households accruing livestock wealth and investing less in education.

4.2. Biased parental investment and economic development

We expected that educational investment would be lower in daughters than sons, assuming men are more able to capitalize on education than women, and because in the patrilocal groups comprising our sample, parents may have more opportunity to recoup benefits from investment in sons rather than daughters, who marry out into other families. Levels of adult education reveal a history of female disadvantage in education in our sample, with 67% of men aged 20 and over having received some education compared to 58% of women. Previous studies have also emphasized the 'double disadvantage' faced specifically by pastoralist girls and women. Historically, Maasai pastoralist women have had low status in comparison to men (Llewellyn-Davies, 1981), and recent qualitative studies have reported that among some Tanzanian Maasai communities girls face barriers such as open resistance to girls' education among community leaders, and the belief that girls' education is a 'waste of money', as girls are expected to move to their husband's family home (Holland, 1996; Kiragu & Warrington, 2012; Raymond, 2014; Temba, Warioba, & Msabila, 2013). However, in this sample girls receive greater educational investment overall, with higher odds of progression to secondary education and greater total years of education obtained than boys. There is some evidence that this biased investment into female education is driven by differences among the wealthiest families. This suggests that investment in girls' education has not only caught up with investment in boys' education in recent years, but in contemporary cohorts, and particularly for wealthy families, our data suggest a marginal bias to preferentially educating girls.

Global trends of rising investment in girls' education are generally understood to reflect a number of shifts accompanying economic development, including relatively delayed and/or reduced early fertility that competes with education, and increased opportunities for female labor market participation. In most developed countries, gender parity in education was reached several decades ago, with the most recent cohorts now showing that more women than men attend and complete tertiary education, leading policy debates in some instances to shift focus on to increasing male attainment (Pekkarinen, 2012). The reasons for this female bias are still being unraveled, but appear to be partly a function of a higher susceptibility of men to behavioral and mental difficulties which do not favor educational progression (Becker, Hubbard, & Murphy, 2010; Pekkarinen, 2012). It seems unlikely that such shifts alone could account for the higher levels of female education observed in this study, and we emphasize that at a national level, recent estimates point to a significant female disadvantage in secondary school attendance and examination performance in Tanzania (DHS, 2010: 18; UNESCO, 2011: 206). However, previous studies have revealed that female-biased investment in small-scale societies can be favored by a number of related factors under specific conditions. For example, it has been hypothesized that opportunities for hypergyny, whereby girls marry into wealthier neighboring populations, drive preferential investment in girls in Kenyan Mukogodo pastoralists and Hungarian gypsies (Bereczkei & Dunbar, 1997; Cronk, 1989). The gender division of work responsibilities may also increase the opportunity costs of school attendance for boys relative to girls. Girls do more household work, which may be more easily combined with school by being done outside of school hours, whereas boys' responsibilities include cattle herding and farm work, which may take them away from the village during the day. Whether or not such explanations could apply in this context is impossible to answer without supporting data on the costs and long-term consequences of education.

We also note that increasing female education in Tanzania has taken place within a wider context of development campaigns, which often focus specifically on educating girls in order to achieve gender equity in education (e.g. United Nations Millennium Development Goals and Education for All goals both aimed to eliminate gender disparity in education). Many development organizations operate in the Arusha region, and it is thus possible that parental perceptions of the costs and benefits of education may be influenced by external interventions. This possibility highlights the fact that for many vulnerable rural communities the returns to education are shifting and uncertain, and parents may lack accurate information about pay-offs to investment.

We also found some evidence of predicted birth order effects in our study among the wealthiest families, with later-borns being disadvantaged compared to earlier-born children. A later-born disadvantage in education has been documented in previous small-scale and large-scale studies (Al-Samarrai & Peasgood, 1998; Gibson & Sear, 2010), and is anticipated given the sequential nature of household resource dilution with increasing family size and anticipated parental preferences to early born offspring (Clutton-Brock, 1991; Hertwig et al., 2002). For both gender and birth order there is some evidence that parental investment biases are more pronounced among wealthier households, with less evidence of differentiation by birth order and gender in poorer

households. These findings parallel recent findings by Gibson and Sear (2010) who observed greater biases in the education of children by birth order and gender among wealthier households in both rural Ethiopian and Malawian communities. They interpreted this pattern in terms of a shift to a 'quality-focused' reproductive strategy in response to increased perceived returns to education and a decreased need for child labor (Kaplan, 1996). This account is not necessarily at odds with the macro-level observation that economic development generally leads to more equal treatment of children, and the common narrative in the policy literature that biased treatment of children arises from poverty (e.g. a recent United Nations report on education states that "poverty exacerbates the gender divide", (UNESCO, 2010: 6)). Instead it suggests a potential intermediate stage whereby in high-fertility populations in the early stages of demographic transition, parents enjoying greater wealth may opt to preferentially educate children with the highest perceived returns on that investment. In later stages, as fertility levels decline, parents become more able to bear the costs of high-level investment in all offspring. Such trends may be largely overlooked because most of what we know about the trends in education associated with economic development comes from large-scale surveys such as the DHS, which are ineffective at examining trends with communities.

4.3. Limitations

While our study has a number of advantages, including a relatively large sample and unusual quantitative exploration of multiple educational outcomes for pastoralists and their farming neighbors, we caution that our measures rely on self-reports of school enrolment. Furthermore, even if a child is enrolled, this does not mean they necessarily attend regularly. Penalties apply to parents who do not enroll their children in primary school, but are more difficult to enforce for children who are enrolled but do not attend. Parents may thus enroll their child in school with little intention of them actually attending, so that our measures of investment effectively over-estimated parental commitments to education (Al-Samarrai & Peasgood, 1998). Self-report data could also hypothetically lead to reporting bias by gender. For example, due to the recent campaigns to achieve gender parity in education, parents may be more reluctant to report that girls are not in school, and that girls are actually not attending school as much as boys. It is also important to note that our results are based on children resident within the sampled households, and this could introduce bias since it is not uncommon for children to be sent away to relatively urban centers to attend secondary school. However, such bias seems unlikely to account for the observed differences between sons' and daughters' education because our sample includes roughly equal numbers of each sex. Finally, we acknowledge that this study deals specifically with one facet of parental investment, educational investment, and that other forms of investment such as time and money may show different results.

4.4. Conclusion

Despite widespread interest in education and its role in the demographic transition, relatively few studies have quantitatively explored its determinants in relation to variation in rural livelihoods, or directly considered how differences in wealth within rural communities influence patterns of educational investment. Our study addresses these issues and also broader concerns regarding an overreliance of education studies on highly aggregated national datasets, which may conceal patterns in minority groups such as pastoralists (Dyer, 2010; IWGIA, 2006; UNESCO, 2010). We find that pastoralists are considerably less likely to send children to school than neighboring farmers and business owners, and that the most salient form of wealth (livestock) among pastoralists has little impact on education. We also find some evidence that overall wealthier families are more likely to invest in education preferentially by gender and birth order within communities. These findings are largely consistent with expectations derived from both evolutionary and economic models of the family. However, we conclude by cautioning that the theoretical grounding of such expectations, in terms of the anticipated costs and benefits of education, remains poorly substantiated empirically by both the present study and the wider literature. In particular, there is a scarcity of studies directly contrasting the extent to which children's education is traded-off against labor contributions for alternative livelihoods, at different levels of wealth and urbanization, and few studies have explicitly examined both the real and the perceived short and long-term benefits of sending children to school for rural communities undergoing economic development. Within the evolutionary anthropological literature such evidence gaps reflect a traditional disciplinary focus on questions most relevant to our evolutionary past, rather than our ever-changing present (Gibson & Lawson, 2015). Focusing future research on these priority areas will not only contribute to our understanding of parental investment strategies and their role in driving demographic change, but also has the potential to yield a richer understanding of decision-making surrounding education and youth employment in rapidly developing rural areas that could help to inform current policy debates.

Supplementary Materials

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.evolhumbehav.2015.10.001.

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