

# Differences between Sons and Daughters in the Intergenerational Transmission of Wealth Electronic Supplementary Materials (Borgerhoff Mulder, et al. 2019)

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#### 1. A model for identifying the limits to making inferences about sex-biased parental investment from parent-offspring wealth correlations.

Here we present a mathematical model to identify the assumptions needed to infer direct sex-biased parental investment (as opposed to other indirect causes) from sex differences in parent-offspring wealth correlations.

Consider the following model of individual wealth development. An individual's wealth,  $W$ , depends on three things: (1) inherited (genetic or cultural) ability to produce wealth in the absence of direct parental investment, (2) direct parental investment, either through actual inheritance or by subsidy of education and other learning experiences, and (3) other random effects. The inherited ability is denoted by  $A$ . The effect of parental investment is equal to the amount of parental wealth ( $W_p$ ) times the effect of parental investment on offspring achievement,  $\beta$ , and the proportion of investment in the sex in question. Assume that a proportion  $I$  is invested in sons and  $(1 - I)$  is invested in daughters. We then derive the following equations for sons ( $s$ ) and daughters ( $d$ ):

$$W_s = A_s + I\beta_s W_p + \epsilon_s \quad [1]$$

$$W_d = A_d + (1 - I)\beta_d W_p + \epsilon_d \quad [2]$$

The  $\epsilon$  term is a random variable representing random effects. Note that  $\beta_s$ , the effect of investment on sons, may vary from that on daughters. We also allow the inherited effects and random effects variance ( $\sigma_A^2$  and  $\sigma_\epsilon^2$ ) to vary between sexes and generations.

Our goal is to estimate  $I$ , the proportion of invested wealth devoted to sons, using only parent-son and parent-daughter correlations. We refer to these correlations as  $\rho_s$  and  $\rho_d$ , respectively.

We compute son-parent and daughter-parent wealth correlations by taking covariances and dividing by  $\sigma_s\sigma_p$  and  $\sigma_d\sigma_p$  for sons and daughters, respectively. These  $\sigma$  terms are the standard deviations in wealth. Using the terminology  $\rho_s$  and  $\rho_d$  as above, we have:

$$\rho_s = \frac{\text{cov}(A_s + I\beta_s W_p + \epsilon_s, W_p)}{\sigma_s \sigma_p} \quad [3]$$

$$= \frac{\text{cov}(A_s, W_p)}{\sigma_s \sigma_p} + I\beta_s \frac{\sigma_p}{\sigma_s} \quad , \quad [4]$$

and

$$\rho_d = \frac{\text{cov}(A_d + (1-I)\beta_d W_p + \epsilon_d, W_p)}{\sigma_d \sigma_p} \quad [5]$$

$$= \frac{\text{cov}(A_d, W_p)}{\sigma_d \sigma_p} + (1-I)\beta_d \frac{\sigma_p}{\sigma_d} \quad . \quad [6]$$

We define

$$\hat{\beta}_s = \frac{\sigma_p}{\sigma_s} \beta_s \quad , \quad [7]$$

and

$$\hat{\beta}_d = \frac{\sigma_p}{\sigma_d} \beta_d \quad [8]$$

as the standardized effects of parent wealth on son and daughter wealth, respectively. Quantitatively, these parameters measure how many standard deviations son wealth or daughter wealth is improved by increasing parental investment by one standard deviation.

Substituting [7] into [4] yields

$$\rho_s = I\hat{\beta}_s + \frac{\text{cov}(A_s, W_p)}{\sigma_s \sigma_p} \quad . \quad [9]$$

Similarly, substituting [8] into [6] gives

$$\rho_d = (1-I)\hat{\beta}_d + \frac{\text{cov}(A_d, W_p)}{\sigma_d \sigma_p} \quad . \quad [10]$$

Note that the covariance terms in equations [9] and [10] capture the indirect effects of parent wealth on the ability of sons and daughters respectively to produce wealth themselves – independent of parental investment. The most plausible mechanisms underlying these effects are the genetic or cultural inheritance of qualities that are passed from parent to offspring, not

due to parental investment. For example, much of the positive correlation observed in height is likely due to the fact that parents and offspring share genes that yield similar height, regardless of rearing environment. These heritability effects may, in general, differ between the sexes. Sex differences in genetic heritability, for example, are commonly found, although these differences are usually small (e.g., Schousboe, et al. 2003). We cautiously assume this term is of similar magnitude for sons and daughters. Proceeding, we find that the son-daughter difference in  $\rho$ , which we denote  $\Delta_\rho$ , is

$$\Delta_\rho = I\hat{\beta}_s - (1 - I)\hat{\beta}_d \quad [11]$$

Finally, if  $\hat{\beta}_s = \hat{\beta}_d = \hat{\beta}$ , then this simplifies to

$$\Delta_\rho = \hat{\beta}(2I - 1) \quad [12]$$

Equation [12] shows that the sign of  $\Delta_\rho$  determines the direction of biased parental investment. For example, if  $\Delta_\rho > 0$ , it follows that  $I > 0.5$ , and thus that parents invest more wealth into sons than daughters. The value of this result is that  $\Delta_\rho$  can be easily estimated from parent-offspring wealth correlations, even if more detailed cultural, genetic, and direct investment information is unknown. (See Figure 1 in the main text, which plots an example for Bangladesh land ownership.) Graphically, if  $\rho_s > \rho_d$ , then the slope of a linear regression of son deviations on parent deviations will be steeper than that of daughter deviations.

The assumption that  $\hat{\beta}_s = \hat{\beta}_d$ , necessary for equation [12] to hold, deserves further clarification. It is not required that the direct effect of parental investment is the same for sons and daughters – and, indeed, that is probably not the case for many forms of wealth. For example, systemic inequality in opportunity may limit the earnings of one sex, even if parents invest equally in both. The equality of these terms only requires that the *relative* effect of investment is the same, such that sex differences in wealth variability are accounted for. For example, investing a fixed amount in a son's education may have historically boosted the son's future wealth more so than for a daughter in absolute terms. If women show lesser variation wealth than men, however, then dividing each effect by the sex's standard deviation (as in equations [5] and [6]) may yield relative effects of approximately the same magnitude.

As written, the model also assumes that all parents follow the same investment strategy  $I$ . The general results of the model hold true, however, if  $I$  varies at random among parents. In that case,  $\bar{I}$ , the mean investment strategy, replaces  $I$  in the above equations. The results do not hold if the investment strategy  $I$  covaries with parents' wealth. Suppose, for example, that wealthier parents invest relatively more in sons than do poorer parents; this would increase  $\rho_s$  relative to  $\rho_d$ , increasing  $\Delta_\rho$  in turn. Evolutionary theory predicts the existence such wealth-dependent investment strategies under some circumstances (Trivers and Willard 1973). If these effects are strong, then the model as written would require two terms quantifying the strength of universal sex bias and how the bias changes with parental wealth, respectively.

In summary, our model reveals that inferring sex-biased parental investment rests on three important assumptions: (1) the ability to acquire wealth is equally heritable in males and females (whether through genetic or cultural inheritance), (2) the relative effect of direct parental investment on offspring wealth (controlling for differences in wealth variation between the sexes) is the same for sons and daughters, and (3) parent wealth is not correlated with a particular investment strategy. The first assumption yields equation [9]; and the second assumption yields equation [10]; and the third assumption is implied in equation [4], where  $I$  is assumed to not correlate with parent wealth.

Though we have not been able to assess the cogency of these assumptions for our data, we nonetheless proceed with estimation of  $\Delta_\rho$ . We wager that a  $\Delta_\rho$  quite different from zero at least suggests some amount of sex-biased investment. Similarly  $\Delta_\rho \approx 0$  may imply that investment is only weakly biased. The results can also direct further detailed investigation of actual investment behavior in specific populations.

## **2. Statistical considerations**

### **2.1 Dropped datasets**

Our data are a subset of a larger collection (Borgerhoff Mulder, et al. 2009) of anthropological datasets gathered by many independent researchers. None of the datasets were gathered specifically for this paper's analyses, and consequently some could not be used. We dropped any dataset that did not contain at least 40 adult sons and 40 adult daughters with parent information. The dropped set is: Ache height and weight; Dominican land; Hadza foraging returns, grip strength, and weight; Ju/'hoansi network size; Meriam RS; Pimbwe weight; Pume height, weight, and RS; and Tsimane household wealth. Some datasets were also dropped because of other complications, excessively skewed data, or missing information on age. These were: Lamalera food shares; Maya land; Mosuo income; Sangu livestock; Tsimane grip strength.

### **2.2 Wealth differences between males and females**

Table 1 includes the mean ages, mean wealth values, and standardized difference between son and daughter mean wealth for each dataset. A standardized difference value of 1 implies that males tend to have one standard deviation more wealth than females, whereas -1 would imply the opposite. Although this appears to provide a rough measure of gender inequality with respect to the variable in question we caution, as noted immediately above, against a simple interpretation of these values because of the complex causes underlying them. First, basic biological constraints may drive the differences, as is likely the case for weight; that sons are larger than daughters is not necessarily evidence that sons are healthier or better nourished. Second, even material wealth measures as shown do not necessarily reflect actual differential advantage in the population. For example, although men and women had access to the same amount of land in Krummhörn, men were the inheritors and had much more control over its use (Volland 1988). Third, in some cases, the wealth variable is necessarily shared between the father and mother (e.g., some land or RS datasets). If every chunk of wealth is owned jointly by one man and one woman, then a sex difference in mean wealth can only be due to an

unequal sex ratio (a point first recognized by Fisher (1958) in his theory of the evolution of sex ratios); the less common sex will necessarily have more wealth as measured here, regardless of its actual control of resources. Because of these problems, we do not further discuss mean wealth differences, acknowledging that population-specific analysis, and qualitative data, would throw more light on this issue.

### **2.3 Model comparison and fitting**

The first step for each dataset was to choose the functional forms of Equation 1 in the text. That is, we sought models for the mean and standard deviation in wealth for each dataset, with age and sex as predictors. We used all individuals in a dataset—not just those with parents—to fit these models, ensuring highest possible accuracy. We used primarily polynomial models (e.g.,  $\mu = \beta_0 + \beta_1 \times age + \beta_2 \times age^2 + \dots$ ), with age predictors up to third order, and interactions between age and sex. In some cases, inverse-logit functional forms (i.e.,  $\exp(x) / (1 + \exp(x))$ ) provided a better fit. For many variables, we used the logarithm of the response variable to reduce skew. All models were initially fit using the *mle2* function in the R package *bbmle*. We then selected the model with the lowest BIC score, as computed by the R package *rethinking*. In many cases, the best model was only marginally better than the next best. Fortunately, in these cases models with BIC scores provided nearly identical estimates of  $\rho$ . Thus our estimates appear to be quite robust to the exact model form.

After choosing the best model, we then fit it with a Bayesian Hamiltonian Monte Carlo algorithm in the *rstan* package in R. For all offspring and parents, the algorithm produces a posterior distribution for the wealth deviation  $D$ , integrating over uncertainty of the model's parameters. We then fit a linear model regressing offspring wealth on parental wealth, using samples from their respective posteriors, to obtain estimates of  $\rho_s$ ,  $\rho_d$ , and  $\Delta\rho$ . The methods ensure that all uncertainty is properly reflected in our final posterior estimates.

The R code for each variable (including specific model form and posterior distribution algorithm) and anonymized data for most populations are archived on github (<https://github.com/babeheim/wealth-transmission-son-bias>).

**ESM Table 1. Summary of wealth datasets**

Population	Wealth type	N Sons	Age Sons (Mean)	N Daus	Age Daus (Mean)	Wealth Son (Mean)	Wealth Daus (Mean)	Standardized Mean Wealth Difference <sup>a</sup>
Bangladesh	Education	596	28.1	516	27.6	7.65	6.89	0.21
	Income	298	47.2	584	40.3	11.11	10.96	0.15
	Land	283	56.5	436	46.4	3.35	3.34	0.01 <sup>b</sup>
Bengaluru	Education	263	36.4	299	32.5	12.89	12.08	0.23
	Social networks	162	34.7	183	31.4	4.04	3.33	0.22
	RS	291	36.1	355	32.1	0.46	0.52	-0.12
Chewa	Education	147	22.5	98	25	6.24	4.85	0.35
	Land	33	29.3	118	31.1	0.7	0.69	0.04
	RS	35	30.2	132	30.8	1.74	2.93	-0.58
Datoga	Livestock	95	30.2	40	32.6	2.05	2.29	-0.22
	RS	95	30.2	40	32.6	2.41	3.54	-0.43
Gambia	Height	390	24	427	24.2	5.12	5.06	1.24
	Weight	390	24	427	24.2	55.19	51.12	0.59
	RS	87	38.5	220	29.4	2.93	2.23	0.34
Himba	RS	54	40.4	92	38.7	3.94	3.3	0.21
Kipsigis	Cattle partners	61	45.6	41	42.3	1.03	0.8	0.3
	Land	161	43.6	109	40.4	1.87	2.16	-0.44
	Livestock	161	43.6	109	40.4	11.52	9.32	0.27
	RS	161	43.6	109	40.4	7.12	5.56	0.45
Krummhörn	Land	708	NA	744	NA	30.4	31.25	0.46
Lamalera	Boat shares	64	36	55	37.6	1.75	2.04	0.46
	House quality	53	35.3	40	37.6	3.15	3.68	0.46
	RS	64	36	55	37.6	2.6	2.73	0.46
Maya	Education	106	31.5	103	32.6	7.5	5.39	0.46
	Height	63	34	78	33.5	5.04	4.96	0.46
	Weight	61	34.1	74	33.6	4.13	4.02	0.61
	RS	99	31.5	88	33.4	2.1	2.49	-0.14
Mosuo	Education	141	27.7	156	28.5	7.42	6.92	0.11
	RS	134	27.9	146	28.7	0.58	0.86	-0.32
Pimbwe	Farm skill	61	35.6	71	31.9	0.11	0.21	-0.04
	Household wealth	77	34.6	92	31.1	4.03	4.09	-0.03
	RS	226	30	215	29.3	1.83	2.48	-0.26
Poland	Education	5781	47.4	7274	47.2	8.64	9.61	-0.35
Tsimane	Knowledge	41	24.1	68	25	0.48	0.52	-0.37
	Weight	110	27	107	26.4	60.93	53.83	0.86
Ust'-Avam	RS	435	30.8	406	29.6	2.5	3.02	-0.22
	Education	55	22.7	45	22.5	9.51	10.16	-0.5
	RS	77	25.6	54	24.3	0.27	0.65	-0.44

<sup>a</sup> Calculated by dividing the difference between their mean wealth by the standard deviation in wealth of sons and daughters combined

<sup>b</sup> Shared land holdings were recorded for Bangladesh married pairs, thus the sample means are almost identical.

<sup>c</sup> Krummhörn data are from historical records for which ages are unavailable.

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### 3. Population site reports

#### **Bangladesh (Contributed by Mary K. Shenk and Mary C. Towner; Fieldwork 2010)**

The Bangladesh sample is drawn from a survey of 944 women (aged 20-64) residing in the Matlab area of Chandpur District, Bangladesh. The Matlab area has been a part of a demographic surveillance area since the 1960s, and is representative of Bangladesh as a whole. The primary economy of the region was traditionally farming and fishing for subsistence and local/regional markets though integration with the global economy has been increasingly important in the area since the 1960s (e.g. Holman & O'Connor 2004). A majority of villagers still participate in agriculture, though many own no land themselves. Income is generated from a variety of sources including agriculture, day labor, local wage labor, handicraft production, and remittances from family members in the city. Labor out-migration has also increased, with more men traveling to cities in Bangladesh or abroad to work as laborers (e.g. Shenk et al. 2013). Women are subject to a limited form of purdah and generally stay at home and work domestically, although some are now entering the labor market (e.g. Shenk et al. 2014). The population has experienced dramatic declines in both fertility and mortality over the last fifty years (Shenk et al. 2013). The 2010 interviews included numerous questions regarding fertility, mortality, education, and material wealth of the focal woman and her husband, their children, and both of their parents.

Households are composed of nuclear or extended patrilocal families, and groups of patrilineally related families typically live near each other in a compound called a bari (Aziz 1979). The majority of marriages are monogamous, with polygyny permitted but quite rare (Aziz 1979, Shenk et al. 2016). Marriage is usually arranged, with the bride's and groom's parents negotiating a dowry, though love marriages are becoming more common (Shenk et al. 2016). Land inheritance is largely patrilineal. Approximately 90% of the population is Muslim while 10% are Hindu. Among Muslims, brothers inheriting equal shares and daughters inheriting either half shares (based on Islamic custom) or nothing at the parents' discretion. In Hindu families, daughters rarely inherit land or other property (such as houses) unless they have no brothers. Consequently, most of the land a family owns usually come through the husband's family by inheritance, but total land may also include land that has been bought or sold or inherited by the wife during the couple's lifetime (Marbourg 2015).

Both material and embodied wealth are important in this population. Material wealth is derived from land and agricultural production, as well as through income from wage labor, including remittances received from labor migrants. Land includes both agricultural and household land, as measured in decimals (a small unit roughly 40.5 m<sup>2</sup>). Income is measured by husband's income and father's income as valued in Taka in 2010 (log transformed). Embodied wealth includes education, as measured by years of schooling. That said, formal education, outside of religious instruction, was quite limited in the earliest years of this sample. Since the 1990s, however, education has become more widely available, including for women. For men, education increases access to the labor market, whereas for women, education may serve primarily in the marriage market and as a hedge against widowhood or divorce (e.g. Snopkowski et al. 2016).

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### **Bengaluru (Contributed by Mary K. Shenk; Fieldwork 2001-2002)**

Bengaluru is a large city and capital of the state of Karnataka in south central India. Ethnically, the people in the study sample are mostly Kannadigas but some are also Tamils or Telugus who have lived in the area for many generations. These data were gathered during a year of fieldwork in 2001-2002 via a survey of adults aged 45-70 which collected detailed retrospective data on 2-3 generations of marriage, parental investment, and family demography (Shenk 2005a). The individuals covered in this sample thus span most of the 20<sup>th</sup> century, capturing a period in which south India's economy has been progressively moving from a subsistence agricultural base with a limited cash economy to a market economy with a wage-labor base. In traditional South India most people had hereditary occupations determined in part by caste and family membership, however, this system has been slowly breaking down for more than a century and in modern urban India most people have adopted skill-based wage-labor occupations (e.g. Srinivas 1978, Shenk 2004).

The people of this region share important social characteristics with other South Asians, most notably a patrilineal kinship system, the joint family, and arranged marriage with patrilocal residence (Uberoi 1994). However, South Indians are less strongly patrilineal and patriarchal than are north Indians and women often have more social and economic freedom. Traditional gender roles dictated that men do most of the labor outside the home while women do most of the domestic labor. In modern India men are still expected to have primary economic responsibility for their families, and virtually all men who do not own businesses themselves participate in some form of wage labor. Though it is becoming increasingly acceptable for women to work outside the home, the prevalence of working women varies a great deal by caste, social class, and the occupation of other household members (Shenk 2004).

Among Hindu Indians, wealth was traditionally divided equally among sons at the death of the father while daughters took their share of their parents' wealth via dowry at marriage (Basu 2005, Srinivas 1984). Muslim Indians sometimes give half shares to daughters as dictated by Islamic tradition and Muslim family law in India, however this is not uniform and, in our sample, is typically practiced when the family is well off and/or when daughters are in financial need. While modern Indian family law dictates equal inheritance by sons and daughters, most people still follow the traditional pattern of leaving most heritable wealth to sons. Many Indians feel that the large expenditures and wealth transfers made on the occasion of a daughter's wedding serves as a primary form of female inheritance (Shenk 2007).

Both traditional and modern Indians place heavy reliance on family relationships as a means of maintaining social and economic stability as well as achieving social status. A key way in which families bolster their positions is to arrange marriages with families having desirable characteristics (Srinivas 1984). When arranging marriages, not just the characteristics of the spouse but the number and characteristics of his or her close relations—and occasionally even more distant relatives—are likely to be considered (Shenk 2005b). Our analysis compares the numbers of people in the in-law networks of a parent and his or her child weighted by the wealth of network members. Although in-law networks are of course not directly heritable, they are heavily influenced by characteristics of both the individual and his or her family. Though Bengaluru is undergoing economic development, social networks created through marriage are still very important socially and the ethnographic evidence suggests that they were even more significant in the past. For these reasons, in-law networks are likely to be a reasonably representative example of relational wealth in intensive agriculturalist societies.

In the past only the sons of upper caste or wealthier families would have received any significant amount of formal education, whether in religious matters or in terms of training for the job market in the colonial state. Over the course of the late 19<sup>th</sup> and 20<sup>th</sup> centuries, however, formal secular education became increasingly common, beginning first among those from upper caste backgrounds but eventually spreading to lower castes as well. In modern urban India perhaps only 10-20% of people still follow hereditary occupations, and most of these are merchants or skilled laborers whose occupations have obvious places in a modernizing market economy. The remainder of people, many of whom were farmers or agricultural laborers in rural India, have now adopted education-based or skills-based occupations. Thus in modern Bengaluru education is both a signal of social status and a means of obtaining wealth, motivating parents to invest heavily in education when they are able.

The education of sons has become ubiquitous, with the level of education based on the child's expected (or hoped for) occupation, and average levels of male educational attainment rose steadily through the 20<sup>th</sup> century. At first the education of daughters lagged well behind that of sons, with many daughters being entirely uneducated. However, a boom in the education of daughters came in the mid-late 20<sup>th</sup> century, and educational rates for women grew steadily such that in many urban families daughters are as well educated as their brothers (Srinivas 1978). Variation by caste and social class is still common, however, with groups that see housewife as the ideal for women lagging behind groups where income-generating occupations are a possibility for daughters (e.g. Shenk 2004).

India has been undergoing a widespread demographic transition to lower fertility since the mid-20<sup>th</sup> century, beginning earlier for wealthier and more urban families and later for

poorer and more rural families. Since we used the older cohorts in the sample for this analysis, many of the families included would have experienced this first reduction to 3 or 4 children, but typically not the later reductions to family sizes of 2. RS is measured here as number of children surviving to at least age 10 in a family.

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### **Chewa (Contributed by Rebecca Sear; Fieldwork 1997)**

Data were collected from two lakeside villages in the Southern region of Malawi in a single round survey in 1997. One village was largely a farming village, of predominantly Chewa ethnic origin. The second was originally a farming village but had expanded with an influx of fishermen from northern Malawi. The population of the agricultural village was very largely Chewa; the population of the fishing village was of mixed ethnic origin, with Chewa making up approximately one-third of the residents. Only Chewa respondents were included in this analysis. The matrilineal Chewa are largely subsistence farmers, though some households are moving into the market economy by engaging in wage labour, small businesses and trade. There was little access to contraception and limited medical care available in this rural area, and both fertility and mortality were high: the TFR in 1996 was 5.89, and 12% of all children born within the 5 years preceding the survey were reported dead. Both sexes married at a relatively young age, the singulate mean age at marriage for women in this population was 20 years, for men 25 years.

The Chewa were traditionally matrilineal and matrilocal. In this sample, over 90% of women reported residing in their own mother's village after marriage. Most women drew husbands from the same village, however: about 60% reported that their husbands' mothers also lived in the same village. Women were allocated land by the matriline when they married (most women in this sample stated they inherited their land directly from their mothers), and farmed this land along with their husband and children. The ideal is of equal distribution of farmland among daughters. However, available farmland is scarce in this densely populated country, and there is some suggestion in the literature that later-born daughters may lose out in the distribution of farmland, as they are the last to marry and be allocated farmland. Certain

political roles, such as chieftainships, may be held by men and are then passed on to sisters' sons. The extended family rarely farms together, though food may be shared and eaten together with kin living nearby. Marriages were usually monogamous: polygyny is not prohibited but in practice is rather rare, and where it does occur co-wives typically live in different villages (2% of women reported co-wives in this sample). Though this summary describes the traditional Chewa way of life, there is some evidence in recent years that the Chewa are adopting more patrilineal customs, with men becoming more likely to own their own land and pass it onto sons (men owned land in 20% of households in this sample, and these tended to be the wealthier households), as tends to happen to matrilineal societies during economic development.

The primary source of economic wealth is land, and garden size (in hectares) is used here as the wealth measure. Typically, only few small livestock were kept and were not considered a source of income. Some households had moved into the monetary economy and listed their primary means of subsistence as wage labour or trade, but these were excluded from this sample. Education is also included as a measure of wealth, as education had become increasingly widely available in the years before the survey. This was collected through self-report data (as years of education received). Reproductive success (RS) is used as an indicator of wealth because children are viewed as both a source and indicator of success. RS is measured as the total number of surviving children.

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### **Datoga (Contributed by Monique Borgerhoff Mulder; Fieldwork 1987-1989)**

The Datoga are Nilotic pastoralists living in northern Tanzania (Borgerhoff Mulder 1991) and were studied between 1987-1989. Their primary livestock source is cattle, although goats

and sheep are important, especially for less wealthy families. Rainfall varies between 300-500mm per annum. The Datoga population was estimated to lie between 62,000 and 82,000 in the late 1970s, with less than 10,000 inhabiting the Eyasi Basin during the period of study. Living in a string of settlements down the east side of Lake Eyasi the area was (and still is) poorly provided with infrastructure, connected to a District town (Karatu) by a rough road through mountainous country. In the late 1980s there was one dispensary to serve the whole area, with patients having to walk sometimes over 60km to receive only basic treatment, and two schools. Datoga have been long feared by outsiders. The Maasai displaced the Datoga from the more productive highland areas (Ngorongoro) in the late 19<sup>th</sup> century (Borgerhoff Mulder et al. 1989), but still refer to Datoga as *Mang'ati*, which means enemy. Central government attempts to settle and educate Datoga throughout the Ujamaa period of rural development (1975-85) failed. Livestock holdings fluctuate quite considerably over years as a result of drought, disease and raiding, primarily from the neighbouring Maasai and Sukuma ethnic groups.

Datoga live in extended patrilineal, patrilocal households. A *gheda* (isolated cluster of huts within a thorn-bush fence, and including specially protected livestock enclosures) consists most commonly of a man (the patriarch), his wife (wives), his married sons (and their wife/wives), and unmarried children of each sex. Marriage is very commonly polygynous, accompanied by a small bridewealth payment. As in most East African pastoralist populations girls marry out of the clan, and settle in different *gheda*, often distant from their natal home, and have limited rights in the disposition (but not the use) of livestock. Analyses conducted prior to the original study (Borgerhoff Mulder et al. 2009) indicated no wealth bias among families with respect to whether or not daughters (or sons) moved out of the study area.

Livestock is the only form of accumulated wealth in this population, and is primarily owned by the male *gheda* owners; accordingly livestock holdings were recorded at this level. Livestock are central to Datoga life. Their products are consumed as food (milk, blood, fat and meat), used for household maintenance (glue, horns, sinew, urine, hides), or sold to generate cash for the purchase of maize, cloth, shoes, women's jewelry, tobacco, honey (for brewing beer), and medicines (both traditional and western, for human and livestock). Livestock are measured in Tropical Livestock Units (Sieff 1999). Some households engage in other economic activities, notably cultivating small patches of millet and maize (Tomikawa 1978). They are however very unproductive farmers (Sieff 1997), and the soda lake Eyasi basin is not blessed with fertile soils. Reproductive success (RS) is also used as an indicator of wealth because children are viewed as both a source and indicator of success in Datoga culture. RS is measured as the number of children surviving to the age of five (with a mortality correction for younger children, since mortality after the juvenile period is low (5%)). Accordingly, two measures of wealth are used in these analyses – livestock and RS.

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### **Gambia (Contributed by Rebecca Sear; Surveyed 1950-1980)**

Data has been collected from inhabitants of this rural area of the Gambia since 1950, when Sir Ian McGregor began a project aimed at investigating health and growth in a tropical environment. Four villages in the West Kiang district of the Gambia were included in the study, and he collected data from these 4 villages between 1950 and 1980. In 1950 he set up a demographic surveillance system recording all births and deaths in the villages. He also conducted surveys at least annually between 1950 and 1980 systematically collecting information on health status, as well as some ad hoc data on migration and marriage. In 1975 the UK Medical Research Council set up a permanent research site in the area, including a medical clinic which provided medical care to villagers.

This is a population of subsistence farmers, growing mainly rice. Some groundnuts were grown as a cash crop, though the cash income that resulted was relatively small. The villagers were mostly of the Mandinka ethnic group, though there were also a minority of Jola, who were originally the slaves of the Mandinka, as well as a handful of individuals from other ethnic groups, such as Fula. The population was primarily patrilineal, with inheritance passing from father to son. However, if women cleared their own rice fields they were able to pass these on to their female descendants. Patrilocality was the norm: sons remained in their father's compound and brought in wives, but the majority of women married within their own natal villages, and also didn't transfer to their husband's compound often until after the birth of a child or two. Polygyny was common, and so spousal age gaps were quite substantial on average.

We have no data on economic wealth in this population, and few individuals were educated until the late 1970s, when a primary school was set up in the area. We have used anthropometric status and reproductive success (RS) as measures of somatic wealth. Anthropometric status is measured as height and weight, which were both collected during McGregor's annual surveys between 1950 and 1980. Each individual's height and weight was calculated as the average of all measurements taken in adulthood (ages 21 years and older; weight measurements taken when women were pregnant were excluded from the average calculation for weight). RS is measured as the number of children surviving to the age of five (with a mortality correction for children under age 5 since mortality after the juvenile period is low (5%)). Only data collected before 1975 were included in the RS calculation, as the medical clinic set up in 1975 rapidly reduced child mortality. And only data collected from two of the four villages was included, as fertility is thought to be under-reported in the other 2 villages. Between 1950 and 1974, both fertility and mortality were high: women gave birth to around 7 children on average, but approaching 50% of children failed to survive to their 5<sup>th</sup> birthday.

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### **Himba (Contributed by Brooke A. Scelza; Fieldwork 2009-2012)**

The Himba are a group of traditional pastoralists living in the northwest corner of Namibia in a part of the Kunene region referred to as the *Kaokoveld* (Bollig 2010). The Kunene region has an arid climate, with a rainy season that typically runs from November to May. Droughts are not uncommon and can last several years. The perennial Kunene River and its seasonal tributaries are the main source of water for the region. The area is very sparsely populated, with a density of only about 1 person per 2km<sup>2</sup> with approximately 20,000 Himba currently living in *Kaokoveld*. There are several community schools in the area, and attendance is on the rise among Himba, particularly for boys. Local health clinics are scattered throughout the region, with a main hospital in the regional capital of Opuwo.

Himba are closely related to the Herero, a Bantu group who arrived in Namibia in the middle of the 16<sup>th</sup> century. The two groups share a language (*Otjiherero*) and many cultural institutions, including a double descent system of inheritance, patrilocal residence, polygyny and levirate marriage (Malan 1995). In the mid 1800s, the Herero came under attack from neighboring Nama bands, who raided most of their cattle and caused a substantial group of Herero to flee across the Angolan border. There, these Herero were re-named "ovahimba" which means "beggar" in the local Ngambwe language, due to their lack of material wealth and refugee status. Many Himba left Angola around 1920 when a prominent warrior named Vita led the group back to Kaokoveld and reclaimed many of their cattle (Malan 1995).

Himba practice double descent, a rare system where individuals maintain membership in both a matriline (*eanda*) and patriline (*oruzo*) (Malan 1973; Scelza et al. 2019). Cattle wealth is inherited mainly through the maternal line (typically from the maternal uncle to a nephew) while political position and control over the family compound is passed patrilineally (Bollig 2005). Himba continue to rely mainly on pastoral production for majority of their calories. They herd cattle, goats and sheep. During the rainy season women also have gardens where they grow maize, sorghum and melons. Market integration remains limited, due in large part to restrictive policies of the colonial South African government (Bollig 1998). Access to cash occurs through livestock sales, as well as pension payments. Items like cell phones and vehicles are increasingly common.

The Himba live in extended family households. Polygyny is common and women tend to co-reside within the same household, though each wife has her own hut. In general, co-wives get along well and often cooperate (Scelza 2015). Women go to live with their husband's family upon marriage, although they frequently visit their kin and will go back to reside in their natal homestead when a marriage dissolves (Scelza 2011a). During the dry season cattle posts are established and the household will often be split between the main compound and the cattle post. This means that husbands and wives are often separated for long periods. Informal partnerships are also common, with most men and women having at least one partner in addition to their spouse (Scelza and Prall 2018). Extra-pair children are often born of these relationships (Scelza 2011b), though strong notions of social fatherhood maintain ties and investment between a woman's husband and her children.

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### **Kipsigis (Contributed by Monique Borgerhoff Mulder; Fieldwork 1981-1984, 1991)**

Kipsigis are agropastoralists who have lived in southwestern Kenya (now Rift Valley Province) for the last 5-600 years on the lower hills of the "White Highlands" (rainfall 1000-1500mm per annum). They speak a Nilotic language (Kalenjin), and were the subject of an ethnographic study in the late 1920s (Peristiany 1939). The research reported here was conducted in 1981-1984, with some additional material from 1991. Although this part of Kenya developed economically very fast both during the mid colonial and early Independence periods, Kipsigis life styles remained largely traditional reflecting strong commitment to ethnic identity,

a characteristic tendency to remain in their home area rather than seek wage labour (Manners 1967), and persistent high fertility.

Kipsigis are organized in patrilineal clans, and intergenerational transmission is patrilineal with an egalitarian inheritance of land and livestock among sons. Marriage is polygynous, with the payment of a substantial bridewealth (Borgerhoff Mulder 1995), and postmarital residence virilocal (patrilocal). Sons share their father's wealth until the latter dies, whereas daughters own no land or livestock wealth formally and are dependent on their husband's wealth, (although there is some evidence women living in poor households seek support from a maternal uncle, Borgerhoff Mulder 2007). Outmigration of sons for economic opportunity was rare in the community during the period of fieldwork. On the contrary, because of the practice of patrilocal post-marital residence, many parent-daughter pairings created for these analyses were characterized by missing data. Analyses conducted prior to the original study (Borgerhoff Mulder et al. 2009) indicated no wealth bias among families with respect to whether or not daughters (or sons) moved out of the study area.

Four measures of wealth are used in these analyses—land, livestock, cattle loaning partners, and RS. Since the 1930s land has been the primary source of wealth for Kipsigis for subsistence and market produce (Manners 1967; Mwanza 1977). Livestock wealth is also economically and culturally significant, used in marriage payments, exchange networks, for domestic (and some commercial) dairy produce, and increasingly for sale to raise cash. Land and livestock are generally highly correlated and are important determinants of health, wealth and fitness for both men and women (Borgerhoff Mulder 1987b, a). Livestock are also the base of important social network capital embodied in the traditional (and now disappearing) institution of *kimanangan*, in which men allocate some of their cattle to livestock-loaning partners in a system designed to reduce spatially the risks associated with herding, such as unpredictable rainfall, raiding, and disease (Peristiany 1939). Generally only the households richer in livestock have *kimanangan* partners. Reproductive success (RS) is used as an indicator of wealth because children are viewed as both a source and indicator of success among Kipsigis. RS is measured as the number of children surviving to the age of five (with a mortality correction for children under age 5 since mortality after the juvenile period is low (5%)).

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**Krummhörn (Contributed by Eckart Volland; 18<sup>th</sup> and 19<sup>th</sup> C records)  
Adapted from Shenk, et al. (2010)**

This is a historic population from the eighteenth and nineteenth centuries in the Krummhörn region in Ostfriesland in northwest Germany. The data derive from a reconstitution study based on church registers complemented with information from tax rolls and other sources, and the sample consists of data from 19 of the 33 parishes that existed in the Krummhörn. The Krummhörn was an ecologically and culturally separate region within Ostfriesland, bounded by the North Sea on three sides and by a relatively infertile heath in the east. The region has an area of about 150 km<sup>2</sup> and mainly consists of very fertile marsh soil—responsible for the great wealth that farmers were able to achieve as of the end of the Middle Ages. A capital- and market-oriented agriculture developed and replaced a pure subsistence economy earlier here than elsewhere in Germany, and large-sized businesses dominated the farming economy. By the end of the nineteenth century, the marshlands covered only about 7% of the province of Hannover but produced over 22% of the agricultural profit (Meitzen 1894).

The social organization of the population was structured almost exclusively by the possession of land. Marriage was monogamous, and although divorce was legal, it was rare (Volland and Willführ 2016). Post-marital residence was virilocal, and the descent system patrilineal. In a socioecological context, it is possible to describe the Krummhörn as a saturated habitat consisting of only a limited number of available breeding places. The population was characterized by a very low growth rate for a long time and had a nearly stable cross-sectional size of roughly 14,000 individuals during the period under study. As no common land was available in this time, and due to the isolated location of the Krummhörn, a substantial increase in the population could not be supported – by either a geographical expansion of the population or an increase in its density. The amount of land owned or under lease was decisive for the right to vote and the right to stand for election – both in the sphere of politics and of the church. The accumulation of returns led to remarkable wealth concentration in some lineages, but also a large mass of landless workers. In most villages, a middle class was essentially missing.

The rules of inheritance among the land-owning part of the Krummhörn population were based on ultimogeniture in the male line, with the youngest son inheriting the landed property, including buildings, equipment, and farm animals. Noninheriting siblings had to receive financial compensation from the heir, and as a rule, brothers received twice the amount that their sisters did. The value of the business was estimated by authorized experts, and each male heir was expected to get the same amount. This put a large economic pressure on the main heir to compensate his siblings—either by selling land or realizing other forms of capital. The social group of “full” farmers was well aware of these risks, and they manipulated both their reproductive behavior and dispersal patterns so as to minimize competition between siblings (Beise and Volland 2008; Volland and Dunbar 1995; Willführ, et al. 2018). In practice, families could – and occasionally did - deviate from the general habits of inheritance, particularly in the latter half of the nineteenth century.

For our wealth measure, we compare landownership between fathers and children, using the husband's land as the land estimate for daughters who did not own land in their own right. Both sexes are included since in the Krummhörn both sexes inherited wealth (although not equally and not necessarily of the same kind). Historic tax rolls give the amount of land owned or leased for individual persons. In this context socioeconomic status was linked to the amount of possessed land, and it was unimportant whether the land was owned or rented. Due to the social structure of the Krummhörn, the sample consists of many landless workers with 0 values for land wealth. A size of 75 grasen was historically regarded as the lower limit for a "full" and self-sustainable farm and defines the group of "full farmers" (1 grasen = 0.38 ha).

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### **Lamalera (Contributed by David A. Nolin; Fieldwork 1997-2006)**

Lamalera (as observed ca. 1997-2006) is a subsistence fishing and sea-hunting community of about 1,200 people on the island of Lembata in Nusa Tenggara Timur province, Indonesia. Lamalera is known for its unique subsistence strategy: hunting large-bodied marine prey, including sperm whale and other toothed cetaceans as well as ray and other large fish. Because the terrain surrounding the village is steep and rocky, large garden plots are rare, and instead the women of Lamalera trade with women from the interior of Lembata for maize, manioc, bananas, and other fruits and vegetables. In the past Lamalera might have been characterized as a complex foraging society: a permanent sedentary population subsisted almost entirely from maritime foraging and trading with agricultural villages of the interior. In the early 1900's, Lamalera was the site of the first church and school on the island (Barnes 1986, 1996). With the expansion of the Catholic Church and the Dutch and Indonesian civil administration in the region in the 20<sup>th</sup> Century, Lamalerans have been well-positioned to take advantage of expanding wage-labor opportunities outside the village. Consequently emigration fueled by education and wage labor opportunities has been a feature of Lamalera

demography for most of the past century (Barnes 1986). Nonetheless, the local economy remains reliant on subsistence hunting and fishing.

The people of Lamalera speak Lamaholot, a language ranging from east Flores through central Lembata, and share many cultural features with other Lamaholot speakers, including patrilineal descent, asymmetric marriage alliance, and (historically) a dualist cosmology. Patrilineal descent is the fundamental organizing principle of political and economic life (Alvard 2011; Nolin 2011). Two autochthonous clans and three founding clans claim greater status and authority than other clans (Barnes 1996; Nolin 2012). This creates a broad, horizontal hierarchy among clans. Each whaling boat is operated by a corporate group whose members are primarily drawn from the same lineage. Members of the boat-owning corporation have share rights in any prey caught by the boat, as do the crewmen and certain craftsmen who helped build the boat and its gear (Alvard 2002; Alvard and Nolin 2002; Barnes 1996). Lineages also hold usufruct rights to tracts of land in the village, though improvements are private and heritable. Houses are nominally inherited by the youngest son, unless the house is the clan great house, in which case the oldest son has the duty to occupy and maintain it. However, in 2006 most houses (70%) were built anew by their current occupants. This is largely the result of a deliberate campaign by the Church to replace virilocal postmarital residence with neolocality, and a house is now considered by most to be a prerequisite for marriage (Barnes 1996). Brideprice was also historically practiced and paid in elephant tusks, and while it is still negotiated it is now paid in cash when paid at all. These high costs of marriage may contribute to the late age of marriage (late 20s by the end of the 20<sup>th</sup> Century) for both men and women. Marriage is monogamous and divorce is extremely rare. A widow may retain control of her husband's property, and will be supported with shares in the boat of their husband's lineage; unmarried adult women may be similarly supported. More commonly, a widowed parent (or unmarried sibling) will co-reside with a married child's (or sibling's) family.

Relational wealth is of great importance in Lamalera. Sharing relationships are the primary means of reducing economic risk in this high-variance subsistence economy. Lineage and clan membership (which determine eligibility for boat shares), customary leadership offices, and relationships with wage-earning relatives outside the village are also important. Somatic wealth, vested in health and the capacity to perform physical work also provides access to the fishery (for men) and the barter market (for women). Noetic wealth in the form of formal education is highly valued, but important primarily *outside* the village. Locally, specialized occupations such as harpooner or shipwright are important for some, but not most, men (Nolin 2012). Finally, material wealth is more important in Lamalera than in other populations subsisting on wild resources, especially share rights in hunting boats. Other important property includes small boats, nets, animals, houses, and household goods. In the present dataset, relational wealth is measured through in- and out-degree of usual food-sharing relationships, as recorded in 2006 (Nolin 2010). These relationships may be established through both the husband's or wife's relationship with other households, and are not strongly gendered. Material wealth is measured here by the numbers of shares in boats and a wealth scale generated from the quality of house features. Boat shares are primarily accessed through the husband's lineage, and his (and any resident unmarried sons) participation in the fishery, though in some cases a household may also hold boat shares through the wife. The house

quality index is a proxy for general wealth and access to cash (Nolin 2008), which are in practice joint resources of the husband and wife.

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### **Maya (Contributed by Karen Kramer; fieldwork 1992-1993)**

The Maya discussed here live in the small village of Xucloc in the Puuc region of the Yucatan Peninsula, Mexico. When the data used in this analysis were collected (1992-1993), all village residents were subsistence maize farmers who also cultivated a variety of other beans, squash, sweet potatoes, and fruits and vegetables. Domesticated turkeys, ducks, chickens and pigs were raised for occasional consumption, and forest animals and honey supplemented their diet. The Maya economic and commensal unit is the household, self-identified as those who eat together and work together. Households cultivate the same milpa (maize garden) and share their harvest. Agricultural and village land are not privately owned. Following the Mexican Revolution, communities throughout Mexico were deeded an *ejido* – communally held land allocated to the village that cannot be individually bought, sold or inherited. Xucloc's *ejido* encompasses some 5200 hectares. The village had no running water or electricity, and due to the distance to town and lack of transportation, villagers participated minimally in the regional and labor market economy.

The Mayan household consists, in many cases, of a nuclear family – father, mother and children. In some cases the household is an extended family, usually consisting of a married son and his family living in his parent's household. Household membership is readily identifiable both through interview and because residential compounds (*solar*) are discrete entities separated by stone walls. Marriages are monogamous and divorce is very uncommon. Marriages are largely endogenous, with little marital migration between villages. Young couples not uncommonly live in the husband's *solar* for a year, until the son has established

his own *milpa* and built a *solar*, or residential compound. The last son to marry may stay in his parents' *solar* upon their death. No material goods are exchanged at marriage, and kinship is organized by double descent. Although land inheritance is a common form of wealth transmission for farmers, Mexican law prohibits the transfer of ejido land.

The variables used in the current analysis focus on nonmaterial forms of wealth, including education, body size (weight and height), and reproductive success. Education (years of school completed by 1993) is included as form of embodied capital because it distinguishes a family's ability to generate income. At the time of the initial study, there was a primary school in the village. Secondary schools were located in towns some distance away and were not free. Body weight and height are reported as relative measures of access to high quality foods and market foods. Unlike many subsistence farmers, the Maya do not experience a seasonal hungry period. They are generally a well-nourished population, but wealthier families do have greater access to meat, oil, eggs and fatty market foods. The Maya at the time of study were a natural fertility population. (Birth control and many other economic changes have been introduced in more recent years.) The number of children surviving to age 15 is reported as a measure of reproductive success.

**Adapted from:**

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**The Mosuo (Contributed by Siobhán M. Mattison; Fieldwork 2008)**

The ethnic Mosuo reside in the Hengduan mountains along the border of Sichuan and Yunnan Counties in Southwest China. The matrilineal Mosuo are well known to anthropologists for their matrilineal kinship institutions: Descent is traced exclusively through female linkages and inheritance is passed communally from one generation of co-resident matrilineal relatives to the next. Historically, marriage was uncommon among the matrilineal Mosuo and men's roles were realized more as mother's brothers than as fathers [1]. In fact, two distinct sub-populations comprise the Mosuo. A patrilineal sub-population is separated geographically from matrilineal sub-populations, located in areas with steeper, more mountainous terrain [2]. Patrilineal and matrilineal sub-populations share a common language and many customs – including traditional attire and coming-of-age ceremonies – and have overlapping ties of kinship. However, patrilineal Mosuo marry and transfer inheritance to sons, especially last-borns.

The Mosuo traditionally are agriculturalists; their subsistence has historically been tied to relatively low-intensity farming and animal husbandry. Cash is increasingly important among

Mosuo residing in all areas and has been the dominant source of subsistence where the Mosuo can derive substantial incomes from the tourism industry and employment opportunities with which it is associated. Personal incomes derived from salaried or freelance occupational pursuits are shared with other household members at the discretion of the earner. Other sources of non-material wealth included in these data are education, height, weight, and the number of living children reported by respondents. Education is increasingly important as a route to success for the Mosuo and is often listed by Mosuo as the most important goal for community improvement [3]. Height and weight are included as measures of somatic capital and the number of children is used as a proxy for reproductive success.

The data included here are drawn from demographic surveys collected in 2008 in patrilineal and matrilineal sub-populations of Mosuo residing in Yunnan County [3]. At that time, lifestyles varied significantly depending on area of residence: among matrilineal Mosuo living near Lugu Lake, individual subsistence was earned via profits associated with a thriving tourism industry whereas matrilineal and patrilineal Mosuo residing in areas away from the lake more often practiced subsistence agro-pastoralism with more limited opportunities for market participation.

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### **Pimbwe (Contributed by Monique Borgerhoff Mulder; Fieldwork 1995-2016)**

The Pimbwe are a horticultural and mostly subsistence-based Bantu population living in the Rukwa valley (rainfall 900-1000mm p. annum) of western Tanzania, who also hunt, fish and collect honey on a seasonal basis (Borgerhoff Mulder, Caro, and Msago 2007). Data come from 7 censuses of a single village conducted between 1995-2010. Mpimwbe (population ~ 100,000) was until 2006 exceedingly poorly connected to the national grid (poor roads, no mobile phone access, no electricity, water available primarily from seasonal rivers) (Paciotti et al. 2005; Seel, Mgawe, and Borgerhoff Mulder 2014). In 2006, largely on account of the efforts of a powerful Member of Parliament and the recent infusion of aid money into a newly liberalized Tanzanian economy, there have been many changes – an improved road, better access to markets, a mobile phone tower, and a second secondary school. Primary schooling has been available in almost all villages since the early 1970s. During the period of study there was very little evidence of family planning (Borgerhoff Mulder 2009, see also unpubl. data)

The Pimbwe were organized as a chiefdom well into the colonial era, with a matrilineally-inherited weak chieftaincy, a class of chiefly advisors and commoners (Mgawe et al. 2013; Willis 1966; Seel, Mgawe, and Borgerhoff Mulder 2014). Currently we detect few sex-biased inheritance norms, largely because there is little to inherit. Marriage (associated with

small marriage payments) is largely monogamous, although polygyny is increasing (unpubl. data). Divorce is common. Post-marital residence is equally split between virilocal, uxori-local and neolocal/ambilocal residence (Borgerhoff Mulder and Beheim 2011).

The Pimwbe have little accumulated wealth. While a few men and women own smallstock (goats) these are generally used as cash savings. Land in Tanzania is crown property but effectively held by village councils, and individuals gain rights to land through cultivation. Sons and daughters may cultivate part of their father's or mother's plots after their marriage, but often they request new or unused land from the village government, or move to a different village in Mpimbwe (or elsewhere) where one or both of them may have relatives. Other types of wealth include bicycles, homemade shot guns, cooking utensils, axes, hoes, watches, mats, baskets, 12v. batteries, and occasionally furniture; a few individuals own carpentry equipment or other specialized tools (bicycle pumps, spanners, drums for brewing, baskets, etc). Accordingly "wealth" is best captured by ownership of material assets (Borgerhoff Mulder in press), with number of children, and farming skill providing additional information. The cash value of household assets was averaged across censuses and corrected for inter-annual trends across the 7 censuses. Farming skill was estimated using the number of months a house is without maize in the granary. While maize production is subject to all kinds of stochastic factors (weather, changing river courses, elephants, pests, theft), the storing and wise annual use of a harvest reflects good storage practices, good preparation and good planning. Reproductive success is measured as the number of offspring who reached 5 years of age, since child mortality drops precipitously after this age. Children who had not yet reached 5 are weighted according to their probability to survive this period (.82). Mobility, particularly post marital, means that the parent-offspring paired data set is biased towards more stable families. While individuals unpaired with parents are younger than individuals with parents, there are no differences in other wealth measures (household wealth and farming skill, Borgerhoff Mulder in press). Similarly individuals unpaired with children are older, but otherwise no different in wealth than individuals paired to children.

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### **Poland (Contributed by Heidi Colleran; Fieldwork 2009-2010)**

This study was carried out in 21 villages and one town in rural southern Poland in the valleys of the Beskid Wyspowy (Island) mountain range in the outer Western Carpathians, in the district (powiat) of Limanowa. The area is characterized by centuries of peasant subsistence farming and, as part of the Galician region of the Hapsburg Empire, was one of the poorest regions of Europe with a long history of both high fertility and mortality and significant out-migration beginning in the 1880s. A history of partible inheritance introduced by the Hapsburg Empire means that as far back as 1899, over 80% of peasant farmers in the region owned less than 5 acres of land. More than 17% of the population could not produce enough food to support their families and starvation was common. Peasants retained their way of life largely intact right through the post-war and communist periods because the program of land collectivization failed in Poland. Accession to the EU in 2004 has brought pressure to modernize smallholder farming, and the population is rapidly transitioning to dependence on the market economy. At the time of the survey (2009-2010) more than 65% of participants lived in households subsisting partly or mainly on farming, but only ~4% of households were completely independent of the market economy. The study area exhibits high fertility despite being located in a developed country that has one of the lowest total fertility rates in the world. The population is highly homogenous with respect to ethnicity and religion (Catholic), though a number of moribund dialect variants are spoken near the region.

Marriage is monogamous, and post marital residence is either virilocal, uxorilocal, or neolocal. There is a high degree of endogamous marriage, with about one third of couples originating in the same village. Divorce is extremely uncommon. The descent system is patrilineal. Male-biased ultimogeniture has long been preferred for inheritance of both land and property, though women are increasingly inheriting land as family sizes shrink and parents invest in the education of their sons (Colleran 2014). International labour migration is heavily male-biased, with financial returns to employment substantially larger for men. Most internal migration is between local villages: 59% of all respondents were resident in their natal villages at the time of the survey and over 74% of respondents were born into one of the sampled groups.

Households increasingly combine farm and off-farm work, formal and informal wage labour, seasonal and migrant work. The main sources of wealth differ depending on whether a family prioritises farming or not: for farmers land holdings are important, for non-farmers wage-labour income matters most. The best proxy of wealth and/or social status that can generalize across the study population and across cohorts is education: it is also the one type of wealth for which there is comprehensive data across multiple generations. Educational levels vary greatly and farmers still tend to obtain fewer years of schooling than non-farmers. Older participants frequently talked about how they attended school only in the winter months or for limited periods, and 17% of the sample has received only part or full primary education. Today the state provides compulsory education to age 18, however access to quality education is

extremely unequally distributed and schoolbooks and other supplies remain the responsibility of parents. Many respondents in the sample claimed they struggle to manage the costs of education. Most perceive the costs to be increasing, with 88% (n = 1,633) agreeing with the statement that children are more 'expensive' now than they were in the past. Because of low education and a lack of human capital accumulation, farmers in this region have some of the lowest economic participation rates in the country. The rural population also outnumbers the urban one, and a large proportion continues to live on undeveloped farm plots, subsisting on state-provided social benefits or pensions. This means that poorer farmers are effectively forced to continue farming, and are therefore an extremely economically vulnerable section of the population.

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### **Tsimane (Contributed by Michael Gurven; Fieldwork 2002-2008)**

Tsimane are mostly a subsistence-based society of over 16,000 forager-horticulturalists living in more than 95 villages with low level market interactions with the cash economy [1]. Horticultural fields containing a mixture of plantains, rice, corn, and sweet manioc are fairly small (<1 ha) and are left to fallow after several years of use, with new fields created based on availability and ownership based on usufruct. In more acculturated villages, fields are often larger because rice and other cultigens are also sold as cash crops. Fishing is common in all Tsimane villages located near rivers, oxbow lakes, or lagoons. Hunting with shotguns, rifles, and bow and arrow is common in interfluvial villages. Income is earned through sporadic wage labor opportunities with loggers, merchants, and ranchers, while a small number of mostly men have been trained as bilingual elementary education teachers.

Tsimane villages are comprised of clusters of related households who often pool resources and labor. Marriage is typically monogamous, although polygyny is permitted [2]. Marital residence patterns tend to be uxorilocal until at least the first child is born and then the traditional pattern is virilocal residence. However, there is much flexibility in this pattern to accommodate personal desires, resource limitation in certain areas, and demographic instability. Mobility was more common a generation ago [3], and with high fertility (total fertility rate = 9 births over the reproductive life of a Tsimane woman who survives from ages

15-49), extended families are often spread across numerous communities. Lineality is organized through double descent. After death, a person's belongings are usually burned or buried with the person, although expensive durable items are passed down in a generally egalitarian manner [4]. Items of value could include domesticated animals such as chickens and ducks, shotguns and rifles used for hunting, axes, radios, watches, bicycles, and dugout canoes.

For most traditional Tsimane, wealth is somatic. It is food stored in human bodies, channeled into growth, reproduction and immune function (the Tsimane are non-contracepting). There is little accumulated material wealth, and no consistent, robust associations between market access and wealth inequality have been demonstrated [5]. Wealth and traditional assets are generally pooled and used widely among household members [6], but a study of parental investment in sons vs. daughters showed that greater possession of modern wealth items by Tsimane mothers associated with greater nutritional status of their daughters, but not sons [7].

Types of wealth included in the current analyses include reproductive success (RS), body size (weight), and cultural knowledge. Measures are constructed from data collected from ongoing fieldwork as part of the Tsimane Health and Life History Project (2002–2008) [8]. RS includes number of children surviving to age 5 among women age 40 and men age 45, with right-censored cases discounted by the average probability of surviving to age 5. Body size is measured as body weight wearing light clothing taken during medical visits using a portable weigh scale. Cultural knowledge is measured from self-reported possession of a large number of sex-specific cultural skills covering economic production, tool and craft manufacture, song and story repertoire, and sociality.

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**Ust'-Avam (Contributed by John Ziker; Fieldwork 1994-2007)**

Ust'-Avam is an indigenous Siberian community of ~550 people on the Taimyr Peninsula, the northernmost extension of the Eurasian landmass. The community is approximately 250 kilometers by air from the regional capital, Dudinka, and 400 kilometers by water from the industrial city of Noril'sk. Ust'-Avam, is approximately 50 percent Dolgan, 45 percent Nganasan, and 5 percent other nationalities from the former Soviet Union (Ziker 2002). Until the mid-1970s, Dolgan families traditionally practiced reindeer pastoralism, mostly in combination with terrestrial game hunting, fishing, trapping, and mercantile trading in extended family groups (Popov 1937, 1964), and later in Soviet-era work collectives. A minority of Dolgan families utilized dog teams for travel instead of domestic reindeer. In the 1920s, Soviet census-takers identified a small proportion of Dolgan families who owned domestic reindeer herds running into the thousands of head (Ziker 2011). Most families migrated along with their reindeer herds to the north or into the mountains during summer, then back to the forest in winter. Some of these families had strong reputations in mercantile trade and would travel hundreds of kilometers from Lake Essei to Volochanka and Dudinka. Soviet authorities viewed such families as exploiters, and many were disenfranchised and arrested as nomadic and clan soviets were established. The Nganasan were traditionally known for their wild-reindeer hunting and use of small herds of domestic reindeer for decoys (Popov 1966). They lived to the north of the Dolgan, and would migrate into northern Taimyr during summer and back to the Dudyppta River and tree line in winter. Shamanism was a strong tradition among the Nganasan, and a few individuals had reputations for being powerful shamans. The Dolgan language is similar to Sakha (Yakut), the northernmost branch of the Turkic language family. Nganasan is one of six languages in the Samoyedic branch of the Uralic language family. Most younger individuals now speak Russian as their primary language.

At the time of the advent of Soviet power, the Nganasan lived in mobile extended family units and had seven exogamous patrilineal clans. Bilateral cross-cousin marriages occurred into the 1940s and 1950s. There have been many mixed marriages between these groups and between members of these groups and non-indigenous individuals in the community in recent decades (Ziker 2002). Descent and postmarital residence norms have shifted significantly since collectivization in the 1930s and development of state farms and permanent settlements in the 1960s and 70s. During the period of data collection (1994-2007), the vast majority of families were living in Ust'-Avam *poselok* (a compact settlement) on the Avam River, 13 kilometers upriver (south) from the confluence of the Avam and Dudyppta Rivers. A small minority of indigenous households (~10) lived in a smaller settlement Kresty Taimyrski at the confluence of the Dudyppta and Piasino Rivers, about half the distance by river to the industrial zone of Noril'sk. Another 10-15 households lived in single family, duplex, and quadraplex housing distributed along the Dudyppta River at its major tributaries. Each house was associated with a hunting territory assigned during the Soviet Union (Ziker 2003). Another dozen or so

households living in the main Ust'-Avam settlement had large (>100,000 hectares) assigned hunting territories north and south of the village and not on major rivers. These territories were located up to 150 km from the community. Most families who had received assigned territories had some historical affiliation to campsites and trap lines within their territory, although because a number of families were moved to Ust'-Avam to make way for the development of Noril'sk in the 1940s, some inheritance was cognatic and some territories were assigned to non-relatives. Inheritance of these territories was generally patrilineal during the period of data collection, although some cognatic inheritance was also observed. Traditionally, a bride price was required for marriage in both Dolgan and Nganasan groups. Some families still maintain this practice to some extent giving items such as frozen fish and skins from fur-bearing animals to the bride's family. There were many single mothers in the community (ostensibly to take advantage of social welfare payments) and divorce was common. There were a few women who had moved from other villages to marry and there are several men who moved to the community during its construction in the 1970s and 80s and married local women.

Educational attainment, an embodied wealth variable, was documented in each census done in 1994, 1997, 2001, 2003, and 2007 as the number of years of school completed. Another embodied wealth variable, hunting skill, was documented in 2003 for 142 men through interviews of 9 informants in the community (Ziker, Nolin, and Rasmussen 2016). Each of the expert informants rated each man according to a 3-point scale (1 = poor hunter, 2 = good hunter, 3 = excellent hunter) and scale was constructed. Hunting material wealth was also documented in 2003 for all part time and full time hunters. Four types of equipment were inventoried: (1) snowmobile, (2) boat motor, (3) rifle, and (4) shotgun. These capital equipment items, plus a dummy variable representing (5) occupation of hunting territories was used to create a hunting material wealth scale. Research on wealth examined embodied, relational, and material wealth effects on men's reproductive success (Ziker, Nolin, and Rasmussen 2016). Extensive genealogical information on the community was collected as part of the community censuses. Relational wealth was counted as the number of parents' siblings and number of first cousins to develop figures on kin group size. Increasing numbers of parent's siblings had a positive effect on men's reproductive success while increasing numbers of first cousins had the opposite effect. Additional wealth information was gathered from 30 men and 30 women in 2003 as part of a cross cultural experiment (Ziker 2014). Participants were asked to list items that could be considered capital wealth, including snowmobiles, sleighs, boats and boat motors, firearms, sewing machines, bank accounts, and other items of capital wealth. Information on cash income was also collected.

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