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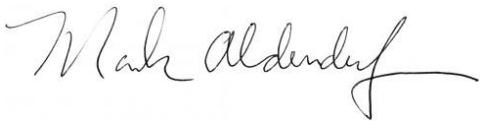
Editorial: Intergenerational Wealth Transmission and Inequality in Premodern Societies

Deng Xiaopeng has been reported to have said, "To get rich is glorious." He is also reported to have said, "Let some people get rich first." The papers in this special issue of *Current Anthropology* can be said to focus on the consequences of Deng's aphorism—how some people get rich and how they manage to transfer that wealth, variously defined, to subsequent generations. As the papers in this issue argue, wealth comes in various forms, and there are different modalities by which these forms are transferred to offspring and kin. What I found particularly compelling, however, was the simplicity of the model Smith and his cast of characters developed: two parameters do the heavy lifting—shocks, which are windfalls or losses, and the degree to which those shocks are transferred to offspring. As both the authors and the commentators note, these models do not explain all that we want to know about wealth transfer; nevertheless, they offer a firm empirical basis for exploring this topic in greater depth and breadth. One outstanding question I would like to see explored is how wealth disparities are eventually transformed into persistent political inequalities that are maintained over the generations. Smith and his coauthors have outlined some of the directions this research may take, and I look forward to seeing it, perhaps in the pages of *CA*.

The editorial offices of *Current Anthropology* are moving once again after a brief stay at the University of Arizona. I am taking up the position of dean of the School of Social Sciences, Humanities, and Arts at the University of California, Merced, the tenth and newest campus of that system. Although this move will not affect the manuscript submission process or production (those activities will, of course, remain at the University of Chicago Press), it will mean, at least temporarily, that two popular departments of the journal—"Anthropological Currents" and "Current Applications"—will go into hibernation. Although Merced does have an anthropology major, it does not have a graduate program and will not have one for the foreseeable future. Graduate students enrolled in a class about the journal are those who write "Currents" and "Apps," as we call them, and we should have enough contributions from my hard-working Arizona students for both of these departments to last through volume 51, so the real effect of this transition will not be felt until 2011.

I have found that one of the most enjoyable aspects of editing the journal has been my interaction with the Arizona students in our version of the *CA* class. Because Arizona is a four-field department, students from each of the subdisciplines usually enroll. Frankly, I have been deeply impressed with the quality of our students and the enthusiasm they bring to the class. And because their interests are diverse, I learn a great deal about areas of anthropology I had little cause to consider before becoming editor. I am well on my way to that place described by Adam Kuper, who said in his reflections on the fiftieth anniversary of the journal, "I learned more from editing *CA* than from any part of my formal training. . . . *CA* made me into a real anthropologist." I hope that the students with whom I have worked over the past two years think of their experience in the class in the same way. I will miss them. And I will miss my colleagues, as well, who offered much advice on manuscripts, reviewers, and books worthy of review. Thanks to all of you for your support.

I am exploring ways in which to bring the *CA* course back to life. Merced has invested heavily in smart classrooms and videoconferencing technologies, and I am now just beginning to explore how the course may be taught within the University of California system, which has some of the best anthropology departments in the nation. Who knows—we may even end up in Second Life! Stay tuned.



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Intergenerational Wealth Transmission and Inequality in Premodern Societies

The Emergence and Persistence of Inequality in Premodern Societies

Introduction to the Special Section

by Samuel Bowles, Eric Alden Smith, and Monique Borgerhoff Mulder

CA+ Online-Only Supplement: Estimating the Inheritance of Wealth in Premodern Societies

In this special section we propose an interpretation of the emergence and persistence of wealth inequality in premodern populations along with ethnographic and quantitative evidence exploring this hypothesis. The long-term trajectory of inequality in premodern societies, we suggest, is based on the differing importance of three classes of wealth—material, embodied, and relational—together with differences in the transmission of these types of wealth across generations. Subsequent essays in this forum use data on individual and household wealth from 21 populations to evaluate this and related propositions concerning the interaction of wealth class, transmission rates, production systems (foraging, horticultural, pastoral, and agricultural), and inequality. Here we motivate our interpretation by applying our ideas to the Holocene transition from more egalitarian to more stratified societies, introduce key concepts that are developed in the subsequent essays, and comment on some of the limitations of our study.

Given that sustained economic inequalities generally leave archaeological signatures, their absence (in the form of funerary assemblages, storage facilities, dwellings, ceremonial objects, and nutritional indicators) suggests that prior to about 24,000 years ago (and possibly much more recently), most humans lived in foraging bands with little economic differentiation among families (Formicola 2007; Pettitt and Bader 2000; Vanhaeren and d'Errico 2005). Excepting groups occupying especially rich fishing and hunting sites, substantial levels of economic inequality became characteristic of many (but far from all) populations only after the domestication of plants and animals, eventually culminating in the emergence of class societies and the hierarchical ancient states. We here offer a unified explanation both of the emergence of highly unequal societies and of the continuum found in the ethnographic and historical record from egalitarian foragers to economically stratified pastoral and agricultural societies.

The key to understanding both the Holocene transition and the inequality continuum among contemporary small-scale societies, we propose, is the degree to which wealth is transmitted across generations, for this will determine the extent to which differences in wealth among families may cumulate over time. An example illustrates what is distinctive about our explanation. The Keatley Creek fishers of British Columbia (Hayden 1997), a sedentary prehistoric population, demonstrate the key role of intergenerational inheritance in sustaining inequality. Archaeological studies reveal dietary and other differences between the residents of distinct longhouses that are traceable to the control by the rich over access to choice fishing sites and the transmission of this privilege across generations.

Our explanation of the dynamics of inequality formalizes the contrast between Keatley Creek with its inherited fishing

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sites and extraordinary inequalities and the more common egalitarian social structure of foraging groups, in which (as we will see) wealth is less readily transmitted. This contrast when fully developed suggests a more general way of thinking about variation in equality in the very long run and across different types of human societies.

Limitations of the available archaeological sources have led us to rely on contemporary or historical data. Prehistoric wealth inequality and its transmission across generations is evident in opulent burials of children and other mortuary practices (Formicola 2007; Pettitt and Bader 2000; Vanhaeren and d'Errico 2005), the nature and distribution of ceremonial goods (Hayden 2001), the size and location of dwellings and storage facilities (Soffer 1989), and measures of stature and health (Cohen and Armelagos 1984). Although the archaeological evidence indicates the presence of prehistoric inequality, it does not allow precise estimates of its degree or the extent of its intergenerational transmission that would permit comparison across differing production systems and historical epochs. Fortunately, current and recent data, when analyzed with appropriate models, can assist in the reconstruction of the past. Examples include the use of contemporary linguistic and genetic evidence to infer ancient patterns of migration (Seielstad, Minch, and Cavalli-Sforza 1998; Wilkins 2006), economic transitions (Ammerman and Cavalli-Sforza 1984), and social structure (Kirch 1984; Nettle 1996).

Other explanations of the Holocene emergence of inequality have attributed a central role to climate change (Boyd et al. 2001), to food storage (Kuijt 2008; Testart 1982), to elite control of circumscribed resources such that the costs of desertion are high (Boone 1992), or to the promotion of luxury consumption and ceremonial display (Hayden 2001). Still other explanations stress population pressure (Cohen 1977; Dow and Reed 2009; Kennett et al. 2008; Shennan 2008), warfare (Rowthorn and Seabright 2008; Spencer 2002; Webster 1975), or developments that permit a more complex division of labor (Henrich and Boyd 2008; Smith and Choi 2007), and others attribute a decisive role to ideological and cultural factors such as a growing concentration of control over ritual (Trigger 2003). Related and additional interpretations have been proposed for the rise of states (Wright 1978), and further explanations are surveyed in Ames (2007) and Johnson and Earle (2000).

Economic and social inequality is generally measured by the extent of enduring differences among people or families in access to valued goods, services, or status. It is conventional to distinguish between achieved differences that may result from differential skill, effort, or other individual attributes, on the one hand, and ascribed differences due to distinctions of ethnic group membership, race, or social origins on the other. Understood as persistent ascribed differences in access to economic resources and other valued ends, inequality is exemplified by the transmission of economic and social advantage within families across generations. As the basis of hereditary elites and of caste and other persistent systems of social stratification, the intergenerational transmission of wealth has figured prominently over the centuries in theories of inequality and social change. Similarly, wealth transmission is central to debates on equality of opportunity, distributive justice, and poverty alleviation.

The intergenerational transmission of education, occupational prestige, physical capital, and other forms of human and material wealth has been extensively studied by economists and sociologists, and its quantitative extent has been estimated in comparative studies in a limited number of modern economies (Björklund and Jäntti 2009; Bowles and Gintis 2002; Corak 2004; Hertz et al. 2007). But for premodern societies, individual-based empirical estimates of the extent of intergenerational transmission are almost nonexistent, despite a long history of ethnographic interest in the more formal rules of inheritance (Goody 1976) and valuable comparative contributions based on ethnographers' subjective assessments (Pryor 1977, 2005).

To remedy this situation, we must address a set of challenges. The first is to identify the distinctive kinds of wealth that are central to the livelihoods of foragers, horticulturalists, and premodern agriculturalists and herders, which include little-studied aspects of wealth such as the skills involved in subsistence production, social connections such as exist in food sharing or coalitional networks, as well as land, livestock, and material possessions and the more commonly studied aspects of somatic wealth (such as body weight). The second challenge is to devise measures of the intergenerational transmission of wealth that are applicable across different kinds of wealth and across different populations, including those with radically different social and demographic structures, including foragers, horticulturalists, herders, and farmers. The fact that the necessary information is not available in standard survey data sets is another heretofore decisive impediment to such comparative studies.

While the degree of intergenerational wealth transmission within families and the degree of wealth inequality among families in a given generation are entirely independent measures, the two are causally linked. As long as wealth is transmitted across generations, any sources of different wealth holdings in a given generation—bountiful harvest or hunt, an incapacitating accident, or theft of one's stock—will contribute to the inequality in the next and subsequent generations. We have explored elsewhere (Borgerhoff Mulder et al. 2009) the interaction between chance shocks to one's wealth and its transmission across generations. This interaction implies a wealth dynamic that may give a stationary (long-run equilibrium) level of wealth inequality. This steady state balances, on the one hand, the tendency of wealth inequality to dissipate over time due to regression to the mean in intergenerational wealth transmission (meaning that the offspring of the rich are closer to the mean than their parents were, and similarly for the offspring of the poor) with, on the other, the offsetting injection of new inequalities in each generation due to shocks.

In this and the following five essays, we and our colleagues report the results of a study of these multiple dimensions of wealth, based on new data from 21 hunter-gatherer, horticultural, pastoral, and agricultural populations. Our studies examine both the distribution of wealth among individuals (or households) and its transmission across generations. We present estimates of dispersion and intergenerational transmission for 43 different types of wealth, and we use these to discuss the dynamics of inequality across different production systems. See also the CA+ online supplement "Estimating the Inheritance of Wealth in Premodern Societies" in the online edition of *Current Anthropology*.

The Nature of Wealth and Its Intergenerational Transmission

We use a broad definition of "wealth" similar to Kaplan's (1996) concept of embodied and extrasomatic capital and to economists' measure of physical and human capital (Schultz 1961), namely, an attribute of the individual that contributes to a flow of valued goods or services. We do this because we want to examine a wide range of causes of inequality among individuals that may be transmitted across generations, whether these inequalities are associated with differences in livestock, land, tools, skills, knowledge, reproductive success, body weight, trading partners, social networks, or other individual attributes. In this respect we converge with the work of social scientists engaged with poverty alleviation who emphasize the nonincome dimensions to poverty such as longevity, literacy, and health, given that the poor generally live shorter and less healthy lives and enjoy less education than the rich (Kanbur 2001). It also converges with that of evolutionary anthropologists, who have made the intergenerational transfer of a whole range of wealth types central to their models of human demographic patterns (Kaplan 1996; Kaplan and Lancaster 2003; Lee 2003; Luttbeg, Borgerhoff Mulder, and Mangel 2000; Mace 2000).

We group these disparate kinds of wealth into three generic categories—material, relational, and embodied. Material wealth consists of real estate, livestock, household goods, farm equipment, and other material items that store wealth, such as jewelry; in this study our primary measures are land, livestock, and household effects. Relational wealth refers primarily to an individual's position in social networks, specifically, the number and status of individuals to whom he or she is linked. Anthropologists have long recognized the importance of such relationships (Mauss 1967). Here we measure relational wealth by number of partners with whom an individual shares food, labor, or livestock; unfortunately, we have no measures of ritual power, an important element of relational wealth and key to institutionalizing inequality in some populations (e.g., Keen 2006). Embodied wealth includes strength, immune function, coordination, skill, and knowledge. Here our measures include body weight, grip strength, practical skills, and knowledge measured by indices such as foraging returns or farming skills and (in predemographic transition populations) reproductive success. We recognize that reproductive success (as a measure of Darwinian fitness) is commonly viewed as a consequence rather than a measure of wealth (e.g., Nettle and Pollet 2008). Here, however, we use reproductive success as a summary indicator of somatic wealth, capturing an individual's ability to produce and successfully raise offspring.

Material, relational, and embodied wealth take different forms in each population. For example, material wealth among East African pastoralists (livestock) is quite different from that of English farmers in the seventeenth and eighteenth centuries (an estate) or the household utensils and tools of a South American horticulturalist. Similarly, the food-sharing networks of whalers in Indonesia are very different from *hxaro* exchange partners among the Botswanan Ju/'hoansi. Nevertheless it is generally straightforward to classify these and other forms of wealth as embodied, material, or relational.

We have collected individual- or family-level data on as many types of wealth as possible that fall into these three classes. The resulting wealth measures for parent-offspring pairs reveal the similarity of wealth levels across generations, allowing us to estimate the degree of intergenerational transmission of wealth. The same data (not restricted to intergenerational pairs) also allow an estimate of the degree of inequality among households and individuals with respect to different kinds of wealth.

Transmission of material resources between generations is a defining feature of humans. It occurs in some nonhuman species, typically, cooperative breeders such as acorn woodpeckers, where 24% of males inherit their parents' territory along with its granary of acorns (Koenig et al. 2000). But species where the young stay in their natal area and benefit from such bequests are unusual, and the extent of bequests is limited compared to those that occur among humans, where offspring generally acquire a great deal more from parents than their genetic material. Anthropologists most commonly refer to intergenerational transmission as "inheritance," examining normative conventions regarding the transmission of material resources, property rights, political office, and more abstract aspects of status (such as caste). For example, they attribute some aspects of cultural diversity to the extent of durable resources that may be transmitted to the next generation (Diehl 2000; Gaulin and Schlegel 1980; Kelly 1993; Price 1995). And where there are such resources to transmit, they have examined how the transmission of material resources, political offices, and other kinds of status is patterned by sex (matrilineal or patrilineal; e.g., Aberle 1961) or sex and linearity (Burton et al. 1996; Collier 1988; Earle 1997; Jones 2003). Anthropologists have also sought to link the existence of heritable property to different kinds of kinship systems (Aberle 1961; Carneiro 1970; Gibson 2008; Gray and Gulliver 1964).

Humans are also unusual in the extent to which embodied wealth in the form of knowledge and skill are transmitted,

and indeed it is this extended dependence of offspring on their parents during which offspring learn to forage for hard-to-acquire foods that many now argue creates the selective conditions that shaped our unique life histories (Kaplan, Hooper, and Gurven 2009). Studies of some other animals show considerable inheritance of dominance rank (Cowlishaw and Dunbar 1991; Engh et al. 2000; Pusey and Packer 1997; Silk, Altman, and Alberts 2006), and for some (e.g., female spotted hyenas; Hofer and East 2003), the transmission process depends critically on the presence of the parent. Humans are thus not unique in the intergenerational transfer of nonmaterial resources. But the unusually long period of dependence on parental support is testimony to the extent that learning from parents and others in the previous generation is essential to human livelihoods.

Transmission-Enhancing Mechanisms

Our measure of wealth transmission across generations is the statistical association between offspring's and parent's wealth (technical details for the model and estimation in this and subsequent essays are in the CA+ online supplement and in Borgerhoff Mulder et al. 2009). We adopt the convenient unit-free convention of measuring this association as an elasticity, namely, the percent difference in offspring wealth associated with a percent difference in parental wealth, which we refer to as β. (Francis Galton's [1889] "regression to the mean" is $1 - \beta$.) Though we describe a process of "transmission," β need not represent a literal passing on from parent to child of such things as tracts of land or herds of stock. Its extent is the result of these bequest-like processes and any other mechanism that links differences in parental wealth to differences in offspring wealth.

In addition to bequests and other direct transfers, the most important of these mechanisms affecting β are assortment in marital, productive, or other resource-sharing activities; the manner in which wealth is invested, developed, consumed, or otherwise used; and the extent to which others may be excluded from the benefits of wealth acquired from parents. Positive assortment contributes to intergenerational transmission because when wealthy individuals share sources of wealth (whether material, cultural, or genetic) with similarly wealthy mates or partners in economic pursuits, regression to the mean $(1 - \beta)$ is limited. The importance of the next mechanism derives from the fact that wealth difference that may be due to differences in transfers or assortment may either grow or diminish over time. In the former case, the result is to enhance the level of association between parental and offspring wealth. This is likely to occur when there is cumulative advantage associated with the use of wealth, as may arise in the case of material wealth if there are economies of scale (e.g., in irrigated agriculture or herding). In these cases, somewhat larger holdings in one generation may result in significantly larger holdings in the next, partially overcoming the pressures for regression to the mean arising from less than perfect assortment and the dissipation of resources among multiple offspring or others in the bequest process. Cumulative advantage may also arise for some kinds of politically deployed network wealth, where the influence one may exert increases more than proportionally with the number of ones' allies.

Finally, there is the extent to which the form of wealth acquired from one's parents allows the offspring to exclude others from its use. An example is knowledge (how to make a tool or where to find honey) that is typically directly transmissible but cannot readily be monopolized by offspring (except for some kinds of culturally protected ritual knowledge). Thus, differences in the degree of transmission (β) associated with different classes of wealth arise because material, embodied, and relational weath differ in the extent to which direct transmission is possible, whether aspects of the wealth class favor assortment, the extent of cumulative advantage, or the extent to which others can be excluded.

Data and analysis in the essays that follow show that the extent of actual transmission is not determined solely by the characteristics of the wealth type and will differ across production systems in response to differences in the cultural norms and political practices of a group and other influences not directly linked to the type of wealth. But the above analysis does suggest that material wealth, because it is directly transmissible, is subject to both positive assortment and cumulative advantage, and is excludable, may be more highly transmitted than either embodied or relational wealth. Our summary of the relevant influences appears in table 1.

Measuring Wealth Transmission, Importance, and Inequality

We seek to estimate β (the percent difference in offspring wealth associated with a percent difference in parental wealth) based on the statistical association of wealth levels for parents and offspring at the same age or at death. For example, for East Anglian farmers in the sixteenth to eighteenth century, our estimate is based on estates at death of the two generations, while our β's for the intergenerational transmission of reproductive success are statistically age corrected to estimate completed reproduction. To provide a more intuitive answer to the question of how much intergenerational inequality a given value of β indicates, we can use the estimate of β to indicate the probability that an offspring whose parent is in

Table 1. Factors enhancing the transmission of three classes of wealth

	Material	Embodied	Relational
Direct transmission	Yes	Limited	Limited
Cumulative advantage	Yes	No	In some cases
Positive assortment	Yes	Yes	Limited
Excludable	Yes	In some cases	No

the top decile (or quintile) of the distribution of wealth will also end up in the top decile (or quintile), to the probability that the offspring of a parent in the bottom decile will end up in the top decile (or quintile). For example, $\beta = 0.2$ implies that the offspring from the top decile in distribution of wealth in the parental generation has 3.6 times the likelihood of being in the top decile of his or her generation as the son or daughter of the bottom decile (for details, see the CA+ online supplement). Thus, what may appear to be "small" intergenerational elasticities imply quite substantial differences in life chances. Doubling the β (to 0.4) more than quadruples the ratio of the above conditional probabilities (to 16.2).

In order to estimate the overall degree of wealth inheritance characteristic of a particular population, we need to average the various kinds of wealth essential to their livelihoods. Because the importance of each wealth type will of course differ across production systems, we use a weighted average, the weights (termed α) measuring the relative importance of a given wealth class for the particular population in question. To determine the importance of a wealth category within a particular production system, we used ethnographers' judgments (for each wealth class in the population they studied) of the percentage difference in household well-being associated with a 1% difference in amount of a given wealth class, holding other wealth classes constant at the average for that population and requiring these percentage effects to sum to 1. We then used these weights to calculate an "importance-weighted" or "α-weighted" average β for the population (details and alternative direct estimates are in the CA+ online supplement).

To determine inequalities in our measures of wealth, we calculated a Lorenz curve-based Gini coefficient on age-adjusted data; a Gini coefficient approaches 1 if in a large population a single person owns all the wealth, whereas a Gini of 0 implies complete equality. (For example, Gini coefficients for grave wealth for some of the Northwest Plateau fishers are in the neighborhood of 0.7, indicating an extraordinary level of economic inequality [Schulting 1995] possibly on a par with modern Brazil or South Africa.)

The Sample of Societies

Table 2 describes the populations studied. As can be seen, these are distributed across all continents, but unevenly (e.g., Africa is overrepresented, the Americas the opposite). Due to the nature of the individual-level data required to estimate β, we utilized primarily ethnographic rather than archaeological data sets; we include three premodern European populations studied through archival material. The paucity of samples, compared, for example, to the Standard Cross-Cultural Sample ($n = 186$), reflects the fact that despite growth in quantitative ethnographic research, there are still few data sets that allow for the reliable estimation of intergenerationally transmitted wealth. This is hardly surprising, given the fact that the fieldwork on which most studies are based is typically short-lived—the length of a PhD, with perhaps a few return visits to a site. Tracing families and households over time is challenging, requiring painstakingly cautious ethnography and sophisticated use of databases. Our strategy is to focus on studies that provide rigorously collected social, economic, and demographic data so as to generate reliable estimates of the distribution and transmission of different wealth types. This yields a sample of 21 populations, one of the largest comparative anthropological studies of small-scale societies based on individual-level data.

Production Systems

As in the case of our three wealth classes, the boundaries demarcating the four production systems that we study—hunter-gatherer, horticultural, pastoral, and agricultural—are a matter of judgment. We employ these conventional categories because past research (reviewed in Johnson and Earle 2000) has suggested that these are strongly associated with different levels of equality and inequality, and we wish to explore what role intergenerational transmission and the importance of different categories of wealth might play in this. We refer to this definitional framework as production systems rather than subsistence systems, even though the latter term is used more conventionally in anthropological and archaeological work, because although each of our societies does produce food for subsistence, they all are (and probably have been for a long time) integrated into local, even regional, markets.

Accordingly, we define hunter-gatherer production systems as those that make no (or minimal) use of domesticated species (either plant or animal), whereas pastoralists rely primarily on the livestock that they raise for subsistence and sometimes commercial purposes. Pastoralists may farm, but the extent of land that is cultivated is constrained not by ownership rights but, rather, by labor availability. Horticulturalists are variously distinguished from agriculturalists in the use of plows and traction animals by the latter, in whether the system is labor or land limited, in commercial orientation, or in the alienability of land. A strict technologically based definition of production systems would focus on the use of plows and traction animals versus hoes. In practice, the systems analyzed here differ in terms of technology as well as in terms of the productivity, scarcity, and alienability of land. Accordingly, horticulturalists cultivate land that is plentifully available with hoes, and agriculturalists cultivate family-owned farms with animal-drawn plows. As subsidiary activities, horticulturalists often fish, hunt and gather, and keep livestock, whereas agriculturalists most commonly supplement their production of crops with livestock rearing. We recognize that distinctions between these production systems are necessarily somewhat arbitrary, and we stress that production systems are in no sense viewed as evolutionarily sequenced stages. They are, however, very useful for defining

Table 2. Sample background

Production system and population	Location and date	Categories of wealth studied	Researcher (key publication)	General description	Type of inheritance for property and positions
Hunter-gatherer:					
Ache	Paraguay (1982–2008)	Weight; hunting returns	Hill (Hill and Hurtado 1996)	Mobile foragers	No formal inheritance of property beyond gifting; foraging territories show weak patrilineal bias; godparental relationships influence status acquisition
Hadza	Tanzania (1982–2008)	Weight; grip strength; hunting skill; digging skill	Marlowe (Marlowe 2010)	Mobile foragers	No formal rules; various kinfolk take miscellaneous items of material property
Ju/'hoansi	Botswana (1973–1975)	Exchange partners	Wiessner (Wiessner 1982)	Mobile foragers	Exchange partners and land rights inherited from both mother and father
Lamalera	Indonesia (2006)	Quality of housing; boat shares; food share partners; reproductive success	Nolin (Alvard and Nolin 2002)	Sedentary fishers, trade with farmers	Patrilineal inheritance of most property; important positions nominally inherited by sons but in practice may be achieved by others
Meriam	Australia (1998)	Reproductive success	Smith (Smith, Bliege Bird, and Bird 2003)	Sedentary fishers with farming	Patrilineal inheritance of land at individual and patriclan level, with some inheritance by daughters; positions generally achieved rather than ascribed
Horticultural:					
Dominicans	Dominica (2000–2008)	Land	Quinlan (Quinlan 2006)	Farmers	Patrilineal inheritance of usufruct of family land; buildings and trees transferred with weak kin bias
Gambians	Gambia (1950–1980)	Weight; reproductive success	Sear (Sear et al. 2002)	Farmers	Primarily patrilineal, with some mother-daughter inheritance of land
Pimbwe	Tanzania (1995–2008)	House/farm utensils; farming skill; weight; reproductive success	Borgerhoff Mulder (Borgerhoff Mulder 2009)	Farmers with some fishing	No formal rules, but possessions usually inherited by same-sex children; matrilineally inherited ritual chiefly positions
Tsimane	Bolivia (2002–2008)	Household utensils; labor cooperation; allies in conflict; knowledge/skill; grip strength; weight; hunting returns; reproductive success	Gurven (Gurven, Kaplan, and Zelada Supa 2007	Farmers with fishing and foraging	No formal rules, but possessions usually inherited by same-sex children; status positions are mostly achieved

Pastoralist:					
Datoga	Tanzania (1987–1989)	Livestock; reproductive success	Borgerhoff Mulder (Borgerhoff Mulder 1992)	Transhumant pastoralists, with some farming	Patrilineal inheritance of livestock, slight advantages to first and last sons
Juhaina Arabs	Chad (2003)	Camels	Fazzio (Fazzio 2008)	Transhumant pastoralists	Patrilineal inheritance of livestock equally among sons
Sangu (Ukwaheri)	Tanzania (1997–2000)	Cattle	McElreath (McElreath 2004)	Pastoralists with some farming	Patrilineal inheritance of livestock equally among sons
Yomut (Charwa)	Turkmenistan/Iran (1965–1974)	Patrimony (livestock)	Irons (Irons 1975)	Transhumant pastoralists, with some farming	Patrilineal inheritance of livestock equally among sons
Agricultural:					
Bengali	India (2000–2001)	Reproductive success	Leonetti (Leonetti et al. 2005)	Farmers with wage labor	Patrilineal inheritance of land
Bengaluru	India (1910–2002)	In-law networks	Shenk (Shenk 2005)	Farmers, merchants, wage labor, urban	Patrilineal inheritance of property equally among sons; daughters given dowries at marriage
East Anglians	England (1540–1845)	Estate value (land); reproductive success	Clark (Clark 2007)	Farmers, with wage labor and merchants	Sons inherit at least two-thirds of father's property, with slight bias toward primogeniture
Khasi	India (2000–2001)	Reproductive success	Leonetti (Leonetti et al. 2005)	Farmers with wage labor	Daughters inherit land from mother; youngest daughter inherits mother's house
Kipsigis	Kenya (1981–1990)	Land; livestock; cattle partners; reproductive success	Borgerhoff Mulder (Borgerhoff Mulder 1995)	Farmers with livestock	Patrilineal for land and livestock equally among sons
Krummhörn	Germany (18th–19th centuries)	Land	Beise (Voland 1990)	Farmers	Ultimogeniture; noninheriting siblings are compensated, daughter's share half of a son's
Skellefteå	Sweden (1800–1888)	Reproductive success	Low (Low and Clarke 1990)	Farmers	Prior to mandate for equality in 1840s, land inheritance primarily to sons
Yomut (Chomur)	Turkmenistan/Iran (1965–1974)	Patrimony (land)	Irons (Irons 1975)	Farmers with livestock	Patrilineal inheritance of land equally among sons

the broad contours of how the intergenerational transmission of their principle wealth types might be correlated with levels of inequality.

Discussion

The distinctive feature of our approach is its use of individual- or family-level continuous measures of a heterogeneous set of wealth types to assess the extent to which differences among families in such valued ends as access to resources and social ties are perpetuated over time. The fact that our measure of transmission is unit-free facilitates quantitative comparisons across wealth types and production systems. The approach may be contrasted with heretofore available comparative studies that have relied not on individual-level data but on an ethnographers' qualitative assessment of the extent of intergenerational inheritance or the degree of wealth inequality in the population as a whole, often converted to an ordinal five-point scale. The qualitative and ordinal nature of these data effectively preclude systematic comparisons across wealth types and production systems. As we will see in the essays that follow, our conclusions do not entirely support the impressions gained from the ethnographic literature.

Using individual data on continuous measures of wealth comes with a price, however. The underlying model is about the dynamics of inequality based on a continuum of wealth in which some have more and others less. It does not represent a class-divided population in which the control over material wealth—land or cattle, for example—differentiates an owning class from those without material wealth—the landless, for example, whose only wealth is embodied and relational and whose livelihood depends on access to material wealth under the control of others. Yet such class distinctions are present, even in some hunting and gathering systems (Ames 2008; Arnold 1993; Hayden 2001; Kennett et al. 2008).

Related to this shortcoming is the fact that we do not consider group inequality such as may exist not only among classes but also between men and women, the young and the old, among castes, and in societies with a history of subordination of subpopulations. Partly for this reason we also cannot study class-based and other forms of collective action and their effects on intergenerational transmission and inequality of wealth. While in the societies under investigation these do not take the familiar forms of strikes, lockouts, and the other commonplace conflicts of industrial economies, collective action in conflicts over wealth nonetheless affects the distribution of wealth and its intergenerational transmission in premodern populations. Examples are the coordinated shunning, threats of ostracism, and other constraints deliberately imposed on would-be aggrandizers in many hunter-gatherer populations (Boehm 2000). Lavish funeral feasting expected to be provided by wealthy families of the deceased is another collective practice that effectively limits direct transmission of material wealth to offspring (Hayden 2009; Parker Pearson 1999).

Due to the limited nature of the available data, our sample of populations is not (in technical terms) representative and for that reason may be biased. Furthermore, within populations, the data sets available for examining parent-offspring associations sometimes lack adequate information about individuals (offspring who have migrated, e.g.). We considered several data sets that, in the end, could not be analyzed with the set of methods we required for comparability.

The next four essays address the intergenerational transmission of wealth and wealth inequality in, respectively, hunter-gatherer, horticultural, pastoral, and agricultural populations, each essay beginning with an introduction to general features of the production system. Each then examines the study populations and field sites and the extent to which these are representative of the production system, as well as methods used for collecting wealth data in each population. Each essay presents the estimates of the relative importance of material, embodied, and relational wealth for success or well-being in that particular production system (α), and then the estimates of the extent of intergenerational transmission (β) and possible transmission mechanisms for each wealth type. A brief concluding essay synthesizes the empirical results, evaluating the linkages between production systems, intergenerational transmission of the most important kinds of wealth, and the levels of inequality.

We hope this effort will encourage others to expand the range of premodern societies for which rigorous analysis of intergenerational wealth transmission is possible and to develop quantitative models more able to capture the full complexity of the process of intergenerational transmission of wealth and the dynamics of inequality.

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Intergenerational Wealth Transmission and Inequality in Premodern Societies

Pastoralism and Wealth Inequality

Revisiting an Old Question

by Monique Borgerhoff Mulder, Ila Fazzio, William Irons, Richard L. McElreath, Samuel Bowles, Adrian Bell, Tom Hertz, and Leela Hazzah

CA+ Online-Only Supplement: Estimating the Inheritance of Wealth in Premodern Societies

Pastoralist societies are often portrayed as economically egalitarian, reflecting the volatile nature of livestock herds and the existence of multiple institutions that allow for the redistribution of wealth as a form of insurance. Motivated by an interest in the role of intergenerational transmission in structuring persistent inequality, we examine the extent of intergenerational transmission of material wealth (four measures) and embodied wealth (one measure) for four pastoral populations from different parts of the world (East Africa, West Africa, and southwest Asia). We find substantial levels of intergenerational transmission and marked economic inequality. We argue that the high correspondence between the material wealth of parents and offspring reflects the importance of the family in the transmission of wealth through bequests, positive assortment by wealth in the domains of marriage and herd management, and positive returns to scale as might occur when raising or defending large herds. We conclude that the analysis of intergenerational transmission provides new insights into the much-debated extent of egalitarianism among pastoralists.

Pastoralism and Intergenerational Wealth Transmission

This paper examines the nature, distribution, and intergenerational transmission of wealth in pastoral societies. Despite the difficulties in working with mobile populations and the complexities in quantifying livestock holdings, researchers find that pastoralists offer a relatively straightforward opportunity for investigating the role of material wealth in structuring inequality. We focus primarily on the distribution of material wealth and the extent to which such livestock holdings are correlated between generations, with a focus on four populations for which we have relevant data. Our four populations represent the pastoralism typical of East Africa (Datoga, Sangu), West Africa (Juhaina Arabs), and southwest Asia (Yomut Turkmen). We use the results to assess the idea that material wealth is particularly amenable to intergenerational transmission and to evaluate claims concerning egalitarianism among pastoralists. With a sample of only four populations,

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we focus less on the differences between populations and more on the intriguing parallels and what these mean for our understanding of the dynamics of wealth inequality in pastoral populations (Borgerhoff Mulder et al. 2009).

Pastoral Production System: Definition, Origins, Typical Features, and Variability

The pastoralist production system is defined by a heavy but rarely exclusive reliance on herding domesticated animals for subsistence and marketable products (modern ranchers with their exclusive commercial focus are omitted from discussion). The most common domesticates are cattle, camels, sheep, goats, horses, yaks, llamas, and reindeer. The material tool kit is often highly portable, and there is a rich and complex fund of knowledge pertaining to the health, behavior, and productivity of domesticated species. In addition to harvesting milk and meat, pastoralists utilize products such as horn, skin, wool, tendons, bone, and urine and employ specific technologies such as the preserving of milk or the harnessing of cartage animals. Pastoralists' diets are universally supplemented (at least seasonally) with grain, either from trade or cultivation, or with other foraged foods. Mobility, either permanent (nomadism) or seasonal (transhumance), is common. Domestic livestock appeared independently (10,000–8000 BP) at three main centers (Bruford, Bradley, and Luikart 2003), and this appearance represents a robust adaptation to living in grasslands or cold or arid regions where agriculture is marginal or impossible.

Traditional pastoral production is a family-based enterprise (commercial ranchers are excluded from discussion here), often complemented with the labor of other families, especially those who are poor in livestock, and fostered children. Core family production generates some production-system-specific demographic and sociocultural correlates (table 1). High fertility is generally desired, but levels are usually lower than those of agriculturalists (Bentley, Jasienska, and Goldberg 1993; Sellen and Mace 1997) and variable, reflecting multiple factors—mobility, pathogens, maternal workloads, unpredictable child mortality, delayed and/or unstable marriages, and the extended absence of men (Galvin et al. 1988; Hewlett 1991; Leslie and Winterhalder 2002; Randall 1994). Pastoralist systems are commonly organized into patrilineal clans and lineages (54% of the Standard Cross-Cultural Sample [SCCS] sample is patrilineal) that function as corporate livestock-owning units, as in the family-owned stock of Inner Mongolia (Sneath 2000). Men are typically the primary owners of livestock wealth (with exceptions such as the Navaho; Kluckhohn and Leighton 1974). There is a sexual division of labor, although women spend considerable time in livestock-related tasks (Fratkin 1989). Polygyny is predominant (in 60% of the SCCS, either <20% (limited) or >20% (general) of men marry polygynously); in Africa at least, polygynous marriage is positively associated with pastoral specialization (Spencer 1998). Men accumulate wives, children, and labor at their homes (87% of SCCS has either patrilocal or virilocal postmarital residence) through payments (71% of the SCCS have either token or substantive bride-price or bride-service), and stock are parceled out among polygynously married wives for use and inheritance following what in Africa is known as the "house property" complex (Gluckman 1950). As classified in the SCCS, pastoralists are either egalitarian (19%) or have one (50%), two (25%), or three (6%) social strata (which include forms of hereditary slavery where specific castes or ethnicities live and work in pastoral households without owning livestock). Famously, pastoralists often exhibit a strong cultural ethos of valor and physical prowess (91% of the SCCS populations have an ideology of "male toughness"), in some groups exemplified by special institutions for warriorhood, often embodied in age-set systems and associated gerontocratic institutions. While data from cross-cultural databases suffer from various degrees of reliability a general pattern emerges from descriptive data such as these.

Pastoralist societies are highly variable. Early typologies emphasize the purity of pastoralism (with respect to reliance on nonpastoral foods), nomadism, and aversion to commercial production (Jacobs 1965). Later overviews explore the dimensions of variation, such as specialized versus diversified production (Salzman 1971), autonomy or articulation with neighboring populations (e.g., Galaty and Johnson 1990), and the range of relationships between property and power (Rigby 1985). Most fundamentally differences can be seen between the (until recently) autonomously organized pastoralists of East and southern Africa (now tolerated as somewhat fringe pursuits within a typically underdeveloped livestock sector) and the erstwhile nomadic empires, which are most typical of the Asian Steppe (e.g., Kradin 2002) but which occur at smaller scales in North and West Africa (Stenning 1959) and the Near and Middle East (Barth 1961). Factors underlying such differences are ultimately ecological (Richerson, Borgerhoff Mulder, and Vila 1996). Where pastoralists develop trade interdependencies with cultivators (exchanging animal goods and caravan products for grain and services), the symbiosis can lead to their becoming almost indistinguishable economically and demographically from settled neighbors (who may even include erstwhile sectors of the pastoralist group).

A final salient feature of most pastoralist groups is the susceptibility of their households to catastrophic loss from disease, drought, and raids (Barth 1964; Bradburd 1982; Dahl and Hjort 1976; Sandford 1983). The impact of such events can be huge, causing at least a temporary shuffling in wealth differences among households, and is commented on by most ethnographers. Although comparative figures are unavailable, the magnitude of such shocks is probably larger for pastoralists than for agriculturists because of the vulnerability of their "wealth on the hoof" to epidemics and theft. Whether such losses, or the impacts of such losses, are stochastic with respect to wealth differentials is addressed later.

Table 1. Geographic, stratification, and inheritance characteristics of pastoral societies (defined by "pastoral contributes most" under the subsistence economy variable) from the 186 societies comprising the Standard Cross-Cultural Sample

Characteristic	% of *n* societies (*n*)
Region (v843):	
Africa	18.6 (16)
Circum-Mediterranean	24.8 (16)
East Eurasia	37.2 (16)
Insular Pacific	0 (16)
North America	0 (16)
South America	6.2 (16)
Descent (v247):	
Patrilineal	53.5 (15)
Duolateral/bilineal	6.7 (15)
Matrilineal	13.3 (15)
Bilateral	13.3 (15)
Mixed	13.3 (15)
Polygamy (v861):	
Polyandry	6.7 (15)
Monogamy prescribed	20.0 (15)
Monogamy preferred	13.3 (15)
Limited polygyny	26.7 (15)
Full polygyny	33.3 (15)
Marital residence (v215):	
Avunculocal	6.2 (16)
Optional	6.2 (16)
Virilocal	12.5 (16)
Patrilocal	75.0 (16)
Bridewealth (v1195):	
Dowry	14.3 (16)
No exchange	14.3 (16)
Gift exchange/token bridewealth	14.3 (16)
Bride-price or bride-service	57.1 (16)
Social stratification (v158):	
Egalitarian	18.8 (16)
Hereditary slavery	50.0 (16)
Two social classes, castes/slavery	25.0 (16)
Three social classes or castes, with or without slavery	6.2 (16)
Ideology of male toughness (v664):	
Absent	9.1 (11)
Present	90.9 (11)
Inheritance of moveable property (v279):	
Matrilineal	6.7 (15)
Children, with daughters receiving less	20.0 (15)
Children equally for both sexes	6.7 (15)
Patrilineal	66.7 (15)
Inheritance distribution of moveable property (v281):	
Equal of relatively equal	80.0 (15)
Ultimogeniture	6.7 (15)
Primogeniture	13.3 (15)

Wealth

Classes: material, relational, and embodied. Livestock are the principal form of *material* wealth among pastoralists, serving as the fundamental form of family capital (the English word "cattle" is the root of the word "capital") and identity. For the West African Fulani, for instance, it is cattle that allow a man to be free and independent, to achieve personal goals, and to generate wealth (Grayzel 1990); for the East African Maasai, Waller (1999: 24) surmises that a "very poor Maasai must be either an ex-Maasai or a dead Maasai."

Contrary to an early belief that herders cumulate livestock for no sound economic reason (an irrational "cattle complex"; Herskovits 1926), pastoralists are repeatedly shown to manage their herds in a highly efficient way, that is, managing not for short-term returns but longer-term prosperity, trading off

meat today for milk tomorrow, consumption benefits now for the children and labor of wives (acquired through bridewealth) in the future. They also show an opportunism (Dahl and Hjort 1976; Homewood and Rogers 1991; Sandford 1983) well adapted to environments characterized by disequilibrial dynamics (Ellis and Swift 1988). Large herds serve as buffers against disasters, as base capital for maximizing herd growth and milk production, and as capital for payments for wives. While livestock also serve as prestige items whose exchange signals multiple social messages (Harrell 1997) and whose strategic use attracts large followings of loyal allies (Harrell 1997; Koptyoff and Miers 1977), this does not detract from their crucial role in ensuring subsistence (Dyson-Hudson and Dyson-Hudson 1980; Schneider 1979). For all pastoralists, then, herds serve as a critical reservoir for investment in the future; additional material stores of value include jewelry, gold, carpets, saddles, tents, and, in recent years, consumer goods.

Successful herd management involves *relational* as well as material capital. Livestock need water, pasture, and labor. Secure access to such ephemeral resources requires the establishment and maintenance of supportive social relationships within and beyond the community, whether in East Africa (Fratkin, Roth, and Galvin 1994), the Hindu Kush (Balikçi 1990), or the Middle East (Barth 1961). These relationships are serviced through exchanges of stock, gifts of coffee and tobacco, and sexual access to wives, and they create social ties that contribute also to labor and defense (Dyson-Hudson and Dyson-Hudson 1980). In an unusually well-quantified study of how pastoralists cope with drought, Bollig (2006) shows for the Kenyan Pokot how richer households provide meat for poorer households largely through their contributions to communal ritually focused feasts. Such families are not repaid in subsequent years and could better ensure their food security through selling goats for maize, suggesting that their generosity builds "symbolic capital" (Bollig 2006: 186) rather than simple risk reduction. For the neighboring Turkana, Johnson (1999) concludes that social networks that distribute food, livestock, and other sources of support are as important to a herder's success as having a wealthy father, and in Dassanetech, senior elders "go to dimi" (a ceremonial liquidation of their material holdings by giving away all their animals to bond partners; Almagor 1978), symbolizing the predominance of relational capital. In other parts of the world, Andean llama herders use reciprocal exchanges to increase the size of their herds (Orlove 1981), and in Central Asia it is the *lack* of redistributive mechanisms that may render Basseri families so vulnerable to dropping out of pastoralism (Bradburd 1989). Finally, for the Norwegian Saami, new data show that broad (districtwide) networks of labor are more important than household labor in enhancing reindeer reproductive rates and carcass body mass (Naess, Fauchald, and Tveraa 2009). In short, *relational* wealth is almost universally acknowledged by ethnographers who emphasize herd owners' concern with reputations as generous and reliable allies and access to labor.

Embodied wealth, which includes both physical and knowledge-based capital (see "embodied capital," Kaplan 1996), is also important in pastoralist populations. Physical condition, performance, and competition are highly valued in the harsh environmental conditions in which pastoralists live, evidenced in the value placed on masculinity, strength, and women's and men's beauty (Sandford 1983). Fertility is also deemed crucial to status, wealth, and the supply of household labor. Detailed research with the Turkana of the arid savannas of Kenya reveals the susceptibility of pastoralists to both seasonal and chronic food shortages (Galvin et al. 1988; Little and Leslie 1999) and the role of household members in supporting one another through periods of ill health. Knowledge of the conditions for successful pastoral production, grazing ecology, weather patterns, migration routes, and the social and political landscape is also critical, although often this information is widely available or accrued through relational wealth, which itself may depend on material wealth. Thus, in Afghanistan only rich shepherds can entertain visitors and obtain the rapidly changing information on economic and security conditions (Balikçi 1990). Intangible property and ritual knowledge, like chant-songs and prayer sticks for the Navaho (Kluckhohn and Leighton 1974) are also very important.

Clearly material, relational and embodied wealth intersect. Herders world over with large livestock holdings can marry multiple wives, produce numerous healthy children, enjoy a large pool of labor to enhance livestock productivity, thereby obtaining status for their families and attracting dependents and political allies who provide critical knowledge on trade, grazing, security, and the connections needed for further success. The implications of such potential economies of scale or synergies among wealth types are revisited in Smith et al. (2010, in this issue).

Intergenerational transmission. Among pastoralists, flows of goods and services are constrained primarily by kin, although raiding or other feats of valor can also be important, especially for raising bride payments. In the SCCS, 67% of the societies show patrilineal inheritance of movable property. Among the inheritors, distributions are relatively equal for 80% of the sample (table 1), though a ruthless meritocracy (informal favoring gifted or energetic sons) is often in evidence. There are many variants in the details, for example, how the sons of cowives are treated, birth order biases, procedures in the case of a patriarch's premature death, the role of the deceased's younger brothers in the inheritance process, the timing of transfers, how conflicts are resolved, and daughters' gifts, topics to which anthropologists have given much attention. Matrilineal cases like the Sahelian Tuareg or the southern African Himba, where men pass wealth to sister's sons, stand out as unusual. Daughters generally receive little material wealth, leaving home at marriage with only their jewelry and clothes, a severance from the family herd portrayed dramatically in the custom of bride capture (Borgerhoff Mulder 1991). In high-latitude groups, like the Koryak of northern Russia, it

is customary for the reindeer herds to be divided equally between sons and daughters (Ingold 1980).

At one level these mechanisms of intergenerational transmission (gifts, bequests, and inheritance rules) are easy to study—they have different names, are transferred at different stages of the life span, and are imbued with either special ritual or jural status (Gray and Gulliver 1964). But in the real world, the culturally proscribed inheritance process is rife with conflict. A vivid example is Goldschmidt's (1969) account of the political intrigue that occurred at the death of a Kenyan Sebei patriarch, dynamics that enmesh even the most prominent of Africans (Obama 2004). Actual patterns of transmission often depart from normative expectations and are rarely documented in ethnographies, with the exception of Irons's (1994) study of patrimony in the Turkmen. For this reason we focus here on the extent to which livestock wealth (or in the Turkmen case, patrimony) in one generation is correlated with that in the next rather than on bequests per se.

Samples and Methods

Overview of Sample Populations

A pastoralist way of life can guarantee autonomy for a local group or be pursued as a regional economic specialization. Our four populations encompass both types. Whereas the Tanzanian Sangu and Yomut Turkmen represent pastoral specializations within a larger economically diverse ethnic group, the Tanzanian Datoga and Chadian Juhaina Arabs are autonomous groups. On other grounds we cannot claim these four populations represent the range of pastoralist specializations or their geographic range (table 1).

Datoga

Ethnographic background. The Datoga (population estimated between 62,300 and 81,900) were displaced from the fertile highlands of northern Tanzania in the sixteenth to eighteenth centuries and have since migrated across the plains adjacent to Lake Eyasi and beyond. Datoga herd cattle, goats, and sheep, driving their animals to seasonally available pastures while maintaining relatively permanent homestead sites. Their sociocultural characteristics are typical of East African pastoralists—polygynous marriage and patrilineal inheritance, with patrilocal homesteads clustered into loose neighborhoods (Sellen, Borgerhoff Mulder, and Sieff 2000). Livestock are central to Datoga life, with their products consumed as food, used for household maintenance, and sold to generate cash for the purchase of maize, cloth, jewelry, medicines, and honey. Livestock are also exchanged generously in informal networks and slaughtered with abandon at widely attended memorial feasts for deceased elders as a demonstration of family status. Livestock are the only form of accumulated wealth in this population and are primarily owned by men. Datoga attempt to cultivate small millet and maize fields but are generally unproductive farmers (Sieff 1997). The data presented here come from three field seasons (1987–1989) in eight different neighborhoods during a period when Datoga were experiencing considerable economic stress. Most families were selling off cattle for grain and veterinary medicines, and the poorer households (a majority) were caught in a declining cycle of poverty (Sieff 1999). Outcomes for health, growth, and nutrition were often severe (Sellen 1999).

Wealth measures and methods. Two measures of wealth are used for this population—livestock wealth and reproductive success. The measure of material wealth focuses on multispecies livestock holdings (reported in Tropical Livestock Units weight equivalents; Sieff 1999) that were censused over one, two, or three surveys and averaged. For sons' wealth, a count was made of the stock in the appropriate categories to which married sons have rights, as specified by traditional terms; similarly, wealth of daughters was calculated on the basis of the daughter's dowry cattle together with the animals given to her (with user rights) by her husband (Borgerhoff Mulder 1991; Klima 1964; Tomikawa 1978). Pairing was focused on fathers (i.e., father-son and father-daughter links); the mother's wealth was not analyzed, being difficult to differentiate from that of her husband as her children grow up and leave. Analyses are based on 95 father-son dyads and 40 father-daughter dyads, the difference in sample size reflecting the outmigration of daughters with patrilocal postmarital residence.

Reproductive success (RS) is used as a measure of embodied wealth. As with other pastoralists, fertility is highly valued, but raising children in this environment is not easy. Datoga in Eyasi exhibit poor achievements in child growth (Sellen 1999) and high levels of fertility and child mortality (Borgerhoff Mulder 1992). For these analyses we use the number of children surviving to 5 years, corrected for the child's probability of surviving to their fifth birthday (.67 boys and .71 girls; Borgerhoff Mulder 1992). As with livestock pairings, analyses focus on father-son and father-daughter links. Descriptive statistics for paired individuals were compared with the fuller sample reported in Borgerhoff Mulder 1992 and suggest no sample bias. Both livestock wealth and RS were controlled for age, determined through the use of a locally constructed calendar.

Juhaina Arabs

Ethnographic background. Juhaina Arabs (approximately 18,000) are a population of transhumant pastoralists originally from Yemen and Saudi Arabia who arrived in Chad in the fifteenth century. Juhaina families live in camps of 4–15 tents and migrate together, covering distances of 250–600 km along the north-south axis. Travel corridors are selected on the basis of the distribution of better pastures, the availability of water, and proximity to markets where they raise cash by selling milk. Strong competition for water resources and livestock incursions into cultivated areas often trigger violent conflicts between pastoralist and farming communities. Juhaina are predominantly camel herders, but they also keep goats and

sheep. Camels are their repository of wealth. Female camels are crucial for reproduction and milk production; males are kept for transport. The Juhaina Arabs are a patrilocal and patrilineal society, and families are the principal corporate livestock holding units. Most of the transmission of livestock from father to son occurs while the father is still alive, with sons gradually obtaining rights over these animals as they get married and start having children. Until a man's marriage, or a few years subsequently, his cattle stay together with his father's herd. Social and economic networks rarely exist outside male kin lines, and loans are rare, with preference given to brothers, paternal uncles, and cousins. These paternal kin are those most likely to help in raising the bride-price. Livestock are partially protected against loss by being distributed among homes of cowives, and less commonly in-laws. Women have very limited effective control over the resources, despite formal rights under Islamic law. All data were collected during two dry-season field expeditions at 26 Juhaina camps in the Chari-Baguirmi district.

Wealth measures and methods. A single measure of material wealth is used for the Juhaina—the amount of milk collected from camels. This was preferable to asking awkward questions about exact numbers of livestock owned. Milk collected/day is a good indicator of the number of female camels owned by a family, especially during the dry season (when these data were collected); this is because Juhaina herders are highly engaged in the milk-selling market and seek to maximize milk collection (Fazzio 2008). Milk produced was recorded in *koros* (2-L bowls). Analyses were based on 5 women and 16 men, all alive and older than 21 years of age; these individuals were linked to 12 fathers. From this data set, paired wealth measures were available for 21 father-offspring pairs (16 father-son, 5 father-daughter). Analyses were controlled for age, which was determined using local calendars and some important historical events.

Sangu

Ethnographic background. Sangu are the principal ethnic group in the Usangu Plains of western Tanzania. They originate from a mixture of Bantu peoples present in the late 1800s, when they united under a hereditary chief and began raiding their neighbors for livestock and taking slaves (Shorter 1972). At the peak of their power they were wealthy cattle pastoralists who wielded considerable military might. Today they are farmers, although 100 families in the villages around Ukwaheri still keep herds on the plains and practice transhumance, and these are the focus of this study. Pastoralist Sangu live in small patrilineally focused clan-based communities. Household compounds consist of extended families. Livestock are important for subsistence and bride payments. Kin often loan and borrow sections of their herds as an intentional risk-avoidance strategy. Cattle, as well as sheep and goats, are controlled by the head of household, while inheritance rights are assigned to wives following the house-property complex whereby wives are entirely responsible for the animals assigned to their section of the herd. When sons marry, their initial herds come from a portion of a mother's share of the livestock. In addition to livestock, every household farms at least 1 acre of corn (McElreath 2004), but low rainfall renders a very low yield compared with that of Sangu agriculturalists in the more southern zone. The data here come from three field seasons from 1997 through 2000, in the pastoral regions of Usangu.

Wealth measures and methods. Material wealth among Sangu pastoralists is best measured by livestock herds that grow at a vastly superior rate to money in the bank. Sangu themselves use cattle head as the most prominent measure of status and success. The measures used here come from surveys and owner self-report, as well as verbal reports from neighbors to check for consistency. In a minority of cases, surveys disagreed with self-report and/or neighbor reports. These cases were readily resolved by pointing out the discrepancies to owner and neighbors. Herd sizes can fluctuate from year to year, such that single-year estimates will contribute noise to the attempt to estimate long-term livestock holdings and thus lower estimates of intergenerational transmission. The data presented here focus only on male ownership, as this is the easiest to measure reliably, and includes cattle that have been assigned to wives for later inheritance by male heirs. Data are available on 108 father-son pairs.

Yomut

Ethnographic background. The Yomut (100,000 in Iran) are a relatively prosperous and large Turkmen descent group occupying an area of what is now the Islamic Republic of Turkmenistan and adjacent areas of Iran and Afghanistan. They are a largely endogamous population. The Yomut of the Gorgan Plain consciously divide themselves into two groups, the Chomur (see Shenk et al. 2010, in this issue) and the Charwa. Charwa are primarily pastoral, raising sheep, goats, and horses, although they cultivate a little for cash and subsistence and weave carpets. After sedentarization during the 1930s, Charwa returned to full time migratory existence beginning with the Soviet occupation of northern Iran in 1941 (Irons 2002). They enjoy extensive networks with Yomut traders who live in towns. Politically, like most pastoralists, they are acephalous (with no socially distinct social strata, unlike Bakhtiari, Qashqai, and Komachi; Irons 1994); their defense is based on a segmentary lineage system. Charwa Yomut live in joint families consisting of parents, unmarried children, and married adult sons. Both land and livestock pass from father to son as a patrimony (primarily consisting of sheep and goats) at the time of household division. This takes place either at the death of the father or when the son's children are nearing the age of marriage. Fathers try to give equal patrimonies to their sons, after which there are no further distributions. Polygny is very limited because of the cost of bridewealth, and dowries given to daughters are trivial in value. The data used

here were gathered over three field trips between 1965 and 1974 in a random stratified sample of households designed to detect variation in demographic parameters within the Yomut population.

Wealth measures and methods. A single measure of wealth is used in this population—the size of the patrimony (Irons 1994) converted into its contemporary monetary value. In 1973–1974, each household head was asked about his patrimony when he became an independent household head and also about the patrimonies that he had given sons who had already separated from the household. Age was not controlled in this analysis, but most patrimonies are transferred when the son is between 30 and 40 years old. Data are available on 22 father-son pairs.

Results and Population-Specific Discussion

The importance of the different classes of wealth to pastoral production is presented in table 2. To obtain these measures, authors used their ethnographic knowledge of the population they studied to provide judgments of the percentage difference in household well-being associated with a 1% change in a given wealth class, effectively a Cobb-Douglas production function of household well-being. Although we are all undoubtedly commonly influenced by the broader pastoral literature, these judgments were made independently, yet they yielded a very consistent pattern. In fact, our α estimates for material wealth are very similar to one subsequently calculated from production functions given by Massell (1963) for the Nyaturu agropastoralists of central Tanzania (see also Berhanu, Colman, and Fayiss 2007 for the Ethiopian Borana). Material wealth is of major significance to pastoralist well-being (average $\alpha = 0.61$), consistent with a whole body of ethnographic evidence outlined above. Embodied wealth is thought to be less than half as important ($\alpha = 0.26$), and relational wealth half as important again ($\alpha = 0.14$). Regarding embodied wealth, it is likely, as noted in the introduction, that although health and fitness are important to well-being, strong family systems support those who are ill or injured, such that they can live normal, even reasonably successful lives. Relational wealth was deemed relatively unimportant (0.10) in the Sangu, Yomut and Juhaina, apart from the Datoga, where it was thought to be important ($\alpha = 0.25$) in assuring protection against local outbreaks of disease and, more importantly, cattle raids. In each of these populations, formal livestock-loaning networks are rare or nonexistent; where loaning, assistance, and exchanges occur, this is mainly among patrilineal kin. Note that α values are not statistical estimates but subjective judgments of researchers based on many months or years of fieldwork.

Our estimates of intergenerational transmission are captured with a unit-free regression coefficient β (table 3; fig. 1). The pattern is very consistent, with high transmission coefficients between parental and offspring wealth ranging between $\beta = 0.535$ and 0.957, all statistically significantly different from a coefficient of 0. The average material-wealth β is 0.67 (SE 0.07). Weighting the material, embodied, and relational β's by their importance to wellbeing (α) produces an overall weighted β for pastoralists of 0.43 (SE 0.06), using the β for Kipsigis cattle partners (see Shenk et al. 2010) for the missing relational-wealth measure.

Table 2. α exponents for the three classes of wealth for pastoral populations (see text for further explanation)

Population	Embodied	Material	Relational
Datoga	.25	.5	.25
Juhaina Arabs	.28	.62	.10
Sangu (Ukwaheri)	.30	.60	.10
Yomut Charwa	.20	.70	.10
Averages	.26	.61	.14

For Datoga sons, the principal wealth transmission mechanism is the bequest. Sons receive most of their livestock directly from their fathers or other paternal relatives. However, the size of the son's herd also reflects the growth of his herd (subsequent to the initial gifts or transfers). This growth factor is not independent of the growth of the father's herd, because of shared exposure to disease and raiding, common access to preferred pastures, and quality of husbandry. It should also be noted that these results focus on the traditional pastoral sector of the Eyasi Datoga; families without cattle who are dropping out of pastoralism (Sieff 1999) are excluded.

Juhaina Arabs also receive most of their animals from fathers and paternal relatives, primarily during their fathers' lives—at birth, circumcision, and marriage. Since sons often continue to camp with their father after establishing independent households, the growth in a son's herd is not independent of that of his father's herd. The β may be slightly underestimated for this population, reflecting measurement error arising from using milk collected from female camels as an indicator of total camel ownership.

Sangu sons similarly receive most of their initial livestock from fathers. Herds subsequently grow with natural increase and bride payments and decline with disease, theft, starvation, sale, and mismanagement. As in other groups, these factors are not independent among fathers and sons because of common environment. A major factor driving wealth accumulation in the Sangu may be the size of patrilineal kin groups. The very high β is driven by two major outliers (although even after deleting these two outliers, bootstrap standard errors show a nonzero elasticity remains). These two men have managed to retain such large herds, relative to other Sangu, perhaps because they are both members of a successful cohort of half-brothers who have supported one another in defense, management, and loans. Thus these kin are buffered against the stochastic effects that lead to herd loss. This notion is supported by other data showing that Sangu herders say they value kin much more than do Sangu farmers (McElreath

Table 3. Wealth transmission and inequality measures for pastoral populations

Population	Wealth type (*N* pairs)	Wealth class[a]	β transmission coefficient (SE)	*P* value[b]	Gini coefficient (SE)[c]
Datoga	Livestock (135)	M	.622 (.127)	.000	.386 (.037)
Juhaina Arabs	Camels[d] (21)	M	.535 (.226)	.018	.346 (.037)
Sangu (Ukwaheri)	Cattle (108)	M	.957 (.424)	.024	.694 (.052)
Yomut (Charwa)	Patrimony (livestock) (22)	M	.564 (.167)	.001	.599 (.042)
Average (first four rows)			.67 (.07)	.000	.51 (.06)
Datoga	RS (133)	E	.066 (.060)	.274	.200 (.018)
Kipsigis[e]	Cattle partners (102)	R	.041 (.139)	.767	.446 (.021)

Note. Sex-specific β estimates for livestock can be made for the Datoga (daughters, 0.561 [SE = 0.159], $P = .000$, $N = 40$; sons, 0.565 [0.150], $P = .000$, $N = 95$) and Sangu (daughters, 0.803 [0.465], $P = .084$, $N = 51$; sons, 1.338 [1.029], $P = .193$, $N = 57$). Sex-specific estimates for reproductive success (RS) can be made for Datoga (daughters, 0.155 [0.101], $P = .123$, $N = 40$; sons, 0.010 [0.09], $P = .916$, $N = 93$).

[a] M = material, E = embodied, and R = relational.

[b] *P* values calculated from two-tailed tests of hypothesis that true $\beta = 0$.

[c] Ginis can generally be calculated in larger samples than can β's (Datoga livestock, 189; Juhaina camels, 33; Sangu cattle, 130; Datoga RS, 186; Kipsigis cattle partners, 181).

[d] Measured by milk collected.

[e] Relational wealth based on Kipsigis cattle partners (see Shenk et al. 2010).

2004). More generally, strong intergenerational association makes sense for the Sangu given clear inheritance rules.

The substantial association between father's and son's patrimonies in the Yomut reflects the greater ability of wealthy men to provide for their sons. It also reveals the tendency of economically independent sons to camp with or near their fathers and to maintain cooperation between the two households. Wealth is not diluted because sons contribute substantially to increasing the wealth of the paternal household before taking away a patrimony (Irons 2002). Note that Salzman (1998: 43), following Irons (1994), concludes there is little intergenerational transmission of wealth ranking and that "livestock patrimonies reflected an 88 percent correspondence to a random shuffle." The β of 0.56 calculated here from the same data indicate that a child born into the top wealth decile is over 80 times more likely to be in the top wealth decile than a child born to parents in the bottom decile (for ratio calculation, see Bowles et al. 2010, in this issue). We interpret this as considerable transmission of material wealth, even though Salzman is right to stress there are few *social* distinctions among Yomut (see above).

Sex-specific β estimates for livestock can be made for two populations. In the Datoga, the estimate for daughters (as well as sons) is significantly different from 0; the same pattern is seen in the Sangu but is not significant (see note to table 3). Both patterns are primarily attributable to assortative marriage (see below) since inheritances to daughters are minimal. In the Juhaina, five of the 16 second-generation individuals are women. Juhaina girls receive no animals from their parents, only wedding gifts, jewelry, and house utensils, and they usually marry close kin (who presumably are similar in wealth status).

Our only measure of embodied wealth (RS for the Datoga) shows a negligible coefficient ($\beta = 0.066$) that, as for most other populations in the broader study (see Smith et al. 2010), does not differ from 0. Given the association between polygyny and wealth we might expect the sons of wealthy and polygynous fathers to be polygynous themselves; this seems to account for the somewhat higher intergenerational correlation in RS found for the polygynous Kipsigis (0.21, $P < .05$; Shenk et al. 2010). One explanation for the low Datoga coefficient may be that the sons in this sample are still quite young and have not yet achieved their full polygynous potential. Another is that livestock ownership in this and many other pastoral groups is not strongly associated with either nutritional outcomes or fertility (Sellen 2003). To the extent that RS is contingent on nutritional status, this might in part explain this nonsignificant outcome.

To quantitatively describe inequality within populations, we use Gini coefficients; these can range from 0 (everyone owns equally) to virtually 1 (one person or household owns everything). Our measured Ginis for material wealth range from 0.346 to 0.694, which when averaged and alpha weighted produce a mean coefficient 0.42 (SE = 0.05).

General Discussion and Conclusion

There is a substantial intergenerational association for material wealth (0.67), the wealth class that is most important for pastoralist populations. Including the single measure of embodied wealth and an estimate of relational wealth (from the agropastoral Kipsigis; Shenk et al. 2010) produces an average weighted β of 0.43. This implies that the child of parents in the top wealth decile is over 16 times more likely to end up in the top decile than a child from parents of the bottom decile. In the discussion we examine what contributes to this substantial intergenerational transmission of material wealth, the limitations of our study, and implications for the broader theme of inequality among pastoralists.

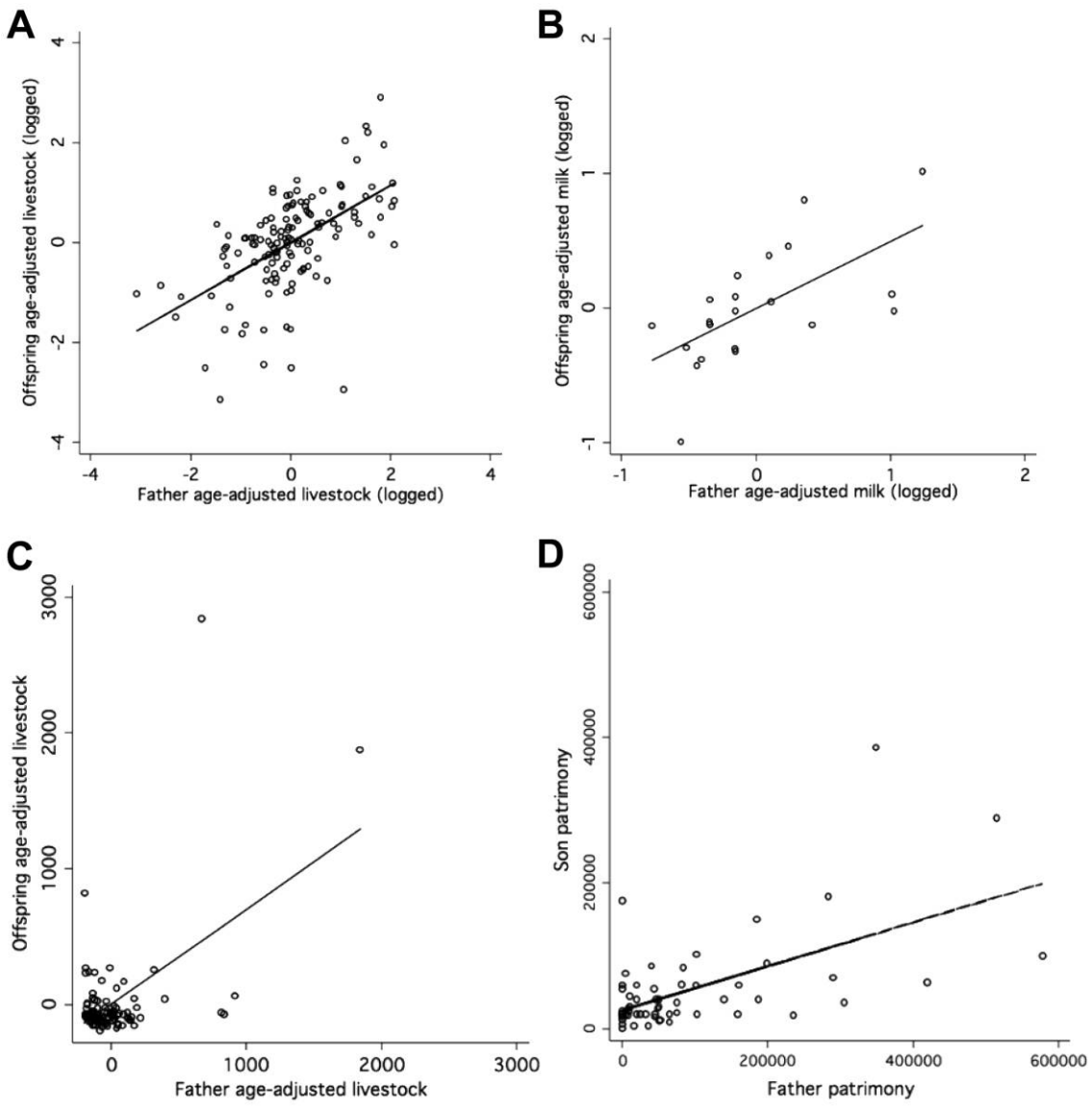

Figure 1. Offspring material wealth plotted on parental material wealth for Datoga (*A*), Juhaina Arabs (*B*), Sangu (*C*), and Yomut (*D*). Graph depicts the linear regression line in the logged data that generates the estimated elasticity reported in table 3 (for further details see CA+ online supplement "Estimating the Inheritance of Wealth in Premodern Societies" in the online edition of *Current Anthropology*; Borgerhoff Mulder et al. 2009).

Why High Intergenerational Transmission of Material Wealth?

Three processes can contribute to a high β coefficient: institutions that ensure that wealth is transmitted primarily within the family (without dilution), positive assortment (e.g., in marriage or in economic pursuits), and returns to economies of scale in herding. In all pastoralist societies material wealth is principally transmitted within the family through institutionalized bequests, pre- and postmortem. With gifts at life transitions (birth, eruption of first teeth, sexual maturity, and marriage), offspring gradually acquire rights to, if not full ownership of, their parents' livestock wealth. Usually such transfers are to sons. Bride payments channel livestock out of the family, but these are generally replaced by the incoming payments received for daughters, except in highly male-biased sibling groups. Such payments also establish relational wealth, consolidating long-term cooperation with affines as shown in

East Africa (Håkansson 1990). In short, livestock differentials persist across generations. Kinship is central to the control and transfer of livestock, excluding market exchanges, as already well known.

The question nevertheless arises of how rich pastoralists prevent the dilution of their wealth? Herd size is commonly associated with polygyny and high reproductive success (Cronk 1991; Irons 1979), and therefore, rich men have more potential inheritors. There are several partial answers here. First, rich men rarely marry wives in precise proportion to their wealth; this is because although women generally assort themselves according to an ideal free distribution among men according to men's wealth, they also show a preference for monogamous men (Borgerhoff Mulder 1990). The greater variance in wealth than in number of wives observed in many pastoralist ethnographies suggests this is a general phenomena. Second, polygynously married women typically have lower numbers of surviving children than monogamously married women, even after controlling for household wealth (e.g., Strassmann 2000), although in some populations this cost is observed only among women married to poorer polygynous men (Borgerhoff Mulder 1997). Third, among most pastoralists, marriage is firmly under the control of elders, as Spencer (1998) shows so clearly for African populations. For example, marriage and fertility in populations depending on slow-breeding camels, such as the Kenyan Rendille, are constrained by parentally monitored cultural conventions that lower fertility and ensure heirs (Roth 2004). These are possible reasons for why polygyny does not lead to a linear increase in number of inheritors and hence the immediate dilution of wealth across generations. Of course parents can explicitly avoid resource dilution through primogeniture (or ultimogeniture), but this form of inheritance is quite rare among pastoralists (see table 1). The possible effect of restricting inheritance to a small set of offspring on equality is discussed in the concluding paper of this special section (Smith et al. 2010), as is the more general topic of partible versus impartible inheritance.

The second process that can contribute to a high β coefficient is positive assortment among families. For sons, this might take the form of herding arrangements. In many pastoralists, a son's animals are herded, at least for several years, together with those of his father (Juhaina, Datoga); in many others, their homesteads are in close vicinity and they continue to share labor (Sangu, Yomut). To the extent these herds can benefit from a father's (or son's) expertise or stock partnerships, such assortment will enhance parent-offspring associations in material wealth. For daughters, positive assortment might occur through marriage, as indicated by gender-specific estimates for both Datoga and Sangu (note to table 3). The extent of intergenerational transmission to daughters in the Datoga and Sanga is a hitherto unrecognized dynamic in pastoralist societies, where wealth is seen almost exclusively as an attribute of men.

Finally, economies of scale might also contribute to high β coefficients for material wealth in pastoralists. Average productivity per animal generally declines with herd size, as a result of both the diminishing quality of care (Herren 1990, for Mukogodo) and higher mortality (Sperling 1987, for Samburu) observed in larger herds of cattle. It is highly unlikely however that *overall* output declines with the size of the herd, and Berhanu, Colman, and Fayiss (2007) found that investments of pastoral labor into livestock production had positive effect of production in the Borana of Ethiopia (see too Naess, Fauchald, and Tveraa 2009, for the Saami). Thus, there are increasing returns to labor as herd size increases (or an economy of scale); that is, if labor is held constant and additional cows produce a net increase in total output, the marginal cost (labor cost per unit of production) is decreasing. According to these arguments, then, high correspondence in livestock wealth between parents and offspring reflects family-based rules of inheritance, assortative mechanisms whereby the wealthy associated with the wealthy and the poor with the poor, and the economies of scale associated with large herds.

Study Limitations

There are several limitations to this study. First, our measures of material wealth focus only on livestock, even though control over pasture, water, and labor can be critical to success in some systems; indeed the term commons, so frequently used for pastoralists' resources, obscures crucial differences in access, usufruct, and political power (Ruttan and Borgerhoff Mulder 1999). Furthermore, many pastoralist groups integrate raising livestock and farming, investing crop surpluses in capital "on the hoof" and profits from livestock in sacks of grain. By focusing on systems where livestock are the primary source of wealth, we greatly simplify the story, with unknown effects on our estimates of material β.

Second, inheritance rules are far more complex than we have conveyed here, as noted in the introductory essay in this special section (Bowles et al. 2010). Since our interest is in the intergenerational correlation of wealth, not the mechanisms of its transmission, these simplifications are legitimate and probably do not systematically bias estimates upward or downward (see Smith et al. 2010). For example, primogeniture (or ultimogeniture; not observed in our samples) should not affect β estimates if all offspring (inheriting and not) are included in the second generation. However if noninheriting offspring emigrate, β may be overestimated (if wealthy individuals have more children) or underestimated (if only disinherited sons of the poor leave).

A third limitation is data. Given that a principal function of the family is the "management of property and offices and their transmission to the next generation through inheritance and succession" (Harrell 1997: 12), it is surprising there is no quantitative information (other than Irons's data on patrimonies) on the role of *intergenerationally transmitted bequests in redistributing or sustaining wealth differences among households*. This is the case despite fine work on stability (or

lack thereof) of herd size over time (as reviewed in Bradburd 1982). We hope that our conclusions drawn from *parent-offspring associations in wealth* will stimulate more research on this topic.

Pastoralism and Inequality

There is a historical tendency to romanticize pastoralism. Early anthropological work, popular coffee table productions, and even some development consultants' analyses lionize pastoralists as fierce, resourceful, and proudly egalitarian (sources reviewed in Waller and Sobania 1994). Pastoralism is thought to have emerged in Eurasia as a form of anarchic revolt among disgruntled peasant pirates at the margins of agrarian states (Lattimore 1951), which was characterized as an unruly engine priming change across European and Asian society (McNeill 1963). This image leaves a residual expectation that pastoralist communities are essentially egalitarian, even if they occupy a clearly ranked position in the broader political-economic system in which they are embedded, as discussed in the introduction.

The argument for egalitarianism is based on two related claims—the volatility, mobility, and indefensibility of pastoral wealth and the existence of institutions that redistribute wealth as a form of insurance. Regarding the nature of the wealth, Schneider's (1979) argument is classic: in the dry areas of East Africa, where there are no tsetse flies and the livestock to human ratio exceeds 1 : 1, egalitarianism emerges from the inability of any person to monopolize its production. Indeed, almost all ethnographers in both Asia and Africa stress the potential for both rapid growth and catastrophic loss of herds, and the consequential fluctuations in a household's livestock wealth over time. Regarding insurance, herders commonly buffer themselves against unpredictable shocks to their capital by subscribing to institutions that ensure redistribution (as described earlier), such that extreme wealth differences are believed to be relatively short lived. Contemplating such institutions in the Somali and other "tribal" societies, Lewis concludes, "The more one produces the more one is expected to give away; the positive side of this equation is that the greater one's generosity the stronger . . . one's corresponding entitlement to support and succor in time of need" (1976: 176). Thus among the cattle pastoralists in Madagascar lavish funeral feasting redistributes the wealth of the elite (Parker Pearson 1999; see too Almagor 1978).

There is, however, abundant evidence of differentials in livestock holdings, production, health, and control of labor that render this perspective problematic (reviewed in Fratkin, Roth, and Galvin 1994). Economic inequalities are found not just in modern ethnographies where pastoralists suffer at the hands of the modern state but also in careful analyses of livestock accumulation among classic "egalitarian" groups like the Nuer (Kelly 1985) and detailed ethnographies of southwest Asian small stock owners (e.g., Barth 1961). Observing extreme wealth differentials among Maasai in 1912–1913, Waller (1999: 41) comments we need not invoke the "specter of development" to explain pastoral poverty. Furthermore, in some populations livestock transfers do not reinforce equality but rather buttress patron-client relationships, as in the Himba, where big men dominate over corporate matrilineal descent groups (Bollig 2006). Such economic disparities are exacerbated by gerontocratic institutions that influence reproduction (Roth 2004), access to pasture (Lane 1996), and gender relations (Talle 1988). Indeed 81% of the SCCS populations (table 1) have some form of stratification. Our findings regarding substantial levels of intergenerational transmission of wealth and high Gini coefficients support the view that persistent economic inequality characterizes pastoralists.

Such inequalities are exacerbated by the role of livestock in buffering households from leaving the pastoral sector (Borgerhoff Mulder and Sellen 1994). Those with plentiful stock can get loans, sell animals, and diversify without diminishing their seed capital for new growth. Thus, in the Maasai (Grandin 1989) and Ariaal (Fratkin and Roth 1990), only rich families retain sufficient animals for pastoral subsistence after a drought. Regressing 1989 livestock holdings on 1987 holdings for Datoga shows that, indeed, the rich get richer whereas the poor get poorer (as explored in detail by Sieff 1999), insofar as the slope (1.146 [SE 0.08], $P < .001$) is >1 (a slope of <1 indicates regression to the mean). Echoing the same sentiment, Lakenkhel shepherds of Afghanistan claim, "When you have small number of sheep, about 60, it is very difficult to get more, but when you have 500 sheep and some money on top of that it is possible to increase the flock" (Balikçi 1990: 313); similar dynamics are reported for the southwest Asian Komachi (Bradburd 1982) and Basseri (Barth 1961). Families with large herds also generally enjoy larger and more durable exchange networks (Waller and Sobania 1994); thus, wealthy Kipsigis households have more cattle partners (mean = 0.55, $n = 156$, $P < .001$; Shenk et al. 2010), and richer Pokot and Himba households use their cattle-loaning networks and exchange partners to reconstitute herds more effectively than poorer households (Bollig 2006). Despite this evidence for how the dynamics of pastoral production generate persistent and high levels of inequality, it is important to acknowledge that some of the more complex stratification seen in central Asian states (not represented in our sample) also reflects the regional political-economic systems in which pastoralist communities are embedded.

Before concluding, there are two points to emphasize regarding this emerging picture of pastoralist economic inequality. First, why do they typically view themselves as egalitarian? One answer lies in their perception of the volatility of livestock wealth—thus the Pokot aphorism "Never laugh at a pauper—tomorrow it may be you who is poor" (Bollig 2006: 373) or an equivalent Yomut taunt: "Rich man, the year of Bijin (thought to bring catastrophic bad luck) is coming!" One reason for this emic misconception may be that pastoral communities are rarely demographically or economically discrete, despite apparent social boundaries. Pastoralists move

with alacrity in and out of herding (Barth 1961; Waller 1985), juggling a variety of economic interests and spawning segments of the population with different subsistence specializations. Sometimes in the pursuit of economic specialization they strategically adopt a new ethnicity, such as the bilingual Maasai-Okiek (see Waller and Sobania 1994 for a historical review of such dynamics). In this way the pastoral system with its ideology of egalitarianism persists, even as the populations shed people who chose or are forced to adopt other ways of life. Indeed formal egalitarian ideologies may be essential to the preservation of actual inequality, while inequality is a guarantee of community survival (Waller 1999). A second reason for this emic perception is that, as Salzman (1998) emphasizes, wealth differences do not necessarily produce status differentials; thus, the Yomut do not recognize their considerable distinctions in economic status in social interaction, symbolism, or ideology. The broader complex relationship between economic differentiation and sociopolitical stratification is not addressed in this paper.

Second, there is strong evidence (for Datoga and other populations, reviewed above) that the *effects* of shocks are not random with respect to wealth—wealthier households weather calamities better than poorer ones. In conjunction with the reliable transmission of material wealth between generations (as shown here), these dynamics generate persistent inequality among households. Bradburd was right to posit that "random fluctuation in herd gain and loss over time is not likely to lead to a long term equalization of wealth among households but, on the contrary . . . to the development of significant differentials of wealth" (Bradburd 1982: 101; see too Barth 1961 and Waller 1999). A further implication of this position is that the prevalence of generosity and leveling mechanisms among pastoralists must ultimately be viewed as signals of goodwill that do indeed effectively buffer the receiver and insure the giver but do not produce the egalitarian systems that they have been credited with ensuring. The analysis presented in this paper demonstrates the importance of not simply cataloguing wealth differences at any one point of time but exploring the underlying mechanisms that contribute to inequality not only over the household's domestic cycle (as has already been done) but across generations.

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Intergenerational Wealth Transmission and Inequality in Premodern Societies

Domestication Alone Does Not Lead to Inequality

Intergenerational Wealth Transmission among Horticulturalists

by Michael Gurven, Monique Borgerhoff Mulder, Paul L. Hooper, Hillard Kaplan, Robert Quinlan, Rebecca Sear, Eric Schniter, Christopher von Rueden, Samuel Bowles, Tom Hertz, and Adrian Bell

CA+ Online-Only Supplement: Estimating the Inheritance of Wealth in Premodern Societies

We present empirical measures of wealth inequality and its intergenerational transmission among four horticulturalist populations. Wealth is construed broadly as embodied somatic and neural capital, including body size, fertility and cultural knowledge, material capital such as land and household wealth, and relational capital in the form of coalitional support and field labor. Wealth inequality is moderate for most forms of wealth, and intergenerational wealth transmission is low for material resources and moderate for embodied and relational wealth. Our analysis suggests that domestication alone does not transform social structure; rather, the presence of scarce, defensible resources may be required before inequality and wealth transmission patterns resemble the familiar pattern in more complex societies. Land ownership based on usufruct and low-intensity cultivation, especially in the context of other economic activities such as hunting and fishing, is associated with more egalitarian wealth distributions as found among hunter-gatherers.

This paper quantifies the level of inequality in the types of wealth common to small-scale horticultural populations and the extent to which wealth is correlated across generations. Knowledge of the variability in each wealth type, how different wealth types combine, and the extent to which wealth is correlated across generations can help us address several important questions concerning the evolution of inequality: (1) Is inequality more common for certain types of wealth? (2) To what extent does inequality in one generation impact the level of inequality in the next? (3) How much socioeconomic status mobility exists across generations? (4) Do different horticul-

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tural populations show similar patterns of inequality within and across generations, such that generalizations about horticultural production systems can be made?

We start by exploring the commonalities among populations that use horticulture as their primary production system, basing our analysis on empirical data collected among extant horticulturalists: Dominicans, Mandinka of Gambia, Pimbwe of Tanzania, and Tsimane of Bolivia.

Horticultural Production System

Horticulture, or "garden cultivation," describes small-scale, low-intensity agricultural production based on human labor inputs and simple tools (Bates 2001). Subsistence is based on modification of plants and their environments in order to increase their productivity and utility to people. Production is aimed at household provisioning rather than cash-cropping or export. Horticulturalists also commonly engage in substantial fishing, hunting, or other extractive foraging activities, but the bulk of the diet comes from domesticated plant species cultivated in garden plots.[1] Unlike many foraging groups, however, horticulturalist households are characterized as relatively self-sufficient. Access to more predictable and storable agricultural produce attenuates interfamily resource sharing and increases sedentism and territoriality. For example, food-sharing networks are more restricted among Ache who live on permanent settlement and grow crops on private plots than among those who forage nomadically in the forest (Gurven, Hill, and Kaplan 2002). Horticulturalists tend to live in aggregations that are larger and more sedentary than those of foragers. Available evidence from precontact societies suggests that raids and intergroup aggression are fairly common among horticulturalists or at least as common as among foragers (Keeley 1996; Wrangham, Wilson, and Muller 2006). Table 1 describes domestic organization, descent patterns, settlement patterns and village size, property right, and wealth stratification among the 83 horticulturalist societies from Murdock and White's (1969) Standard Cross-Cultural Sample (SCCS).

Horticultural production first appeared in Southwest Asia and the Middle East during the Neolithic 9,000–11,000 years ago and in other geographical regions by 3,000–6,000 years ago (Bellwood 2005). Plant domestication and animal domestication have been viewed as watershed processes in the development of human cultures and civilizations. All civilizations have been based on cultivation of one or more of six plant species: wheat, barley, millet, rice, maize, and potatoes. Population pressure, climatic and environmental change, reduced densities of large animals, and cultural transmission have been cited as key ingredients in the adoption of food production (Flannery 1973; Rindos 1987). Variability in the timing and expression of agriculture has been related to local differences in these factors and in the availability of domesticable species and trade networks (Diamond 1999; Harris 1977).

Horticultural societies vary along ecological, social, and political dimensions, but commonalities can be identified (Bates 2001). First, horticulturalist households tend to be relatively independent and make their own decisions in regard to food production without centralized authority. Second, horticulture provides relatively low yield per land area, and so surpluses are unusual. Farming techniques found in many horticultural systems are slash-and-burn and polyculture. Slash-and-burn involves the clearing and burning of trees and brush to reduce competition from wild plants and to add soil nutrients from the ashes. After several cycles, productivity declines as a result of low nitrate and potassium levels, and the cleared areas are left fallow to return to brush or forest. Polyculture involves a mix of crops or varieties interspersed in the same field, including root crops, fruit trees, palms, and cereals (maize, millet, barley, or rice). The mix of crops ensures ground cover for most of the year and helps prevent erosion. A reliance on tree crops is also common. As gardens "age," the combination of trees and crops will vary. Relatively short cropping periods and long fallows mean that new fields may be created frequently. Third, horticulture relies on simple tools such as digging sticks, hoes, machetes, and axes rather than plows, machines, or irrigation. Without irrigation, horticulturalists depend on the seasonal cycle of rainfall. Horticulture is best suited to humid, tropical conditions, where more intensive techniques such as monocropping and clear-cutting, in combination with heavy rainfall, often lead to soil erosion and degradation and fungal infections of crops.

Wealth

For many horticulturalists, wealth is somatic: stored in human bodies and channeled into growth, reproduction, and immune function. Most horticultural populations do not practice efficient birth control, and fertility tends to be relatively high, averaging more than five offspring per woman (Bentley, Jasienska, and Goldberg 1993; Wood 1994). A wealthy horticulturalist is healthy, well fed, and fertile.

Ecological knowledge is important for efficient food production. While several studies emphasize the difficulty of hunting (Gurven, Kaplan, and Gutierrez 2006; Ohtsuka 1989; Walker et al. 2002), horticulture may also require substantial knowledge and skill to learn proper timing for burning, plot rotation, planting techniques, pest control, and soil management (Conklin 1957). Although the bulk of the calories in horticultural groups comes from carbohydrate staples, such as yams, plantains, and rice, much time is spent engaging in other activities that provide important nutrients as well as prestige, such as hunting and spear fishing (Hames 1989). Animal domestication is not uncommon but is usually confined to small animals such as chickens, goats, pigs, and sheep.

Despite the self-reliance of horticultural households, social networks through kinship or alliances are important to insure

1. Because much of the protein and lipids in the diet often come from animal and fish consumption, these groups have often been referred to as horticulturalists-foragers or forager-horticulturalists.

Table 1. Geographic, social, and inheritance characteristics of $n = 83$ horticultural societies

Characteristics	Percentage (%)
Region:[a]	
Africa	18.1
Circum-Mediterranean	3.6
East Eurasia	12.0
Insular Pacific	28.9
North America	9.6
South America	27.7
Domestic organization:	
Independent nuclear families, monogamous	3.6
Independent nuclear families, occasional polygyny	26.5
Polygyny	16.9
Minimal (stem) extended families	6.0
Small extended families	16.9
Large extended families	28.9
Descent:	
Patrilineal	34.9
Duolateral/bilineal	7.2
Matrilineal	22.9
Quasi lineages	4.8
Ambilineal	3.6
Bilateral	26.5
Mean size of local villages:	
<50	13.3
50–99	18.1
100–199	14.5
200–399	12.0
400–1,000	12.0
1,000–5,000	1.2
5,000+	2.4
Settlement patterns:	
Migratory or nomadic	7.2
Seminomadic	8.4
Semisedentary	6.0
Compact impermanent settlements	3.6
Dispersed family homesteads/separated hamlets	27.7
Compact, permanent settlements	43.4
Complex settlements	3.6
Inheritance of real property:	
Absence of property rights or inheritance rules	31.3
Matrilineal (sister's sons)	3.6
Other matrilineal heirs (e.g., younger brother)	7.2
Children (with daughters receiving less)	4.8
Children (equally for both sexes)	2.4
Other patrilineal heirs (e.g., younger brothers)	6.0
Patrilineal (sons)	20.5
Distribution of property among individuals of same category:	
Real property:	
Equal or relatively equal	24.1
Exclusively or predominantly to the one adjudged best qualified	.0
Ultimogeniture (to the junior individual)	1.2
Primogeniture (to the senior individual)	15.7
No rules or insufficient information	57.8
Movable property:	
Equal or relatively equal	44.6
Exclusively or predominantly to the one adjudged best qualified	1.2
Ultimogeniture (to the junior individual)	2.4
Primogeniture (to the senior individual)	13.3
No rules or insufficient information	38.6
Class stratification (prevailing type):	
Absence among freemen	45.8
Wealth distinctions	24.1
Elite (control of land, etc.)	2.4
Dual (hereditary aristocracy)	25.3
Complex (social classes)	2.4

Note. The 83 societies were defined by groups showing "casual agriculture," "extensive or shifting agriculture," and "horticulture," from the 186 societies comprising the Standard Cross-Cultural Sample (Murdock and White 1969).
[a]Percent of 83 societies.

long-term livelihood (Hadley, Borgerhoff Mulder, and Fitzherbert 2007; Patton 2005). Networks are vital for soliciting aid during episodes of sickness or disability (Sugiyama and Chacon 2000), crop failure (Hadley 2004), and recruiting allies during conflict (Patton 2005). Indeed, many horticulturalists in the Amazon and New Guinea were involved in frequent raiding of their neighbors (Keeley 1996). Physical size and muscular strength are associated with others' perceptions of dominance. Prestige and leadership are based largely on behavioral attributes, such as intelligence, charisma, and oratory skill, and are achieved and maintained through social support (Henrich and Gil-White 2001; von Rueden, Gurven, and Kaplan 2008).

Numerous studies examine status differentials among horticulturalists (mostly men) and link these to favorable cultural outcomes. Owners of more land and with resident parents show higher reproductive success (RS) in the Caribbean (Flinn 1986; Quinlan and Hagen 2008). High-status Ifalukese men marry at younger ages, and their wives have higher fertility because of smaller interbirth intervals (Turke and Betzig 1985). Yanomamö with *unokai* status for killing other men have more wives and more surviving children (Chagnon 1988). Better Tsimane and Piro hunters show greater fertility and RS (Gurven and von Rueden 2006). Healthier and taller adults also show higher fitness among rural Kavango in Namibia (Kirchengast and Winkler 1995, 1996) and rural Gambians (Sear 2006; Sear, Allal, and Mace 2004). Polygyny is fairly common among horticulturalist societies, where men compete to obtain multiple wives.

As among foragers, material wealth is limited among most horticulturalists. Food is often used as a currency for exchange, recruitment, and signaling, beyond immediate consumption. Other rare and valued materials may signal wealth, such as shells, carved stone, ivory, bone, ceramics, tools, and decorative objects. In resource- or land-limited regions, however, access to land, water, fish, or game may be restricted, and so access to territories and farming land may be controlled and transmitted through lineages.

Few studies have measured variability in wealth holdings among horticulturalists. An analysis of rice holdings, cash income, and household assets among 511 households from 59 Tsimane villages revealed Gini coefficients ranging from 0.28 for household wealth to 0.54 for cash income (Godoy et al. 2004). Interestingly, there was little increase or decrease in inequality among villages that varied by level of acculturation. In two villages, Gini coefficients of 0.31 and 0.38 were calculated for number of close kin, a form of relational wealth (von Rueden, Gurven, and Kaplan 2008).

Equality and Inequality

Sexual Division of Labor

Sexual divisions of labor are present in horticultural societies. Men's activities sometimes receive higher public recognition than do women's, although men's work and women's work have also been viewed as "separate but equal" spheres (Collier 1988; Sanday 1981). There may be less division of labor among horticulturalists than among foragers because both men and women contribute to horticulture. Some notable exceptions to sexual egalitarianism exist, from common menstrual taboos to punishment of female disobedience by group rape among the Mundurucu (Murphy and Murphy 1974). Some societies that engage in frequent warfare (e.g., Gebusi, Mehinaku) have men's houses, where socialization of boys occurs separately from that of girls (Knauft 1985).

Status Differentiation

Not all horticulturalists fit the same traditional labels popularized by Service (1962; e.g., band, tribe, or chiefdom) or those popularized by Fried (1967; egalitarian, ranked, and stratified societies). Many horticultural groups are fairly egalitarian and autonomous but show more status differentiation than foragers. Village leaders or headmen are often older charismatic adult men with many kin ties and allies (Arhem 1981; Kracke 1978; Maybury-Lewis 1974; Mindlin 1985; von Rueden, Gurven, and Kaplan 2008); they often carry no real authority or power to reward and punish but instead may coordinate activities, host events, and negotiate relationships with outsiders. Horticulturalists characterized by high mobility, little storage, small group size, and interdependence are more likely to be egalitarian, similar to foraging groups, whereas horticulturalists that differ along these dimensions tend to display greater levels of inequality, as found among complex hunter-gatherers (Testart 1982). Property ownership and territoriality are more culturally explicit among horticulturalists than among many foragers, while leveling mechanisms designed to maintain egalitarianism (Wiessner 1996) are less evident but not absent. Accusations of witchcraft or sorcery among aggrandizers are common in horticulturalist societies (Hill and Gurven 2004; Paciotti and Hadley 2003). Extensive wealth accumulation and self-aggrandizing are atypical among egalitarian horticulturalists. Craft and ritual specialists, politicians, and formal leaders are not uncommon (Chagnon 1968; Johnson and Earle 1987). In the past, when skirmishes over arable land were likely less of a problem than today, competition may have been greater over labor to work fields and generate surplus. The need for labor sometimes was reflected in a formal or legal possession of slaves (Koptyoff and Miers 1977). Slavery is rare among ethnographically present societies, although several horticulturalist populations traditionally had slaves (Colson 1960; Stearman 1988); 21 out of the 83 horticulturalist societies from the SCCS show former presence of slavery.

In contrast to Amazonians and several African farmers, island horticulturalists such as those in Oceania show greater status and wealth differentiation. Big-men and great-men leaders typical of these societies possess greater political influence, larger gardens, and more material wealth than do other group members (Turke and Betzig 1985). These societies are found where resources are densely concentrated, predictable, and defendable

and where surpluses are created. Surpluses are generated by labor recruitment efforts, competitive feasting, and redistribution of prestige items such as shell bands and domesticated pigs (Hayden 1996). Classic ethnographies of Trobriand Islanders (Malinowski 1922; Weiner 1976), Samoans (Gilson 1970), and Enga (Wiessner 2002) describe big men, the privileges that accrue to chiefly lineages, and competitive yam exchanges and feasts. For example, residential and yam houses belonging to Trobriander chiefs are larger and more ornately decorated than commoner houses. Chiefly status permits the right to have multiple wives, engage in kula exchanges, and avoid certain food prohibitions (Weiner 1988).

Other groups show a mixed egalitarian and ranked stratification social structure, such as the Dani of Western Papua, where leaders accumulate wealth and prestige but inequality does not carry over to land ownership and farming. Instead, Dani big men largely help organize rituals and war parties (Heider 1990). Evidence for highly complex horticulturalist societies is scant (but see Erickson 2000). Several kingdoms in Africa were highly structured and prestige based, such as the Asante of southern Ghana, a conquest state with kings and chiefs who had lavish courts maintained by the trading with Europeans of gold, kola nuts, and slaves (Fortes 1969). But even among the Asante, land was held by matrilineages for group members to farm as needed.

Sedentism, resource concentration and predictability, surplus production and storage, and higher population density have all been linked to greater inequality in subsistence populations (Carneiro 1970; Hayden 1995; Testart 1982; Upham 1990). An often-cited but incomplete idea is that agriculture permits a surplus sufficient to maintain nonproductive classes such as warriors, priests, and politicians (Childe 1954) and inequalities beyond those due to age, sex, and abilities. Surplus production, however, is likely an endogenous outcome of other inequality-generating factors, such as differential access to patchy, predictable, and accumulable resources. When territorial resources are concentrated in dense, high-quality patches, they become "economically defensible," leading to monopolization by emergent elites (Boone 1992; Brown 1964; Dyson-Hudson and Smith 1978). Storage and accumulation of material resources over time can lead to greater disparities in wealth than exist when resources are transient. Leaders or "managers" may arise to organize raiding parties, redistribute resources, or deal with localized resource stress (Flannery 1972; Smith and Choi 2007). According to the "agency" approach to inequality emergence (Wiessner 2002), upstarts or "aggrandizers" strive for influence by controlling access to resources or by extracting labor from others through debt cycles or coercion (Arnold 1995; Boone 1992). Nonelites, however, are not necessarily deprived of resources. In a system of "managerial mutualism," subordinates may also benefit when provided goods by elites who compete for prestige and supporters (Boone 1992, 1998).

Intergenerational Transmission

Kinship is the basis for navigating social life and the flow of goods and services in horticultural societies. One-third of horticultural societies in the SCCS show patrilineal inheritance, one-fourth show matrilineal inheritance, and one-fourth show bilateral inheritance (table 1). More egalitarian horticulturalists tend to show bilateral descent, such as among the Gainj (Johnson 1982). One-third of societies show no formal property rights or inheritance rules; among those that do, the most common pattern is for property to be distributed relatively equally among sons (table 1). Among more egalitarian horticultural societies, there is very little wealth to inherit, except perhaps land in more circumscribed areas and occasional wealth items. Personal items may be burned or buried with the deceased, while large or expensive items, such as canoes, knives, and shotguns, are usually divided among surviving family members (Murphy and Murphy 1974). Inheritance of these items may be sex biased (Crocker 1990), although women's items may also pass to daughters-in-law instead of daughters (Bohannan and Bohannan 1953). Land privileges are often granted through usufruct. As long as crops are growing in a field, permission must often be asked before others may use the field (Bergman 1980). In the nonegalitarian Polynesian horticultural societies, property and land rights are often organized strictly along descent group lines. When land is continuously rotated with long fallow periods, individual private ownership and land inheritance may not be sensible. Instead, descent groups often own communal land, and distribution of access rights to member households is coordinated by lineage heads (Bohannan and Bohannan 1953; Holmes 1974).

Ethnographies report that sons and sometimes daughters benefit from the social position of parents, particularly fathers (Heider 1990). Leadership positions, however, are not usually strictly heritable but remain in part dependent on individual skills and personality (Wiessner 2002). Positions, however, may be held by other family members. It is important to acknowledge that traditional structures of horticulturalist societies with a history of chiefly lineages and kingdoms, such as the Asanti, Ganda, and Shambala, are no longer intact. It is possible that remaining horticulturalist societies, especially those represented here, show less inheritance of individual-level privilege and rights. However, even among the African kingdoms mentioned above and the Classic Maya (Edmonson 1979), land was not held privately and most inhabitants were commoners with communal access to farm land through their lineages.

Sample and Methods

Overview

We present data from four horticultural populations: rural Dominicans, Mandinka, Pimbwe, and Tsimane. Dominicans are rural peasants of Dominica in the Caribbean. The Man-

dinka and Pimbwe are dry-land farmers from the Gambia and Tanzania, respectively, and the Tsimane are Amazonian rain forest horticulturalist-foragers from Bolivia. Our reliance on only four groups means that our sample cannot be representative of horticulturalists either today or from the past. The majority of the societies from the SCCS in table 1 come from the insular Pacific (29%), Africa (18%), and South America (28%). Today, many horticultural groups occupy marginalized areas in the humid tropics and arid regions where prospects for intensive agriculture are poor. Availability of wealth data varies among our sample populations, as do the levels of market integration and other indicators of acculturation during the study periods. The largest number of wealth measures exists for Pimbwe and Tsimane, and so we devote more attention to these societies.

Rural Dominicans

Ethnographic background. Bwa Mawego, one of the least developed villages on the windward side of Dominica, contains about 700 full- and part-time residents of mixed African, European, and island-Carib descent (Quinlan 2005). Economic activities include subsistence taro-based horticulture, fishing, bay leaf oil production, banana production, shopkeeping, and limited wage labor. Average annual household income in Bwa Mawego is currently about EC$5,000 (US$1,850). Opportunities for education are limited. About 30% of villagers born between 1955 and 1986 have attended "high school" equivalent to ninth and tenth grade in the United States; older adults have less education. The population is relatively healthy for the Caribbean region. Kinship and family are the foundation of economic, social, and reproductive behavior, with almost everyone in the village related by blood or marriage. Many households consist of several women and their children; conjugal, single-mother, and other alternative styles are also common (Quinlan and Flinn 2005). Several households of closely related kin often live together in a family compound. There are several large patrilineages and many small lineages; matrilineages are not recognized. Patrilineal descent provides individuals with access to ancestral family lands through usufruct, which can be advantageous to individuals whose immediate family does not own land.

Wealth measures. Land is the basis of economic production in Bwa Mawego. *Bwa den* (bay leaf *Pimenta racemosa* L.) is the primary source of cash. Villagers extract bay oil from *bwa den* and then sell it to a cooperative that in turn sells the oil to global distributors as an ingredient in soap and perfume. Most villagers either own or work *bwa den* for income. *Bwa den* field sizes (in acres) owned by living and recently dead residents of the village who were aged 25+ in 2005 were estimated on the basis of interviews with two groups of locals (Quinlan and Hagen 2008). Interrater reliability across the two groups was moderate (Cronbach's $\alpha = .68$), and reliability tests based on kinship and sex suggest little bias in field size estimation. Although women can and do own *bwa den*, interrater reliability scores suggest that women's claims to land are somewhat ambiguous.

Mandinka

Ethnographic background. Four villages in the West Kiang district of the Gambia were first studied by physician Ian McGregor in 1950, chosen because of their remote location and poor health profile (McGregor 1991). The residents are mostly Mandinka, though the samples also include a minority of Jola, former slaves of Mandinka. During the study period, all villages practiced horticulture, with rice as the main subsistence crop by the end of the study period. Additionally, groundnuts were grown as a cash crop. Rights to land use reside largely with men, and these rights are inherited patrilineally; however, women do the bulk of the subsistence farming and may occasionally own their own rice fields and pass them to their daughters. Residence patterns are patrilocal, but mobility is low so that most women marry within their natal village. Transport links to other regions of the Gambia were relatively poor during McGregor's observation period, though they have improved considerably over the past few decades. Few individuals were educated until the late 1970s, when a primary school was established in Keneba. Before the primary school, only a few boys would have been sent away to receive an Islamic education. In 1975, the Dunn Nutrition Unit (DNU) set up a permanent research station and medical clinic in Keneba, the largest village. The clinic had an immediate effect on child mortality rates, while morbidity was less affected (Rayco-Solon et al. 2004). Fertility, however, has only recently started to decline, despite the availability of contraception at the clinic. Before 1975, both fertility and mortality were high: women averaged seven children, and more than 40% died by age 5 (Billewicz and McGregor 1981). Polygyny was high, with most men acquiring more than one wife by the time they reached late middle age. Men married much later than women (mean age at first birth was 18 for women but 31 for men) and therefore reproduced until much older ages.

Wealth measures. Given the exclusive focus of McGregor and the DNU on health and mortality, data exist for only two forms of embodied wealth: anthropometric status and fertility/RS. We use data only from individuals who were alive and reproduced in the pre-DNU period because of the substantial influence of the DNU clinic. Anthropometric data were collected between 1950 and 1980. Only individuals who reached the age of 18 years were included in the analysis; average weights were calculated for each person on the basis of repeated measurements. RS data are based on births occurring before 1975 and calculated for only those individuals who reached the age of 15 years before 1975. Age controls were included for individuals to account for those who died or

were censored before the end of their reproductive period, as was a control for birth cohort. RS was defined as the number of children surviving to age 5, and children censored before the age of 5 were discounted according to their age-specific probability of surviving to 5 years. Fertility and mortality data were available from the demographic surveillance system, which has recorded all births and deaths since 1950, supplemented by birth histories collected from those who began reproducing before 1950. Only two of the four villages were included in the RS analysis because demographic data were thought to be underreported in the other two villages in the early years of the study.

Pimbwe

Ethnographic background. The Pimbwe of the Rukwa Valley (Tanzania) are mostly subsistence farmers who also seasonally hunt, fish, and collect honey (Borgerhoff Mulder 2009). Until Tanzanian independence (1963), the Pimbwe were subject to internecine war and a chiefly system. Chiefly and other high-ranking positions were transmitted to a sister's son, although inheritance sparked bitter disputes (Willis 1966). Below the chiefly levels, Pimbwe society is eminently egalitarian, with a virulent system of witchcraft accusations and counteraccusations serving to dissuade anyone from rising above the crowd (Paciotti and Hadley 2003) and with social order now maintained at least in part by a local vigilante organization (Paciotti and Borgerhoff Mulder 2004) and in part by the organs of a modernizing state.

Pimbwe have no electricity and limited access to clean water, all-weather roads, and (since 2006) mobile phones (Paciotti et al. 2005). Primary schooling has been available in almost all villages since the early 1970s, although schools are not well maintained or funded. The Pimwbe have little accumulated wealth. Less than 10% of the population own smallstock (goats), which are generally used as cash savings and sold only in times of need; the same is true for the more commonly raised poultry. Families have rights to land through cultivation, but land is largely freely available. Production is limited by the availability of family labor and the health of adult household members. Family illness is cited by Pimbwe as one of the primary reasons for deficits in food production.

One source of cash among the Pimbwe is the sale of maize and other cash crops such as sunflower, rice, and peanuts. Average earnings from cash crops are very low and show high interannual variation due to vagaries of weather and crop damage by wildlife and pests. Some men earn income from a seasonal craft or trade, such as fishing, hunting, honey production, carpentry, dispensing traditional medicine, providing witch doctor services, trading old clothes, and manual labor. The primary source of women's additional income is brewing and distilling of maize, products sold either privately or in one of the village bars.

Wealth measures. Analyses based on six surveys from 1995 to 2006 are focused on the villagers of Mirumba. The sample includes all individuals aged 15+ ever interviewed. Given the lack of privately owned material wealth such as land, the vagaries of livestock raising, and the near-complete erosion of the traditional chiefly statuses, wealth in Mpimbwe is best thought of as deriving from health, strength, fertility, and control of (children's) labor. Intergenerational transmission is therefore investigated for weight, RS, household wealth, and farming skill. RS is defined as the number of offspring surviving to age 5 among women aged 45+ and men aged 55+. Children who had not yet reached 5 years of age were weighted according to their probability of surviving this period (.82). Household wealth is measured as the currency value of the sum total of household items, including the materials of the house itself. Farming skill is measured as the number of months a house was with maize in its granary. Land is freely available and not strictly heritable, and so a household's success in providing food throughout the year is due not to differential land ownership (although cultivated land was controlled for in the measure) but rather to skills in farming, storage, and resource management; dependency ratios are closely correlated with land under cultivation. Maize production and annual availability are subject to stochastic shocks, such as inclement weather, changing river courses, elephants, insect pests, and theft. Although not all of these shocks can be directly countered, skill, foresight, knowledge, wise planning, hard work, and good social relations with neighbors and kin can help reduce the risks of spending many months without food in the granary.

Tsimane

Ethnographic background. Tsimane are a subsistence-based society of more than 8,000 forager-horticulturalists living in more than 50 villages with fairly minimal external market interactions. 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 is also sold as a cash crop. Fishing is common in all Tsimane villages located near water rivers, oxbow lakes, or lagoons. Hunting with shotguns, rifles, and bow and arrow is common in interfluvial villages. Mobility was more common a generation ago, and with high fertility (total fertility rate = 9), extended families are often spread across numerous communities. Villages are composed of clusters of related households who often pool resources and labor.

Traditionally, there were no official leaders; older men and shamans wielded community-wide influence (Daillant 1994; von Rueden, Gurven, and Kaplan 2008). Very few shamans remain today. In recent decades, Tsimane villages have adopted a system of elected chiefs (*corregidores*) and other officials in larger villages for representation purposes and interaction with outside interests. Chiefs wield no real power;

their main tasks are to hold and conduct meetings in the event of conflicts, help organize community labor events, and represent village interests in transactions with outsiders. They are usually young or middle-aged men fluent in Spanish and with some experience dealing with Bolivian nationals. In villages where loggers make deals with Tsimane, chiefs and their families benefit more than other families. There is little accumulated wealth among Tsimane, and no consistent, robust associations between market access and wealth inequality have been demonstrated (Godoy et al. 2004). Items of value include shotguns and rifles used for hunting, axes, radios, watches, bicycles, and dugout canoes. 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. Another source of wealth includes domesticated animals such as chickens, ducks, and, in some rare cases, pigs and cows. Chickens are often raised for consumption and sometimes for trade. Pigs and cows are used for barter and also for consumption during festivals. After death, a person's belongings are usually burned or buried with the person, although expensive durable items such as shotguns are passed down to a relative (usually a son).

Wealth measures. Data exist for eight types of wealth covering the somatic-knowledge, material, and social domains that comprise key components of Tsimane production and cultural success. These include RS, body size, cultural knowledge, hunting success, household wealth, field labor networks, and alliances. Measures are constructed from data collected from ongoing fieldwork as part of the Tsimane Health and Life History Project (2002–2008). 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. Each person's score is the proportion of sex-specific skills held (total 53 for women, 67 for men). Hunting success, measured by the average number of calories gained per hour spent hunting, is based on a combination of focal follows and interviews of hunters and is reported in Smith et al. (2010, this issue). Household wealth describes the sum monetary value (based on the buying price in the nearest town) of shotguns, rifles, watches, radios, bicycles, and domesticated animals among all nuclear family members.

Cooperative labor partnerships are measured as the number of helpers in horticultural tasks during the previous year, based on interviews in 11 remote villages. Larger communities that engage in more cash-cropping (mostly rice) were excluded from the sample. People paid in money, goods, or farm product for their labor were not included in the tally. Only father-son dyads were considered here. Alliances were measured according to a ranking procedure where local raters ranked sets of eight photos of their peers on the basis of who would have more allies help them in the event of a conflict (von Rueden, Gurven, and Kaplan 2008). A block design insured that no two photos appeared together in the same array more than once. The range of possible scores was 8–64.

Methodological Limitations

Table 4 presents the sample size of parent (F_1) and offspring (F_2) dyads by wealth type for each of the four populations. Sample sizes vary substantially and tend to be larger for more easily measured variables, ranging from 41 for hunting skill among Tsimane to 1,274 for weight among Mandinka.

Values for several F_2 wealth measures are paired with the midpoint value of their biological parents. This does not mean that children consistently coresided with both of their biological parents. Our choice for F_1 and F_2, however, is the best metric for capturing intergenerational transmission in social systems where children may live with one, the other, or both parents for at least the majority of their period of dependence, in which there are no strict rules of intergenerational transmission, and in which children learn primarily from the adults in their household.

The reliance on F_1-F_2 dyads requires information on two generations. For many individuals, death before study and residence in a nonstudy village leave many unpaired individuals. These are probably the largest possible sources of bias. Trait values for complete F_1 and F_2 generations were compared with those remaining after removing unpaired individuals. The most common bias favors stable group members and disfavors immigrants or highly mobile individuals; the repeated panel design of the Mandinka, Pimbwe, and Tsimane studies helps to reduce this bias.

While the four populations lived fairly traditional lifestyles during the data collection periods, each has had a history of interaction with other populations, national society, and increasing integration to the market. Traditional subsistence activities occur in the context of increasing formal education of the current generation, cash-cropping, and wage labor. Novel wealth types, such as competency in the national language or years of formal schooling, were not analyzed here because of the rapid pace of change. To some extent, we attempted to control for some of the effects of acculturation. Among Tsimane, where economic activities can vary in different parts of their territory, we added a "region" variable to regressions to help control for both environmental variation and acculturation. Statistical methods for computing wealth elasticity (β) for each wealth type and population are described in the CA+ online supplement "Estimating the Inheritance of Wealth in Premodern Societies" in the online edition of *Current Anthropology*.

Table 2. Judgments of α exponents for horticulture societies in the Cobb-Douglas production function of household well-being

	Wealth type				
Population	Somatic	Knowledge	Embodied[a]	Material	Relational
Dominica	.30	.20	.50	.20	.30
Mandinka	.40	.15	.55	.20	.25
Pimbwe	.40	.20	.60	.30	.10
Tsimane	.25	.20	.45	.15	.40
Average	.34	.19	.53	.21	.26
Standard deviation	.07	.03	.06	.06	.13

[a]Embodied wealth combines somatic wealth and knowledge-based wealth.

Results

Alphas (α's) from Production Function

Table 2 presents each researcher's judgment of the relative importance of somatic (s), knowledge (k), material (m), and relational (r) capital for overall production or cultural success, hereafter referred to as "household well-being" (w; see Borgerhoff Mulder et al. 2009). For comparability across the production systems and to reduce ambiguity, we combine somatic and knowledge wealth as embodied (e) wealth (Kaplan 1996). The relative importance of different types of capital is described by the α's (alphas) from the Cobb-Douglas production equation $w = A \times E^{\alpha_e} M^{\alpha_m} R^{\alpha_r} + \delta$, where $\alpha_e + \alpha_m + \alpha_r = 1$ (see Borgerhoff Mulder et al. 2009).[2] Given the impressionistic nature of these judgments, we do not attempt to explain small differences in α but instead highlight several general patterns. Consistent with the typological descriptions of wealth outlined in "Wealth," material wealth does not appear to be a substantial component of household well-being, contributing an average of only one-fifth (0.21) of total wealth importance. Material wealth was judged to be the least important wealth type among all four populations. Embodied wealth accounts for a substantial one-half (0.53) of well-being. Two-thirds of this is somatic capital, and the remaining third is knowledge. Finally, the α for relational social capital, constitutes, on average, one-fourth (0.26) of the total wealth input exponents. Table 2 reflects our impressions from "Wealth" that emphasized the importance of relational capital for cultural success, even (or especially) among egalitarian horticulturalists, and the lower importance of material capital. Only hunter-gatherers show a higher mean α for relational capital and a lower α for material capital (see Smith et al. 2010). Figure 1 illustrates the α's for all horticultural populations in a ternary plot. Despite the geographic, ecological, and cultural variation in our sample, there was a fairly low amount of variation in our judgments for somatic and knowledge-based α's.[3]

2. A is a positive constant; E, M, and R are a household's embodied, material, and relational wealth, respectively; and δ represents exogenous shocks to a household's wealth.

Wealth Inequality

Table 3 provides several common measures of inequality for each population-specific wealth type. These include the standard deviation, the coefficient of variation, and the Gini coefficient. We focus attention on the Gini coefficient because of its unit-free properties and wide usage. The Gini coeffi-

3. We briefly speculate on a few notable differences in α: Pimbwe scored the highest for material wealth and the lowest for relational wealth, perhaps owing to the highly uneven pace of integration and accumulation of human capital. While strong, healthy bodies are critical for successful food production and mate selection among Tsimane, their somatic wealth α scored the lowest; overall well-being, especially during critical times of need, may be affected more by variability in social networks than by differences in somatic or knowledge-based wealth.

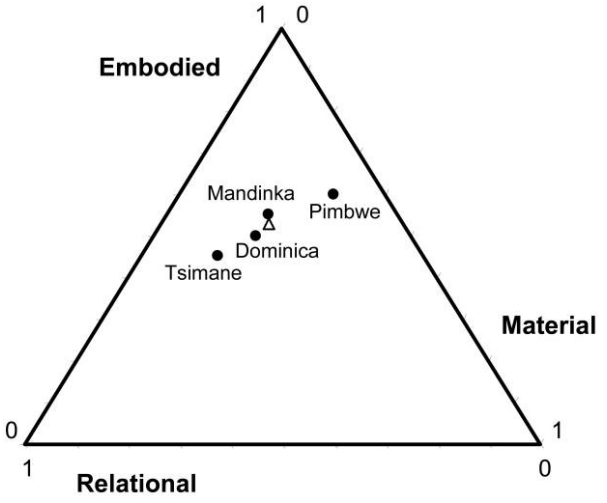

Figure 1. Ternary plot of $\alpha = \{e, m, n)$ for embodied, material, and relational wealth. The α's describe the proportion of overall household well-being due to each type of wealth. Circles refer to horticultural populations, and the triangle represents the average for all four populations.

Table 3. Mean level of each wealth variable and intrapopulation age-adjusted inequality as measured by standard deviation (SD), coefficient of variation (CV), and Gini coefficient

Wealth class, group, and wealth type	Mean	Inequality measure			*N*	Mean age
		SD	CV	Gini		
Embodied wealth:						
Mandinka:						
Weight	54.4	7.1	.13	.073	2,355	34
Reproductive success	3.7	2.3	.62	.328	1,935	43
Pimbwe:						
Weight	56.7	8.2	.14	.079	395	33
Farming skill	4.4	2.4	.55	.308	507	43
Reproductive success	5.63	1.94	.34	.190	1,041	38
Tsimane:						
Hunting returns	1,190.2	877.0	.74	.371	40	37
Cultural knowledge	.7	.1	.14	.076	265	35
Weight	59.0	9.2	.15	.087	1,033	36
Grip strength	172.0	79.6	.46	.263	1,249	36
Reproductive success	7.09	2.5	.35	.190	1,288	38
Average			.36	.196		
Material wealth:						
Dominicans:						
Land	.3	.4	1.56	.671	315	. . .
Pimbwe:						
Household wealth	176.5	212.4	1.20	.563	614	40
Tsimane:						
Household wealth	4,424	3,328	.75	.326	361	39
Average			1.17	.520		
Relational wealth:						
Tsimane:						
Field labor partners	3.7	2.2	.58	.315	234	38
Alliances	38.1	9.4	.25	.141	130	38
Average			.42	.228		

cients for the 15 horticulturalist wealth measures range from near 0 to more than 0.6, with a mean of 0.265 ($e = 0.20$, $m = 0.52$, $r = 0.23$). When weighted by the importance of each wealth type to population-specific wealth (based on the α's), as well as by the inverse of their estimated variances (to account for the differing degrees of precision of the various estimates), the mean Gini across wealth classes dropped to 0.21. Material wealth consistently shows the highest levels of inequality, on par with income inequality in the United States (0.463 in 2007). We highlight some notable patterns by wealth type. Material wealth has the highest average Gini (0.52), while body weight has the lowest (0.08). Ginis for RS (0.24) and skill/productivity (0.25) are intermediate. We hesitate to compare inequality levels among societies, given the variable number of wealth categories for each population. Only among the Tsimane do wealth data exist for all categories, resulting in an α-weighted Gini of 0.17.

Intergenerational Wealth Elasticity (β)

Table 4 summarizes the estimate, the standard error, and the statistical significance of the transmission coefficient between parental wealth and offspring wealth (hereafter referred to as β) by wealth type and population, as determined from multiple regression analyses described in the introductory paper in this special section (Bowles, Smith, and Borgerhoff Mulder 2010, in this issue). Figure 2 illustrates several examples. Embodied wealth is based on 10 measures from three societies, material wealth is based on three measures from three societies, and relational wealth is based on two measures from only one society. The overall β for horticulturalists, weighted by the importance (α) of each wealth type in promoting household well-being, is 0.18.

Embodied wealth. The mean β for embodied wealth for horticulturalists is 0.17 (table 4). Measures include body weight, grip strength, RS, and hunting performance. Parent-offspring elasticities for body weight are the strongest of all β's, varying from 0.25 to 0.39. Given the relatively large β's for weight, it is surprising that the β for grip strength is very small. Grip strength is correlated with weight, given Tsimane leanness (mean adult body mass index = 23). A similar high β for weight but low β for grip strength was also observed among the Hadza (Smith et al. 2010).

The β's for RS were low, consistently <0.13. Additional analysis by child (F_2) sex, however, revealed consistently larger β's for sons than for daughters (parent-son vs. parent-daugh-

Table 4. Wealth elasticities (β) for different wealth types among four horticultural populations

Wealth class, population, and wealth type	Transmission (β)	SE	*P*	*N* pairs (F_2)
Embodied wealth:				
Mandinka:				
Weight	.391	.041	.000	1,274
Reproductive success	.088	.086	.309	967
Pimbwe:				
Farming skill	−.015	.097	.875	217
Weight	.377	.096	.000	148
Reproductive success	−.057	.107	.592	599
Tsimane:				
Hunting returns	.384	.130	.003	26
Cultural knowledge	.111	.094	.240	181
Weight	.253	.069	.000	383
Grip strength	.070	.042	.094	490
Reproductive success	.128	.073	.079	849
Average	.173	.047	.001	568
Material wealth:				
Dominicans:				
Land	.137	.140	.327	62
Pimbwe:				
Household wealth	.107	.318	.735	283
Tsimane:				
Household wealth	.024	.071	.731	110
Average	.090	.087	.309	152
Relational wealth:				
Tsimane:				
Field labor partners	.181	.106	.086	67
Alliances	.338	.103	.001	45
Average	.260	.106	.020	56.0

Note. Averages are arithmetic. *P* values were calculated from two-tailed tests of hypothesis that true β for a given row equals 0.

ter $\beta \pm$ SE: Mandinka, 0.093 ± 0.083 vs. 0.033 ± 0.046; Pimbwe, 0.182 ± 0.349 vs. -0.042 ± 0.133; Tsimane, 0.225 ± 0.115 vs. 0.064 ± 0.047). Given the lower variance in RS among females than males in the mildly polygynous Mandinka, Pimbwe, and Tsimane, women may find it easier to obtain mates and support offspring, regardless of parental RS. Although it might be expected that increased competition with more siblings might reduce sons' RS, larger kin groups, especially of older sibs, might provide additional critical support in finding mates. A variety of alternative caretakers may also help improve child survivorship relatively cheaply because of depreciating costs of babysitting and other care activities. Parents with greater RS may themselves come from larger sibships, which will provide a larger set of available cross-cousins to marry in societies, such as Tsimane, where the ideal mate is a cross-cousin.

Unlike the case for Tsimane hunting (discussed in Smith et al. 2010), there is no intergenerational transmission for Pimbwe farming skill. Even though farming production was averaged across multiple years to reduce the effects of annual variability, it is possible that stochastic factors in an unpredictable and pest-ridden environment overwhelm heritably transmitted knowledge. The farming skill measure also combines knowledge with planning and work effort. Each of these may be transmitted differently, and farming knowledge itself might be widely available. Tsimane cultural knowledge shows low intergenerational transmission, with $\beta = 0.11$. Many common skills are readily obtained by Tsimane during development and early adulthood; individual abilities and experience may swamp the effects of informal parent-offspring social transmission.

Material wealth. The overall β for material wealth in this sample is 0.09 (table 4). Data exist only for household wealth and land. Household wealth showed no relationship. Among Pimbwe and Tsimane, there is little household property transmitted directly between parent and offspring households, especially because most household items last for only a few years. Houses themselves survive for only about a decade. Among Pimbwe, a fierce ideology of self-reliance limits interhousehold sharing and kin support. When asked about support received by others for food, school fees, and medical bills, Pimbwe react with disgust, insisting on their independence. Fear of sharing and dependence stems from deep concerns with witchcraft that pervade all aspects of Pimbwe social life. Help among households is somewhat low but more forth-

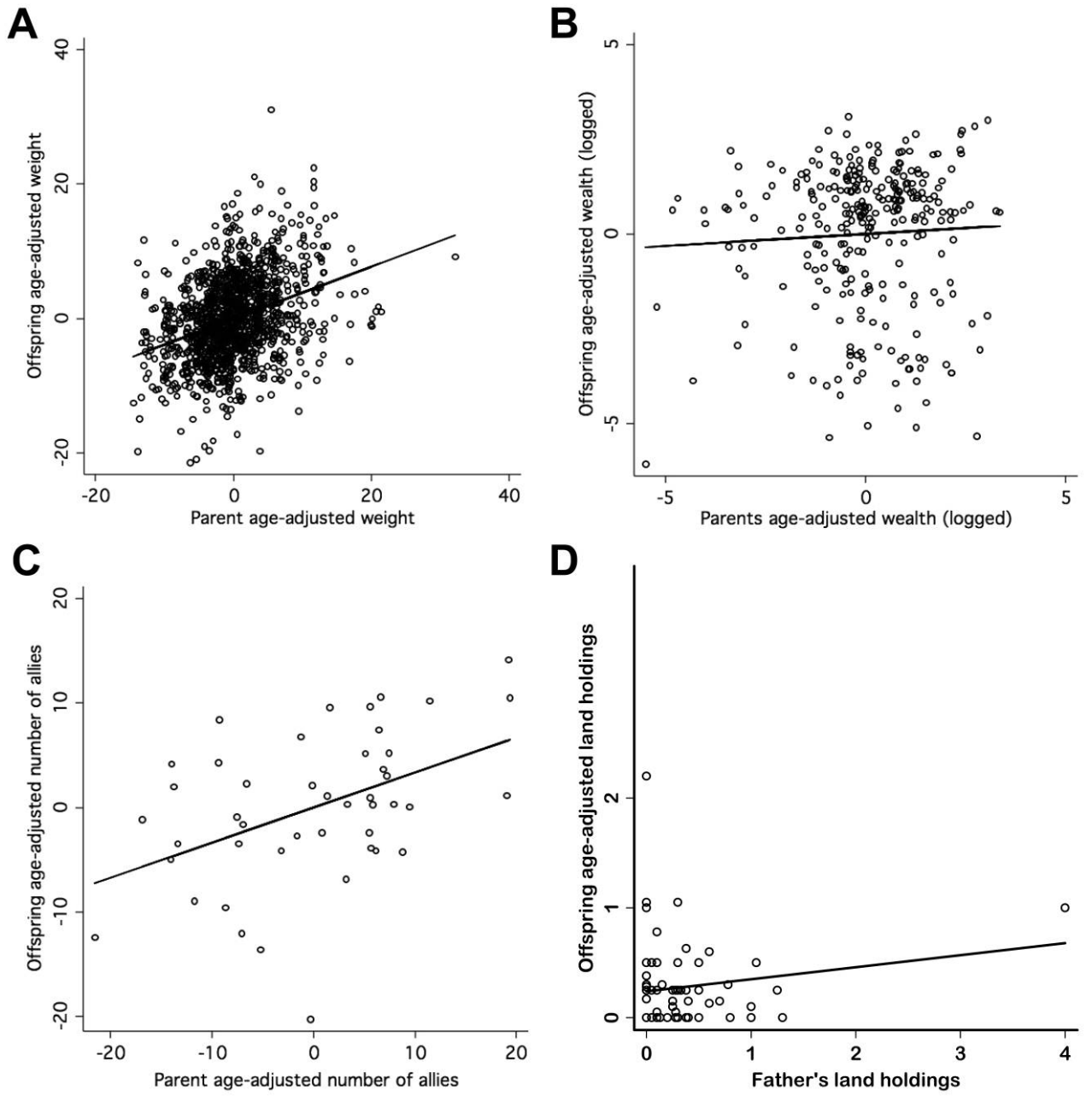

Figure 2. Offspring (F_2) and parental (F_1) wealth, adjusted for age. *A*, Weight among Mandinka ($\beta = 0.391$). *B*, Household wealth among Pimbwe ($\beta = 0.107$). *C*, Allies among Tsimane ($\beta = 0.338$). *D*, Land holdings among Dominicans ($\beta = 0.137$). Fathers' age controls had no effect on the elasticity estimates for land holding in Dominica and were dropped to improve statistical precision.

coming among Tsimane. While complaints about the inadequacy of help received from others are common, there is no similar ideology or concern about witchcraft. Tsimane accusations of sorcery are usually directed toward outgroup members and, if anything, are more common when people refuse to share.

We expected that transmission of material wealth to Dominican sons would be more substantial because of loose patrilineal inheritance norms (Quinlan and Flinn 2005). However, we found little evidence of intergenerational inheritance of land among Dominicans, with $\beta = 0.14$. Sons are often viewed as risky investments, and relatives other than

children usually contribute many years of agricultural labor to these plots. It is possible that these other relatives may inherit land through oblique transmission. Parents sell bay leaves and use the cash to finance children's education and migration. Bay leaf farming is recognized as difficult work, so productive parents may use their profits to provide other opportunities for children, although parents' *bwa den* plot size is not significantly associated with the probability of children's migration.

Relational wealth. Our only measures of relational wealth are for the Tsimane: number of helpers assisting in agricultural field activities and number of male alliances during conflicts. Fathers with more helpers were somewhat more likely to have sons with more helpers ($\beta = 0.18$). While this relationship is not driven by the set of data points represented by parents and offspring with no helpers, it is weakened by excluding either shared individuals who help both F_1 and F_2 or help exchanged between F_1 and F_2.

Allies are an important resource during interpersonal conflicts with other Tsimane and with Bolivian colonists, merchants, or loggers. The number of named allies in the event of a conflict is highly correlated with several measures of social status and respect (von Rueden, Gurven, and Kaplan 2008). The relationship between the number of parental and offspring allies was stronger than that found among labor partners ($\beta = 0.34$). This result was not driven by parents and offspring naming each other.

Discussion

Material wealth was considered the least important contributor of household well-being across the four horticultural societies in our study, while embodied and relational wealth were considered the most important (table 2). On average, intergenerational transmission of material wealth was low, even though inequality was relatively high (table 3). Embodied and relational wealth are both important determinants of well-being among horticulturalists. Physically robust and healthy bodies are needed to produce and defend resources, acquire the repertoire of cultural skills, and attract mates and allies. Higher transmission coefficients were found for somatic wealth (except RS) than for knowledge or skill. Cultural knowledge and information may be easily obtainable from a wide variety of kin, peers, and others, and/or individual experience and abilities may trump the value of any specialized traditions or knowledge passed from parents to children. Social networks are also important to horticulturalist household well-being. The number and quality of kin and allies mediate access to resources and mates and to support when conflicts erupt or when one is disabled. Although based on data from only one population, the level of intergenerational transmission for relational capital is nontrivial, with transmission coefficients averaging 0.26. A similar level of wealth elasticity is found for embodied capital (average = 0.17).

Despite the implication that intergenerational wealth elasticities are higher for the types of wealth that are more important in each society, we found no significant correlation between our set of 15 α's and β's ($r = 0.12$, $P = .662$); this contrasts with the significant correlation reported for the larger sample of hunter-gatherers, horticulturalists, pastoralists, and intensive farmers (Borgerhoff Mulder et al. 2009; Smith et al. 2010). However, the relationship for horticulturalists improves after eliminating RS measures, which showed consistently very low β's ($r = 0.38$, $P = .217$).

The nontrivial β's and measured inequality are remarkable, given the roughly egalitarian nature of these four horticultural societies. Overall wealth transmission (mean β weighted by α) for horticulturalists is low (0.18), very close to that calculated for hunter-gatherers (0.19), and about half of that reported for pastoralists and intensive farmers (see Borgerhoff Mulder et al. 2010, in this issue; Shenk et al. 2010, in this issue; Smith et al. 2010). The importance of such low β's, however, should not be underestimated: a β of 0.2 implies that a child born into the top wealth decile of the population is 3.6 times more likely to remain in the top decile than is a child whose parents were in the bottom decile (as discussed in Bowles, Smith, and Borgerhoff Mulder 2010). The wealth elasticities for each of the three wealth classes are also similar among horticulturalists and hunter-gatherers, as is the overall α-weighted Gini index measuring wealth inequality (0.27 for horticulturalists vs. 0.25 for hunter-gatherers).

Given the β's in table 4, we can say that the steady state levels of variance in logarithm of wealth (a standard unit-free measure of inequality) range from $1.004 \times \sigma_\lambda^2$ (material wealth) to $1.034 \times \sigma_\lambda^2$ (relational wealth), where σ_λ^2 is a measure of the variance in wealth shocks in one generation and the coefficient multiplier is $(1 - \beta^2)^{-1}$ (see Borgerhoff Mulder et al. 2009). Thus, at equilibrium, there is greater inequality in the wealth measures that are of greater utility to horticulturalists, that is, relational and embodied. Thus, not all types of wealth are equally distributed and inherited across generations. Another important conclusion here is that the domestication of plants alone does not lead to greater inequality. Limited access to storable or defendable resources such as land, technology, or animals is a necessary ingredient for high levels of inequality to emerge. Such limitation is minimal in our sample but is common among intensive agriculturalists and pastoralists.

Although our inferences here refer to intact horticultural societies, our four societies vary in their degree of acculturation and market integration. Each has a history of contact, conquest, and, to some extent, marginalization. It remains to be seen how integration into the market economy has and will continue to impact inequality. Production functions may include a greater reliance on material wealth and new forms of human capital, such as formal schooling, proficiency in national language, and local politics. Relational capital may include important contacts in distant locations for the purpose of trade, cash-cropping, and wage labor opportunities.

It is likely that novel forms of wealth show greater inequality than traditional forms expressed in this paper, and so overall inequality in extant horticultural societies may be more exaggerated than the portrait given here.

The Kuznets hypothesis, proposed to explain differences in inequality among nations, suggests an inverted U-shaped relationship between economic development and inequality (Kuznets 1955). At low levels of development, most work in subsistence agriculture and land rights is based on usufruct. With increasing market integration, economic inequalities increase as subgroups selectively opt to obtain formal education, sell produce, trade, and engage in wage labor or service occupations. At high levels of development, few practice subsistence agriculture, and most, if not all, work for wages. Presumably, income inequality decreases at higher levels of economic development, accentuated by social welfare programs that promote redistribution. The only empirical test of the Kuznets hypothesis in a small-scale society was done among the Tsimane and did not lead to consistent, conclusive results across wealth types or econometric specifications (Godoy et al. 2004). Greater inequality requires greater reliance on limited, predictable, and monopolizable resources, particularly material wealth. Deliberate social norms that promote economic redistribution will also dampen inequality. It is noteworthy that the average Gini index of inequality from our four populations is similar to that of Scandinavian countries that employ strong social welfare programs. Sharing norms based on a risk-sharing foraging economy often remain, even if somewhat modified, following economic change.

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Intergenerational Wealth Transmission and Inequality in Premodern Societies

Intergenerational Wealth Transmission among Agriculturalists

Foundations of Agrarian Inequality

by Mary K. Shenk, Monique Borgerhoff Mulder, Jan Beise,[1] Gregory Clark, William Irons, Donna Leonetti, Bobbi S. Low, Samuel Bowles, Tom Hertz, Adrian Bell, and Patrizio Piraino

CA+ Online-Only Supplement: Estimating the Inheritance of Wealth in Premodern Societies

This paper uses data from eight past and present societies practicing intensive agriculture to measure the transmission of wealth across generations in preindustrial agricultural societies. Focusing on embodied, material, and relational forms of wealth, we compare levels of wealth between parents and children to estimate how effectively wealth is transmitted from one generation to the next and how inequality in one generation impacts inequality in the next generation. We find that material wealth is by far the most important, unequally distributed, and highly transmitted form of wealth in these societies, while embodied and relational forms of wealth show much weaker importance and transmission. We conclude that the unique characteristics of material wealth, and especially wealth in land, are key to the high and persistent levels of inequality seen in societies practicing intensive agriculture. We explore the implications of our findings for the evolution of inequality in the course of human history and suggest that it is the intensification of agriculture and the accompanying transformation of land into a form of heritable wealth that may allow for the social complexity long associated with agricultural societies.

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Intergenerational Wealth Transmission among Agriculturalists

This article uses data from several past and present populations from Africa, Asia, and Europe to explore wealth transmission in societies practicing intensive agriculture. We begin by defining the production system of intensive agriculture, the forms of wealth most important in such societies, and the important components of agricultural societies as they relate to social inequality and the transmission of wealth between generations. We follow with a discussion of the ethnographic background of the eight societies in our sample and the different types of wealth analyzed for each. After presenting quantitative results on the extent and form of intergenerational transmission for each society and type of wealth, we conclude with a summary of our results and discussion of their importance for understanding key themes of social structure and inheritance in agricultural societies.

Agricultural Production Systems

We classify agricultural production systems as those that cultivate crops using technologies such as plows and traction animals and that are characterized by land-limited cultivation systems, and in some cases by markets for land and agricultural labor. Intensive agriculture is characterized by the cultivation of plants using technologies that supplement human labor; these technologies allow for more yield per acre as well as larger fields of crops (e.g., Boserup 1965; Scarborough 2003; Wittfogel 1957). In the literature on Eurasia, the most well-known and widely discussed technologies include various forms of irrigation and the use of plows pulled by large domesticated animals (Barker 2006; Scarborough 2003; Wittfogel 1957). However, many other forms of intensive agriculture have been in widespread use including raised fields, terracing, reservoirs, chinampas (stationary floating islands of arable land constructed on shallow lake beds), and various types of organic fertilizers including manure, charcoal, bone, and shell (e.g., Erickson 2008; Rostain 2008; Scarborough 2003; Wenke 1984).

Although the domestication of crops began around 12,000 years ago, the first farmers used only human labor and hand tools in a subsistence pattern that many anthropologists refer to as horticulture (Barker 2006; Bellwood 2005; see Gurven et al. 2010, in this issue). It would take thousands more years before there was evidence for the practice of intensive agriculture in highly populated river valleys in Mesopotamia (4100 BCE), Egypt (4000 BCE), China (2400 BCE), and South Asia (2400 BCE), contemporaneous with the rise of early complex societies in those regions (Barker 2006; Bellwood 2005; Feinman and Price 2001; Scarborough 2003). Intensive agriculture also developed independently in Mesoamerica beginning around 2000 BCE and in Andean South America around 1300 BCE (Billman 2002; Denevan 2001; Moseley 2001; Scarborough 2003).

The initial development of agriculture gave rise to farming societies characterized by sedentary people, villages with permanent structures, and food storage (e.g., Barker 2006; Bellwood 2005; Wenke 1984). Despite higher rates of communicable diseases, agricultural populations typically had higher fertility and faster population growth rates, a trend sometimes referred to as the Neolithic demographic transition (e.g., Bocquet-Appel and Bar-Yosef 2008; Caldwell et al. 2006; McKeown 1988; McMichael 2001). The very early farming societies are often thought to have been relatively egalitarian or to have only limited hierarchies and primarily local forms of political integration; evidence for this has come primarily from the archaeological literature (e.g., Barker 2006; Hayden 2001) or has emphasized ethnographic data from traditional societies (e.g., Johnson and Earle 2000; Service 1962).

The development of intensive agriculture is historically associated with the rise of complex societies, including complex chiefdoms and states (Boserup 1965; Fried 1967; Hayden 2001; Johnson and Earle 2000; Service 1975; Stein 2001; Wenke 1984). Complex societies are characterized by social stratification (economic and social differentiation among people) as well as political integration of communities resulting in multiple levels of sociopolitical hierarchy (Johnson and Earle 2000). They are also characterized by complex divisions of labor, including a rise in full-time occupational specializations such as artisans, merchants, religious specialists, bureaucrats, tax collectors, and soldiers, often concentrated in urban areas (e.g., Fried 1967; Johnson and Earle 2000; Service 1975; Stein 2001) and with greater concentrations of people, including the formation of the first towns and cities (Boserup 1965; Carneiro 1970; Johnson and Earle 2000; Stein 2001; Wenke 1984). Despite these developments, however, the majority of people in such cultures may continue to live in rural areas and/or work in agriculture (Boserup 1965; Johnson and Earle 2000; Scarborough 2003; Wolf 1966). All populations studied in this paper are a part of modern or historical state societies, though some exist on the rural margins of the state while others exist closer to urban centers.

Wealth and Inequality in Agricultural Societies

Material, embodied, and relational wealth. As discussed in the introductory paper in this special section, in order to capture important aspects of wealth in very different types of societies our project defines wealth in a very general sense as any attribute of individuals that contributes to their long-term well-being. We distinguish three categories of wealth. *Material wealth* refers to animals, objects, or spaces in the physical world over which individuals have ownership or use rights. *Embodied wealth* refers to attributes contained in the bodies of individuals, including somatic attributes such as strength and immune function as well as mental attributes such as knowledge and skills (see Kaplan 1996 for a more general treatment of the concept of "embodied capital"). *Relational wealth* resides in the social connections and relationships be-

tween individuals through which they are able to gain access to information or flows of resources.

In most traditional agricultural societies, land is a—if not the—primary form of material wealth. Agricultural societies usually recognize property rights in land held by a kin group or an individual (Boserup 1965; Goody 1976; Harrell 1997). Land has two peculiar characteristics that influence its importance: arable land is finite, and if divided into small enough parcels it may no longer be enough to support a family. In contrast to horticulturalists, agricultural societies are characterized as being land limited rather than labor limited (e.g., Goody 1976; Harrell 1997; Johnson and Earle 2000). Population growth can result in all of the arable land in an area being owned and under cultivation (Beise and Voland 2008; Boserup 1965; Johnson and Earle 2000; Low 1990; Voland and Dunbar 1995). Truly land-unlimited agricultural populations may occur only during the expansion of agriculturalists into a frontier area (e.g., American pioneers) and are thus temporary situations. Intensive agriculturalists also possess other important material wealth currencies. Farmers may have significant wealth in livestock, a more movable form of subsistence-related wealth than land that is often subject to less complex inheritance dynamics (Goody 1976; Goody, Thirsk, and Thompson 1976). Stored grain can serve both as a subsistence staple and as a form of currency for paying rent on land or other kinds of debts (Feinman and Price 2001). Durable goods such as plows, carts, tools, furniture, cooking vessels, jewelry, and clothing can be important forms of wealth that often can be divided among multiple heirs (Goody 1976). Finally, it is in intensive agricultural societies that money first becomes a common form of wealth, often associated with commerce in urban areas but also penetrating into rural areas where trade may sometimes take place in cash rather than in kind (Boserup 1965; Johnson and Earle 2000; Wolf 1966).

As in other types of societies, kin ties remain an important source of social support and relational wealth (Harrell 1997; Johnson and Earle 2000). Preindustrial agricultural societies are overwhelmingly patrilineal (see table 1), though relatives through the female line are usually acknowledged and may be important sources of political alliances and marriage partners (Ember and Ember 1983; Goody and Tambiah 1973; Harrell 1997). Bilateral societies are not uncommon, but true matrilineality is rare in agricultural societies, and the examples that do exist are mostly small in scale (Ember and Ember 1983; Harrell 1997).

In preindustrial agricultural societies, embodied wealth in health, longevity, and knowledge usually covary with, and may often be the result of, class structure and differences in material wealth (e.g., Caldwell et al. 2006; Clark and Hamilton 2006; Lee 1973; Milanovic, Lindert, and Williamson 2007; Scott and Duncan 2002). The same is also true for the number and survival of children, the form of embodied wealth that has received the most attention in the literature. For agricultural laborers, peasants, and other types of workers—usually comprising the largest portion of the population—a large number of children is often considered ideal as it increases the labor pool available to a family, provides insurance to parents in old age and siblings in case of disability, and accounts for the likely loss of children due to high rates of mortality (Caldwell et al. 2006; Harrell 1997; Wolf 1966). While child mortality is often lower among wealthier people (Clark and Hamilton 2006; Milanovic, Lindert, and Williamson 2007; Scott and Duncan 2002), for propertied classes in agricultural societies, a large number of heirs is not always welcome as they may necessitate the division of the property and thus a dilution of social status (e.g., Baker and Miceli 2005; Goody 1990; Goody, Thirsk, and Thompson 1976; Harrell 1997; Saller 1994). While this problem is most commonly dealt with using preferential inheritance rules (see below), sometimes it may result in the limitation of family size through infanticide or other methods (e.g., Caldwell and Caldwell 2005; Dickemann 1984).

Intergenerational transmission. Agricultural societies commonly have highly codified rules regarding inheritance, especially inheritance of land. While the equal division of land between all children does occur, some type of exclusion is more common (see table 1; Baker and Miceli 2005; Harrell 1997). Such practices range from primogeniture in favor of the oldest son to ultimogeniture in favor of the youngest son (or occasionally daughter) to the exclusion of one sex or the other altogether from the inheritance of land—most commonly, the division of the father's property among sons only (Baker and Miceli 2005; Goody 1976; Harrell 1997). In contrast, the inheritance of cash, animals, and household goods may be somewhat more equal, and it is common for daughters excluded from inheriting land to inherit these items (Goody 1976, 1990; Goody and Tambiah 1973; Harrell 1997).

Given the importance of material wealth in agricultural societies, arranged marriage is common with a key consideration being the wealth or social status of the partner's family. While bride-price is the prevailing custom in small-scale agricultural societies or among people of low or moderate status, dowry marriage—a custom unique to intensive agriculturalists—characterizes high-status groups in several of the largest complex societies of Eurasia (Boserup 1970; Fortunato, Holden, and Mace 2006; Goody 1976; Goody and Tambiah 1973; Pagel and Meade 2005; table 1). The most detailed treatment is that of Goody and Tambiah (1973), who maintain that dowry is a means of passing inheritance through both sons and daughters, as opposed to bridewealth systems in which little to no wealth may be inherited through daughters.

While both polygyny and monogamy are common among small-scale agriculturalists (table 1), monogamy is the dominant form of marriage in many large-scale complex state societies (Betzig 1986; Ember and Ember 1983; Goody 1990). Goody (1976) argues that farmers are more likely to be polygynous in Africa because land is not limited, while many Eurasian farmers are monogamous because of land shortages and a motivation to limit heirs. While elite men in monogamous societies may still have sexual access to other women,

Table 1. Characteristics of 61 societies practicing intensive agriculture as defined by codes 5 (intensive agriculture using fertilization, crop rotation, or other techniques to shorten or eliminate fallow period) and 6 (intensive irrigated agriculture) on variable 232 "Intensity of Cultivation" in the 186 societies comprising the Standard Cross-Cultural Sample (Murdock 1967; Murdock and White 1969)

Parameter	% of *n* societies (*n*)
Region (v200):	
Africa	13.1 (61)
Circum-Mediterranean	37.7 (61)
East Eurasia	26.2 (61)
Insular Pacific	8.2 (61)
North America	8.2 (61)
South America	6.6 (61)
Domestic organization (v210):	
Independent nuclear family—monogamy	13.3 (60)
Independent nuclear family—occasional polygyny	18.3 (60)
Polygyny	11.7 (60)
Minimal (stem) extended families	8.3 (60)
Small extended families	31.7 (60)
Large extended families	16.7 (60)
Degree of polygamy (v861):	
Polyandry	0 (57)
Monogamy prescribed	24.6 (57)
Monogamy preferred	14.0 (57)
Limited polygyny	31.6 (57)
Full polygyny	29.8 (57)
Descent (v247):	
Patrilineal	47.5 (61)
Duolateral/ bilineal	3.3 (61)
Matrilineal	9.8 (61)
Quasi-lineages	1.6 (61)
Ambilineal	3.3 (61)
Bilateral	26.2 (61)
Descent (v70):	
Patrilineal	59 (61)
Matrilineal	8.2 (61)
Ambilineal	3.3 (61)
Bilateral	29.5 (61)
Mean size of local communities (v235):	
50–99	11.5 (52)
100–199	11.5 (52)
200–399	13.5 (52)
400–1,000	3.8 (52)
1000–5,000	5.8 (52)
5,000–50,000	15.4 (52)
50,000+	38.5 (52)
Mode of marriage (v208):	
Bride-price	45.9 (61)
Bride-service	1.6 (61)
Token bride-price	16.4 (61)
Gift exchange	6.6 (61)
Sister or female relative exchanged	3.3 (61)
Absence of consideration	14.8 (61)
Dowry	11.5 (61)

Table 1. (*Continued*)

Parameter	% of *n* societies (*n*)
Inheritance of property:	
Real property (v278):	
Absence of property rights or inheritance rules	3.6 (56)
Matrilineal (sister's sons)	1.8 (56)
Other matrilineal heirs (e.g., younger brother)	3.6 (56)
Children—with daughters receiving less	14.3 (56)
Children—equally for both sexes	12.5 (56)
Other patrilineal heirs (e.g., younger brothers)	5.4 (56)
Patrilineal (sons)	58.9 (56)
Movable property (v279):	
Absence of property rights or inheritance rules	5.5 (55)
Other matrilineal heirs (e.g., younger brother)	1.8 (55)
Children—with daughters receiving less	20.0 (55)
Children—equally for both sexes	16.4 (55)
Other patrilineal heirs (e.g., younger brothers)	5.5 (55)
Patrilineal (sons)	50.9 (55)
Distribution of property among individuals of same category:	
Real property (v280):	
Equal or relatively equal	52.5 (53)
Exclusively or predominantly to the one adjudged best qualified	9.8 (53)
Ultimogeniture (to the junior individual)	3.3 (53)
Primogeniture (to the senior individual)	21.3 (53)
No rules (or insufficient information)	13.1 (53)
Movable property (v281):	
Equal or relatively equal	52.5 (51)
Exclusively or predominantly to the one adjudged best qualified	8.2 (51)
Ultimogeniture (to the junior individual)	3.3 (51)
Primogeniture (to the senior individual)	19.7 (51)
No rules (or insufficient information)	16.4 (51)
Class stratification—prevailing type (v270):	
Absence among freemen	19.7 (61)
Wealth distinctions	21.3 (61)
Elite	1.6 (61)
Dual (hereditary aristocracy)	19.7 (61)
Complex (social classes)	37.7 (61)

Note. The Standard Cross-Cultural Sample is a group of ethnographically well-known societies from around the world chosen to facilitate cross-cultural research while attempting to avoid the problem of cultural similarity arising from historical relationships or cross-cultural contact.

monogamy limits the number of legal heirs to a man's property, thus helping to maintain the integrity of an estate in land and concentrate wealth in order to compete for social status (Gaulin and Boster 1990). In general, bridewealth persists in polygynous cultures, whereas monogamous groups may practice either bridewealth or dowry (Gaulin and Boster 1990; Goody and Tambiah 1973; Harrell 1997).

While many agriculturalists reside in nuclear families, at least for part of the domestic cycle, the usual family structure in such societies is some form of extended family (table 1). These range in size and makeup from smaller extended families including parents, their heir, and the heir's family, to larger extended families including parents, their adult children of the same gender (usually sons), and those children's families (e.g., Ember and Ember 1983; Harrell 1997). Inheritance typically takes place at the dissolution or formation of households (Goody 1976, 1990; Harrell 1997), through marriage, fissioning, or the death of an elder member.

Status and inequality. Inequality is a fundamental characteristic of societies practicing intensive agriculture (Fried 1967; Johnson and Earle 2000; Service 1962, 1975). This inequality may be between individuals or groups within the society and may have many dimensions, including different types of wealth, occupation, and gender.

Most notably, social differentiation is often organized around how much land individuals own or have access to the income of and under what kind of land tenure system (Boserup 1965; Goody 1976; Johnson and Earle 2000). Differences in land tenure run the gamut from small holdings allocated by kin groups to small holdings directly held by parents and passed to children, to larger holdings owned or legally held by landlords who either rent the land to tenants in exchange for part of the crop or hire agricultural laborers to work for them directly, and to state societies that "farm taxes" from the citizenry by means of tax collectors (Boserup 1965; Johnson and Earle 2000; Netting 1993; Richards 1993*a*; Wolf 1966).

Relatively egalitarian smallholding systems were common throughout Europe, Asia, and Africa, but large, premodern state societies in Europe and Asia often had systems of land tenure in which large amounts of land were held by small numbers of elites (e.g., Caldwell and Caldwell 2005; Johnson and Earle 2000; Goody 1976; Maddison 1971; Netting 1993; Richards 1993*a*; Wolf 1966). Even in this regard there was variation, though, from states in which land was considered the direct property of the head of state (e.g., India under the Mughals), and people were temporarily awarded the right to collect rent from it, to states in which landlords owned land directly and had the power to farm it, rent it, or sell it (e.g., premodern England; Boserup 1965; Maddison 1971; Richards 1993*a*).

While the most basic form of social inequality in agricultural societies lies in ownership of and relationship to land (landowner, landlord, tax farmer, smallholder, tenant, serf, slave), inequality may also be related to other kinds of occupational or craft specializations, commonly including artisans, soldiers, priests, and bureaucrats (Johnson and Earle 2000; Service 1975). Occupational specialization may be related to formal types of social differentiation including hierarchical systems of *castes* (hierarchical systems based on heredity that define and limit members' occupations or social opportunities) and *social classes* (hierarchical systems based on occupation, wealth, or social position; e.g., Dumont 1970). Alternately, status differences may be based on differences in monetary wealth generated by control of land or through participation in trading or commercial ventures (Goody 1976; Johnson and Earle 2000).

Gender inequality can be pronounced in agricultural societies, especially in cultures where men perform most of the agricultural labor (Boserup 1970; Sanday 1981). In such cases, women may be subject to a variety of constraints including claustration (e.g., purdah), body modification (e.g., foot binding), enforcement of modest behavior, and a strong emphasis on virginity at marriage and chastity thereafter (Harrell 1997; Low 2000). Such practices are usually more common among people of higher social status (Dickemann 1979; Low 2000). Perhaps the most pervasive form of gender inequality in agricultural societies can be found in their customs of inheritance, which are overwhelmingly patrilineal and which in more exaggerated cases involve the exclusion of women from ownership of land or other types of property altogether (Goody 1976; Low 2000). Even in cases where women may be given substantial dowries, their control of this wealth may be limited (Goody and Tambiah 1973; Sharma 1993).

The preferential marriage of people of similar social standing (also called isogamy) is quite common in agricultural societies (Dumont 2006; Harrell 1997). This may include rules or practices of endogamy by caste, social class, occupation, or wealth. The marriage of daughters up the social hierarchy (hypergyny) may also be practiced, particularly in dowry-giving cultures (e.g., Dickemann 1979), while celibacy (nonmarriage) is not infrequently practiced when resources are scarce or would become diluted by large numbers of heirs (e.g., Betzig 1986). Overall, an important effect of preferential marriage in agricultural societies is the continued concentration of wealth within families and the consequent perpetuation of inequality across generations (Harrell 1997).

Sample and Methods

In this paper we use 12 measures (five material, five embodied, and two relational) from eight populations to explore patterns of intergenerational wealth transmission in agricultural societies. Here we give critical ethnographic background, introduce our wealth variables, and discuss how they are measured.

Overview of Sample Populations

This paper presents data on intergenerational wealth transmission from eight agricultural populations. Our small sample cannot be statistically representative of all intensive agriculturalists, but it covers much of the range of geographic and social characteristics discussed above. While many of our populations had several estimates of wealth available, those analyzed here are limited by considerations of data quality or relevance to our focus on inequality in preindustrial societies. Each of the contemporary populations are experiencing varying degrees of economic development, thus measures of education and income were excluded as having unclear meaning in a preindustrial context. While it is clear that both existed in large premodern agricultural societies such as those of historical Europe and historical South Asia (e.g., Clark 2007; Richards 1993*b*), the forms of education and monetary income exhibited in recent societies have often been influenced by their incorporation in modernizing states and thus may not have the same form as in the past. Measures of reproductive success were excluded if there was evidence of a demographic transition because it was unclear whether more children would represent greater wealth under such conditions.

East Anglians

Ethnographic background. This is a historical sample composed of men's wills from preindustrial England during the years 1540–1790. The wills used are mainly from testators in East Anglia, Essex, and Suffolk and are part of a collection of more than 8,000 wills from these counties that have been transcribed. England at this time was an agricultural society with a strong mercantile component. Rural areas were occupied by landowning members of the gentry and smaller-scale farmers, while towns were centers of local commerce where there were concentrations of people working outside of agriculture including traders, craftsmen, and professionals. Further details of the society can be found in Clark (2007).

The sample consists of wills of fathers and sons, including 114 father-son pairs. The relationship of testators was estab-

lished through the details contained in the wills and sometimes in additional material from church registers of baptisms, burials, and marriages. There is some uncertainty in these matches: for a match to be declared, someone of the son's name had to appear in the will of the father, and if the son's first and last names were common, then some other details in the son's will would have to match with the father's. Wills as a source of data are described in detail in Clark and Hamilton (2006).

Wealth measures. Wills contained a variety of information, of which two variables will be used in these analyses: estate value and reproductive success (RS). Estimates of estate value were constructed from the information in wills by adding together the cash payments directed by the testator with the estimated value of houses, land, animals, and grain bequeathed by the testator in the will. As land is often the most valuable asset left in the will, this measure can also be seen as a proxy for wealth in land. The RS in this sample is the number of surviving children at the time the will was written, which was typically within a year of the testator's death. Estate value is an excellent measure of material wealth in this society, since it includes most of the large types of material wealth that were socially important in the period. The RS is also a good a good measure of embodied wealth in preindustrial England since wealthier people tended to have more surviving offspring (Clark and Hamilton 2006).

Because this data set is based on recorded wills there are special problems of bias that need to be addressed. Not all men made wills, and the frequency of will making was correlated with wealth. Occupations of men in the sample are biased toward the gentry, professionals, and yeoman farmers but also include traders, craftsmen, shepherds, and laborers in smaller numbers. For a given set of fathers making wills, richer sons were more likely to also make wills and so to enter the data set. This will bias downward the estimation of the coefficient measuring the link between the wealth of generations. Another problem is that wealth is measured with substantial error, again biasing coefficient estimates downward. A third bias is that for a father-son pair of will makers to be identified, the father had to have a son who survived to age 16 or more. Since England in these years was a Malthusian preindustrial society with slow population growth, the average man had only slightly more than one son surviving at time of death (Clark and Hamilton 2006). However, the number of surviving children was higher for wealthier individuals who were more likely to leave wills. The poorest testators left one son on average, the richest two sons. Given that wealth correlates across generations, this again increases the likelihood of wealthier father-son pairs. However, this bias will not affect the estimates of the intergenerational linkage.

Skellefteå

Ethnographic background. The Skellefteå region is a cluster of five contiguous parishes in northern Sweden. During the nineteenth century, farming was the major occupation and there were low levels of market penetration. Land was the most important resource and had strong effects on reproduction and other variables (see Low 1990 for details). Inheritance laws mandated that only men owned land, though widows could hold the land in trust for their children. During the study period, new land came into cultivation and the number of landowners increased. In the 63 villages for which tax records were read, the landowners of record increased steadily from 283 in 1830 to 511 in 1890; the average amount of land held declined from 183.46 to 106.34 hundredths of a *mantal.* While most of the population was engaged in agriculture, there were social class differences related to occupation and landownership. These categories include upper middle class (business owners with many servants), lower middle class (small businessmen, artisans, soldiers), farmers who owned land (*Bönder*), tenant farmers (*torpare*), crofters (smaller land renters), agricultural workers, and paupers. For further details, see Low and Clarke (1990) and Low, Clarke, and Lockridge (1991).

Wealth measures. We consider the embodied wealth measure RS, measured here as number of children born. The sample includes men born between 1800 and 1845 who remained alive until adulthood (18) and their kin in any of 63 villages along the Skellefteå River in Norbotten County in northern Sweden. The years of the data are 1800–1888, and the total number of pairs in the sample is 2,515. Data come from the *mantalslängder* (land tax records) for the years 1830, 1840, 1850, 1860, 1870, 1879 (records were missing for 1880), and 1890. The records link men to fathers, spouses, and children. We restricted the sample to all men age 18 and up for whom we have complete records of their reproductive lives (i.e., they died in record or were alive and age 45 or older at the end of the sample; outmigrants aged <45 were excluded). Reproductive success is an appropriate measure in this society since it is a predemographic transition society with relatively high fertility (Low 1990); there is also a relationship between material wealth (primarily in land) and RS.

Krummhörn

Ethnographic background. This is a historic population from the eighteenth and nineteenth centuries in the Krummhörn region in Ostfriesland (northwest Germany). The data derive from a reconstruction study based on church registers complemented with information from tax rolls and other sources, and the sample consists of data from 19 of the 32 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. It has an area of about 150 km^2 and consists mainly of very fertile marsh soil. This fertile soil was 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 population was characterized by a very low growth rate and a nearly stable cross-sectional size of approximately 14,000 individuals during the period under study. In an ecological context, it is possible to describe the Krummhörn as a saturated habitat consisting of only a limited number of available breeding places. The social organization was structured almost exclusively by the possession of land. The amount of land owned or under lease was decisive for the rights to vote and to stand for election in the spheres of both politics and the church. The accumulation of returns led to remarkable wealth concentration in some lineages. Consequently, a "two-class society" developed, with big farmers who owned both the land and the capital on the one hand and a large mass of landless workers on the other. In most villages, a middle class was almost completely missing.

Traditionally, the youngest son inherited the landed property (ultimogeniture), although this habit became more flexible in the latter half of the nineteenth century. Noninheriting siblings had to receive financial compensation from the heir, and as a rule, brothers received twice the amount that their sisters did. This inheritance pattern 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 Voland 2008; Voland and Dunbar 1995).

Wealth measures. In this paper 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). 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 of no importance whether the land was owned or rented. Due to the social structure of the Krummhörn, the sample consists of many landless workers with zero 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."

Kipsigis

Ethnographic background. Kipsigis are agropastoralists who have lived in southwestern Kenya (now Rift Valley Province) for the last 500–600 years on the lower hills of the White Highlands. Although this part of Kenya developed economically very fast both during the midcolonial and early independence periods, lifestyles remain largely traditional, reflecting both Kenyan commitment to ethnic identity and an unusual and persistent tendency among Kipsigis to remain in their home area. Since the 1930s, land has been the primary source of wealth, critical for both subsistence and market production. Livestock wealth is of both economic and cultural significance; cattle and goats are used in marriage payments and for exchange networks, domestic dairy produce, and commercial sale.

Land and livestock are generally highly correlated and are important determinants of health, wealth, and fitness for both men and women (Borgerhoff Mulder 1987*a*, 1987*b*). Land and livestock are inherited by sons following a rule of equal division; daughters disperse at marriage with no property. Inheritance is a fluid process: young men in their late teens start cultivating a small patch of land on their father's plot and gain use rights to certain livestock. On their marriage, an allocation of livestock and of farming/grazing land is made; these capital assets are seen as still "owned" by the father but effectively used by the son. In making these allocations, fathers anticipate claims from sons who are still young (and even unborn).

Livestock are also the basis of important social network capital embodied in the traditional (and now disappearing) institution of *kimanangan* wherein 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.

Wealth measures. Land (in acres) and livestock (counts) are determined either by the Kenya Government Land Office or by field interviews. Reliability of acreage reports were very high as measured across two different surveys ($r = 0.93$). Cattle numbers, the principle source of livestock wealth, were recorded for all men in the sample in 1982–1983 and in 1991 (1991 data are used here). Reliability is estimated from the correlation between years (1983 and 1991) of $r = 0.75$ (taken from a larger sample), undoubtedly reflecting temporal changes in livestock holdings. For women, land and livestock measures are the allocations made to them by their husbands.

For some families data were available on the number of *kimanangan* (cattle-loaning) partners of fathers and sons, taken from interviews and informal conversations conducted at various times during this study; daughters do not have *kimanangan* partners—their measure is based on their husband's number of partners. These data were not systematically collected and did not exist for all male residents, but the information is not private and all cross-reports were consistent; therefore, data quality is thought to be relatively good.

Reproductive success is likely to be a good measure of embodied wealth given this high-fertility society with a moderate rate of infant mortality, and it is measured as number of children surviving 5 years. It is very high for some men due to polygyny. Due to the demographic focus of the original study (and great familiarity with the subjects due to a yearlong

time-allocation study), measures are likely to be highly reliable. For the younger generation, children under 5 years of age are common but are devalued by the probability of surviving to age 5 (.84 in the broader population; Borgerhoff Mulder 1998).

The sample includes all houses in three neighborhoods settled by Kipsigis in the first half of the twentieth century (Borgerhoff Mulder 1990). All households were visited and all reproductive-aged individuals were interviewed, either in 1983 or in both 1983 and 1991. For this study records are retained only for those who have reached 30 years of age, so as to focus on men and women who were well advanced in their reproductive and economic careers; some of the F_1 individuals were recently deceased, but their household wealth could be reconstructed.

Yomut

Ethnographic background. The Yomut are one of several large Turkmen descent groups that occupy a contiguous area in what is now the Islamic Republic of Turkmenistan (the former Turkmen Soviet Socialist Republic) and adjacent areas of Iran and Afghanistan. The Yomut of the Gorgan Plain in northern Iran divide themselves into two groups: the agriculturalist *Chomur* and the pastoralist *Charwa*, though this is a difference in emphasis and both groups practice agriculture and pastoralism. We discuss data from the agricultural *Chomur* here; data from the pastoral *Charwa* are discussed by Borgerhoff Mulder et al. (2010, in this issue). The *Chomur* practice a combination of subsistence production (primarily rainfall cultivation of wheat and barley) and production for market exchange (e.g., cotton). Most agricultural work is done by men; thus, households with large male labor pools are better able to enhance their wealth over time (Irons 1975), and investment is biased toward sons (Irons 2000). At the time of field research (1965–1974), the Yomut were a prosperous group by Iranian standards, and there was almost no migration out of the Gorgan Plain.

The Yomut are patrilineal as well as patrilocal and live in joint families consisting of parents, unmarried children, and married adult sons. Both land and livestock pass from father to son at the time of household division, which takes place either at the death of the father or when a son decides to leave the joint family because his own children are nearing the time of marriage. Most fathers try to give equal patrimonies to each son, but as conditions change this is not always possible. A son's patrimony is usually a subject of discussion among a father and all his sons for a period of time before the actual separation and granting of a patrimony occurs. After a son has received a patrimony, he does not inherit anything more at his father's death.

Wealth measures. The wealth measure used here is Yomut patrimony in land, probably the most important measure of material wealth in this society. Data comes from a 1973–1974 survey of 566 households in a random stratified sample of 21 communities including both *Chomur* and *Charwa*. The survey gathered data on household histories, wealth, and demographic history. Each household head was asked what he had received in land as a patrimony when he became independent and also what amount of land he had given as a patrimony to any of his sons who had separated from his household. The amount of land was converted into Iranian Tomans, which at the time were valued at 7 Tomans to $1.

Bengali

Ethnographic background. The Bengali ethnic group is located in northeast India (where most are Hindu) and Bangladesh (where most are Muslim); the study population is a Hindu group from the southern part of the Indian state of Assam. Bengalis are culturally and linguistically related to the dominant Hindu cultures of South Asia and follow the regional practices of patriliny, patrilocality, and the joint family. Marriages are arranged, and the woman joins her husband's household to be supervised by her mother-in-law. Dowries and bride-price rarely figure in these arranged marriages since the group is so poor. Most of the Bengalis in this sample are members of Scheduled Castes, low-status groups formerly called "untouchables."

Bengalis grow primarily rice in paddies that are plowed by hand. Men do most of the agricultural labor, control all property, and dominate selling and buying in the markets. Women do not go to the market nor work in the fields but apply themselves to tasks such as winnowing and kitchen gardening in addition to household work. Resources available to both groups are generally very low. Mean income from all sources for Bengali households in our study sample is \$979 $\pm$ \$1,071 per year, while median income is \$556. Labor migration does occur in this population but is much more common among sons than daughters. Women, however, do sometimes migrate out of the region through marriage.

Wealth measures. The Bengali data on reproductive success compare the fertility of mothers to the fertility of their sons (or in reality, son's wives, as men are monogamous and rarely marry more than once). The sample included all married reproductive-age women in the study villages; the age range was 16 to 50. Only members of scheduled castes were included, as members of higher castes may have begun to undergo a demographic transition. Current contraceptive use is only recorded for about 14% of women and shows no effect on fertility until age 40 and above, and a high fertility of 6.2 TFR (total fertility rate) is found for women in the sample (Leonetti, Nath, and Hemam 2007*a*). Data are also missing on a number of sons, many of whom have probably migrated, which may have a limited effect on the sample. Thus, the sample used is 382 of a total sample of 612. For RS we use children alive at age 5 years and those alive under age 5 years devalued by .95 (representing the risk of mortality during those ages). Measurement error is likely to be quite low as any child who survived to age 5 among the mother's offspring

or any currently living child among the son's offspring would have been reported. Given that the Bengali are a high-fertility population with a moderate rate of child mortality, RS is likely to be a good measure of embodied wealth in this society.

Khasi

Ethnographic background. The Khasi are a tribal people located in northeast India and Bangladesh; the study population comes from the eastern part of the state of Meghalaya in India. They are culturally and linguistically related to other Austro-Asiatic tribal groups from Southeast Asia, and follow the regional pattern of matriliny and matrilocality. Marriages are based on love attachments, and when a woman marries, her husband usually (but not always) joins her household. The couple often continues to reside with her mother until one or two children are born, and then they are expected to move into her own household in the same village, often in close proximity. The youngest daughter is expected to stay with her mother and inherit the house and spiritual headship of the lineage.

In the system of Khasi matriliny studied here, women have control of and direct access to resources. Khasi women own property and run the markets. They also work the fields, run businesses and work for wages, although many are housewives. Men usually provide agricultural labor and income, first to their mother's household and then to their wife's household. Khasi grow rice paddy in plowed fields but also cultivate vegetable gardens on the hillsides using hoes. Both genders share in field labor, with women dominating hillside gardening. While Khasi live on the fringe of India's fast-developing economy, wealth and market integration in this population are both low. Mean income from all sources in our study sample is \$726 $\pm$ \$495 per year while the median income is \$622 per year for Khasi households. Migration is not common among the Khasi as their tribal status makes it difficult for all but urban members to be comfortable in the larger Indian society. Women from villages also would find it more difficult than men to migrate.

Wealth measures. The Khasi data on reproductive success compare the fertility of mothers with the fertility of their daughters, who may have borne children by more than one husband (Leonetti et al. 2004). Daughter's ages range from 17 to 70 years. For RS, we count children alive at age 5 years and those alive under age 5 years devalued by .97 (representing the risk of mortality during those ages). Measurement error is thought to be quite low as any child who survived to age 5 among the mother's offspring or any currently living child among the daughter's offspring would most likely have been reported. Given that the Khasi are a high-fertility population with a moderate rate of child mortality, RS is likely to be a good measure of embodied wealth in this society.

Bengaluru

Ethnographic background. Bengaluru (formerly Bangalore) is a city of 5 million people 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. The people of this region share dominant social characteristics with other South Asians, most notably a patrilineal kinship system, the joint family, and arranged marriage with patrilocal residence. However, South Indians are less extremely patrilineal and patriarchal than are North Indians (e.g., Bengalis) and women often have more social and economic freedom. Among Hindu Indians, wealth is traditionally divided equally among sons at the death of the father, while daughters take their share of their parents' wealth via dowry at marriage.

In traditional South India, most people had hereditary occupations determined by caste and family membership, primarily including priests, merchants, farmers, artisans, and agricultural laborers. However, this system has been slowly breaking down for more than a century, and in modern urban India perhaps only one-quarter of people still follow hereditary occupations, while others have adopted skill-based wage-labor occupations. Traditional gender roles dictate that men do most of the market labor while women do most of the domestic labor. In modern India, men are still expected to have primary economic responsibility for their families. Though it is becoming more 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).

The data presented here were gathered in 2001–2002 as part of a survey of 400 adults aged 45–70 that collected detailed retrospective data on three generations of the respondents' families. The older generation in the sample includes the people surveyed, born from the early twentieth century through the 1940s. The younger generation in the sample contains their children, born from the 1930s through 1970; the sample was restricted to those born before 1973 to avoid the effects of rapid economic growth that began with Indian market liberalization in the 1990s. These data capture a period in which South India's economy was slowly moving from a subsistence agricultural base with a limited cash economy in the early twentieth century to an agricultural and commercial economy with increasing emphasis on wage labor in the mid–late twentieth century. Much of the earlier generation comes from rural areas while the more recent generation is split between urban and rural areas.

Wealth measures. Both traditional and modern Indians place heavy reliance on family relationships as a means of maintaining social and economic stability and achieving status. A key way in which families bolster their positions is to arrange marriages with families having desirable characteristics. 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 2005). The wealth variable used in this article, *in-law networks*, reflects the number of a spouse's close relatives including parents, siblings, and siblings' spouses (the data are retrospective, so all are adults) weighted by their wealth compared to that of the focal parent or child. The analysis compares the degree of similarity between the number of people in the in-law networks of a parent and those of his/her child. Although such in-law networks are of course not directly heritable, they are heavily influenced by characteristics of both the family and individual. Though Bengaluru is undergoing economic development, social networks created through marriage are 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.

Results and Population-Specific Discussion

Analytical Measures

Each researcher who contributed data to this project was asked to give his or her judgment for the variable α for their population. Alpha (α) denotes the relative importance of embodied, material, or relational wealth and is defined as the percentage change in a family's well-being associated with a percentage change in a particular wealth category, holding other wealth categories constant (see the introduction to this special section [Bowles, Smith, and Borgerhoff Mulder 2010]). The α estimates for the eight agricultural populations discussed above can be found in table 2. Researchers nearly universally rated material wealth as the most important wealth class in agricultural societies, with some estimates of α reaching very high levels (e.g., 0.7 or 0.8 out of 1) and the average α being 0.59. Estimates of the relative importance of embodied wealth were more moderate, with the average α being 0.27. Finally, the estimated α for relational wealth was on average just 0.14. The α judgments given by researchers are very close to several independent estimates of α for agricultural societies including the agropastoralist Nyaturu of Tanzania and eight grain- and four rice-producing areas in India. These estimates and methods of estimation are discussed in the concluding essay in this special section (Smith et al. 2010, in this issue; see also CA+ online supplement "Estimating the Inheritance of Wealth in Premodern Societies" in the online edition of *Current Anthropology*; Borgerhoff Mulder et al. 2009).

The primary quantitative measure discussed in this paper is β, the estimated percent difference in child's wealth associated with a 1% difference in parent's wealth. The β value is unit free, allowing us to compare across numerous types of wealth from different social settings. In table 3 we present β coefficients for 12 wealth types divided between the three classes of wealth (material, relational, and embodied). Our results give evidence of high levels of intergenerational transmission for material wealth, and variable (low to moderate) levels of transmission for embodied wealth and relational wealth.

Table 2. Judgments of α (wealth importance) exponents for eight agricultural societies in the project sample (see text for further explanation)

	Type of wealth		
Population	Embodied	Relational	Material
Bengali	.30	.20	.50
Bengaluru	.30	.30	.40
East Anglians	.50	.00	.50
Khasi	.40	.25	.35
Kipsigis	.20	.10	.70
Krummhörn	.15	.10	.75
Skellefteå	.10	.10	.80
Yomut (Chomur)	.20	.10	.70
Mean (SD)	.27 (.134)	.14 (.098)	.59 (.171)

In order to discuss whether the transmission of wealth is related to inequality, we have also estimated a Gini coefficient for each wealth type and calculated an average Gini coefficient for each wealth class (see table 3). The Gini coefficient is a measure of inequality ranging from 0 (equal wealth) to approximately 1 (all wealth held by a single household) and is commonly used to compare levels of inequality across societies (e.g., Milanovic, Lindert, and Williamson 2007).

Material Wealth

We have five measures of material wealth in our sample: three of land, one of cattle, and one of estate value. The β's for these variables are quite high, ranging from 0.36 to 0.64, as well as highly significant, indicating a high degree and consistency of transmission of material wealth between generations. High transmission of wealth is associated with and has the potential to generate high levels of inequality, as indicated by Gini coefficients ranging from 0.45 to 0.71. High β's also have the potential to perpetuate inequality over time; our estimates imply that a child born into the top material wealth decile in an agricultural society is much more likely to end up in the top decile as an adult than is a child born into the bottom decile (see further discussion below). These patterns are likely to lead to the persistence of wealth within families and the perpetuation of a hierarchical social structure over time. Figure 1 gives a graphical comparison of the material wealth data for four societies in our sample.

Estate value among East Anglians. The β for estate value among East Anglians, 0.642, is quite high and statistically significant. The Gini coefficient is 0.608. This is despite the fact that the estate-value data are likely to be biased downward due to (*a*) the greater likelihood of wealthy individuals entering the sample (reducing variance in the sample as com-

Table 3. Transmission coefficients (β) for different wealth types in eight agricultural societies

Wealth class, population, wealth type (*N* pairs)	β (SE)	*P* value[a]	Gini (SE)
Material wealth:			
East Anglians:			
Estate value (land; 210)	.642 (.073)	.000	.608 (.022)
Kipsigis:			
Land (270)	.357 (.041)	.000	.482 (.036)
Livestock (270)	.635 (.098)	.000	.450 (.019)
Krummhörn:			
Land (1,602)	.610 (.043)	.000	.708 (.008)
Yomut (Chomur):			
Patrimony (land; 58)	.528 (.147)	.000	.615 (.028)
Material wealth averages	.55 (.07)	.00	.57 (.05)
Embodied wealth:			
Bengali:			
Reproductive success (382)	−.074 (.057)	.191	.228 (.006)
East Anglians:			
Reproductive success (200)	.171 (.150)	.255	.415 (.016)
Khasi:			
Reproductive success (650)	.165 (.045)	.000	.198 (.004)
Kipsigis:			
Reproductive success (270)	.213 (.106)	.044	.301 (.015)
Skellefteå:			
Reproductive success (2,515)	.010 (.028)	.714	.251 (.002)
Embodied wealth averages	.10 (.07)	.16	.28 (.05)
Relational wealth:			
Bengaluru:			
In-law networks (249)	.114 (.073)	.117	.468 (.189)
Kipsigis:			
Cattle partners (102)	.041 (.139)	.767	.446 (.021)
Relational wealth averages	.08 (.11)	.47	.46 (.08)
Overall averages (all wealth)[b]	.36 (.05)	.00	.48 (.04)

[a] *P* values are calculated from two-tailed tests of the hypothesis that true β for a given row equals 0.
[b] Overall average weights the wealth class averages by the mean values of α from table 2.

pared to the real population) and (*b*) errors in measuring wealth expected when deriving data from the texts of wills. Nonetheless, these results are in keeping with expectations for the heritability of wealth in a large, complex state society with large wealth differentials and several distinct social classes, especially as estate value estimates include the key variable of land (usually the most valuable item in a will and the most significant correlate of wealth). Please see figure 1*A* for a graphical comparison of parent-offspring estate value among East Anglians.

Land in the Krummhörn. The estimated heritability of land in the Krummhörn area of Germany is 0.610 and the Gini is 0.708, estimates well in keeping with other figures for heritable wealth in complex agricultural societies and with the very stable socioecological and demographic situation that obtained in the Krummhörn during the study period. Land was the single most important source of wealth, and there was low social mobility, even lower for men than for women. While there was a certain downward mobility (due to overreproduction of the wealthy group of farmers), there was hardly any upward mobility. For instance, the correlation between a father's wealth and a child's wealth is slightly higher for sons than daughters since some daughters might marry down, while sons did not marry without sufficient wealth. See figure 1*B* for a comparison of parent-offspring landownership in the Krummhörn.

Yomut patrimony in land. The β coefficient for patrimony in land is 0.528 (Gini = 0.615), a high and statistically significant value that is consistent with other estimates for the transmission of material wealth among agriculturalists. However, the value is a bit lower than that for East Anglians and the Krummhörn, perhaps because Yomut families are larger and land is inherited relatively equally by all sons rather than through a preference for primogeniture. See figure 1*C* for a comparison of father and son land value among the Yomut.

Kipsigis land and livestock. The β coefficients for father-offspring pairings, both for land (0.357, Gini = 0.482) and for livestock (0.635, Gini = 0.450), are high, reflecting the fact that Kipsigis who settled in Abosi faced a largely unsaturated habitat and settled very large initial plots (Borgerhoff Mulder 1990). Men with many wives, or with the livestock to acquire many wives, tended to claim and protect large plots, and these were inherited by their sons. Since there can be an economy of scale to both the herding and the protection of

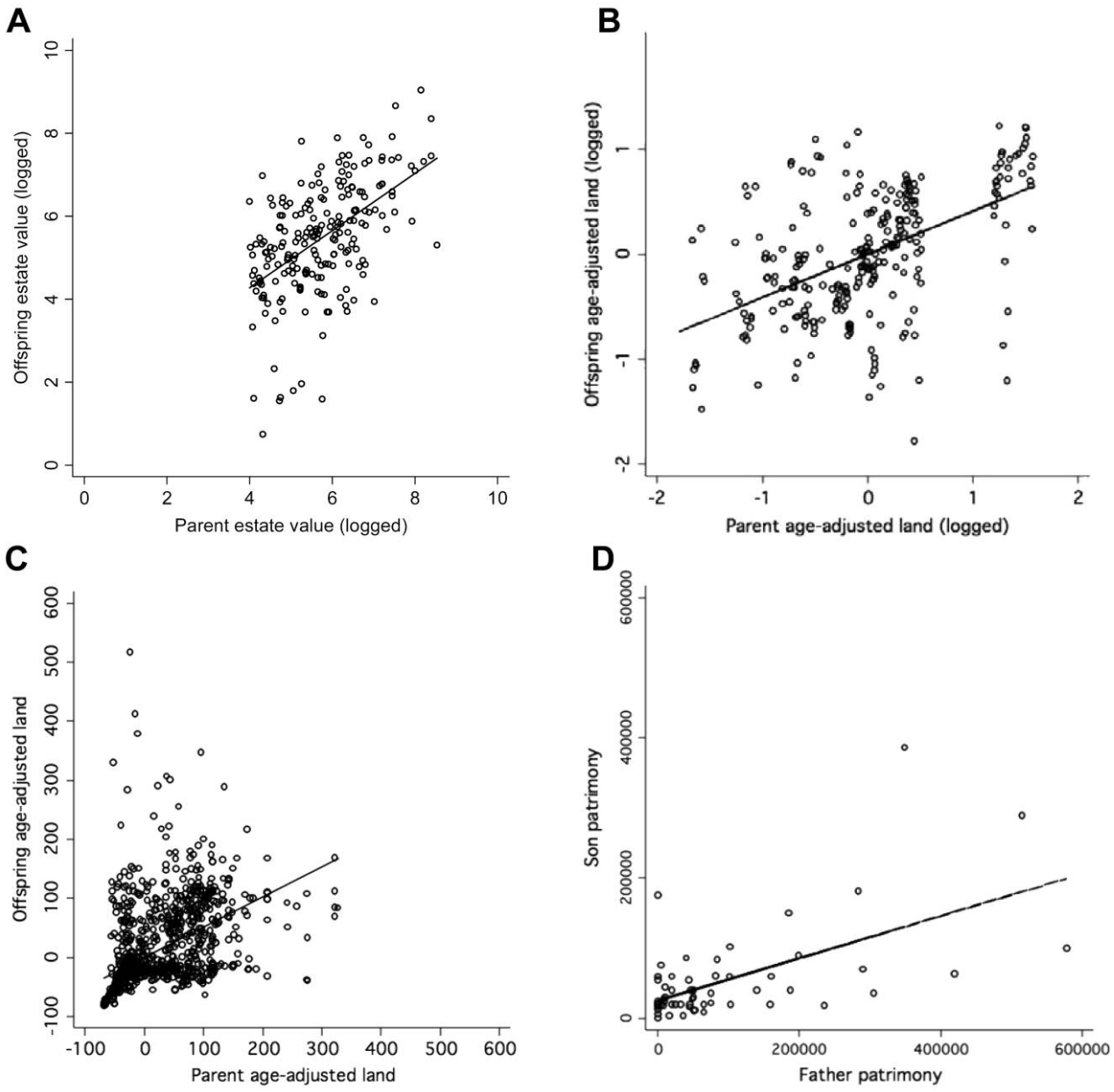

Figure 1. Comparison of parent-offspring material wealth in four societies: *A*, estate value among East Anglians, $\beta = 0.642$; *B*, parent-offspring landownership among Kipsigis, $\beta = 0.357$; *C*, parent-offspring landownership in the Krummhörn, $\beta = 0.610$; and *D*, father-son patrimony in land among the Yomut, $\beta = 0.528$. (The line through the points in each panel depicts the underlying linear regression on which the β estimates are based.)

livestock (see Borgerhoff Mulder et al. 2010), those with initially larger herds will be favored, generating high β's in unsaturated habitats. The high β's also reflect the great economic expansion in the mid-to-late colonial and early independence periods, with some Kipsigis working on adjacent European farms and investing their wages in livestock. Polygyny appears not to have diluted the parent offspring correlations. Even though wealthy men attract more wives than poorer men, women's marriages did not entirely follow an ideal free distribution (Borgerhoff Mulder 1990); in other words, wealthy men in this sample still tended to have sons who were wealthy, despite their polygyny (see Borgerhoff Mulder et al. 2010).

See figure 1*D* for a comparison of parent-offspring landownership among the Kipsigis.

Embodied Wealth

Our five measures of embodied wealth are all estimates for reproductive success, the number of surviving children left by the parent(s) as compared to the child. Two of our measures of β are close to 0, while the other three show a moderate degree of heritability (0.165–0.213), two of which are statistically significant. These findings suggest that (*a*) there can be a moderate degree of transmission with regard to RS in agricultural societies but also that (*b*) there is likely to be variability among agricultural societies on this measure. The Gini coefficients range from 0.20 to 0.42, indicating moderately high levels of inequality with regard to RS in the societies being studied.

Reproductive success among East Anglians. The estimated heritability of reproductive success among historical East Anglians is 0.171, though it is not significantly different from 0. Mortality patterns in sixteenth- to eighteenth-century England varied consistently by social class, which is likely to be a primary factor in producing the observed positive association. Error introduced by obtaining data on RS from wills and because people with more children are more likely to enter the sample is likely to bias the estimate downward, suggesting that it is possible that the actual value is higher or is significant. The Gini coefficient of 0.38, however, suggests that there is considerable variability in the existing sample.

Skellefteå reproductive success. The estimated β for reproductive success among nineteenth-century Swedish agriculturalists is 0.010, a very low figure signifying essentially no inheritance of this trait, though the Gini of 0.251 shows considerable inequality in RS in the population. Sample size cannot account for the low β since $N = 2{,}515$, a very high number for this study. This was in a period, however, when only half of all Swedes, like other northern Europeans, married overall (Low, Clarke, and Lockridge 1991). Since arable land was saturated, many people did not have the means of obtaining or supporting a spouse. Unmarried siblings might migrate or stay in their natal households and help their married sibling(s) with production and reproduction. The older generation in the sample is all fathers (who by definition married and had children), while all of their children, many of whom did not marry and thus had no recorded offspring, remain in the sample. Furthermore, while there is evidence that landholders have marginally more children and that sons of landholders are more likely to be landholders themselves, as well as more likely to marry, these associations fail to produce a consistent reproductive advantage to the offspring of parents with high RS (Low 1991; Low and Clarke 1990). This may in part reflect the movement away from agriculture during this period—entrepreneurial men who obtained land through routes other than inheritance had more children than the sons of landowners who inherited land.

Kipsigis reproductive success. At 0.213, the β coefficient for reproductive success is moderate and in keeping with the results from some other agricultural societies. The Gini coefficient of 0.301 also reflects a moderate amount of inequality in RS. Given polygyny as well as the high intergenerational correlations for land and stock between fathers and sons, this lower value is somewhat surprising and may in part reflect sample bias—specifically, the relatively young age of the children in this sample, insofar as wealth in this population primarily affects RS through polygyny and length of reproductive life span (Borgerhoff Mulder 1988). The β for RS, however, is significant only for sons and not for daughters, suggesting (again) that the intergenerational correlation of RS is driven largely by wealth and polygyny.

Bengali reproductive success. The β coefficient, -0.088, is low and not significantly different from 0. The Gini coefficient shows a moderate level of inequality in RS at 0.228. The Bengali sample is all from the scheduled castes (former untouchables) who are not only very poor but whose lives are circumscribed by social restrictions on access to economic opportunities and social resources. They are often malnourished (Leonetti et al. 2005), and their reproductive health is also poor. The low β may indicate that the data reflect demographic transition even though family planning use is very limited. It may also be due to delays in marriages in the past quarter-century as socioeconomic conditions in India have altered people's lives with costs they did not formerly face, such as longer times in school for their children. Such constraints are especially high for people with high RS since they must face the costs of marrying and educating more children (Leonetti and Nath 2009).

Khasi reproductive success. The β coefficient is 0.165 ($P = .000$), indicating moderate transmission of fertility levels between mothers and daughters among the Khasi. The Gini coefficient of 0.198 shows moderate inequality. The Khasi are a high-fertility matrilineal population (TFR of 6.7 children for women in the sample) where help from the mother's kin supports reproduction. On the other hand, because women usually have several sisters (over half have three or more), more variance in reproductive success may occur due to competition among daughters for mother's resources or help with children (Leonetti, Nath, and Hemam 2007*b*) resulting in an uneven distribution of fertility among sisters. Also, divorce rates are high (24% of women in the sample have been divorced), which may produce differences in resources and help from husbands leading to differences in RS (Leonetti et al. 2004; Leonetti, Nath, and Hemam 2007*b*). In other words, strong upward pressure from cooperation among matrilineal kin (such that big kindreds produce big kindreds in the next generation) is countered by downward pressure resulting from variance among kin and from competition over resources among kin resulting in a moderate value.

Relational Wealth

Finally, we have two measures of relational wealth, one of which (cattle partners) shows little heritability while the other (size of in-law network) shows a modest degree of transmission between parents and children. Since in-laws cannot be added or shed at will, while cattle partnerships are mutually voluntary, this difference is consistent with structural differences in the types of networks analyzed. Both measures of relational wealth show similarly high levels of inequality, however, suggesting that the difference is in the transmission processes rather than in the form of relational wealth.

Kipsigis cattle partners. The β coefficient for cattle-loaning partners is effectively 0, while the Gini coefficient 0.446 shows moderately high levels of inequality. Among Kipsigis there is no direct transmission of cattle-loaning partners—they tend to be selected from among age mates. Wealthier cattle owners tend to have more partners than owners of few cattle ($r = 0.55$, $n = 156$, $P < .001$), and therefore, to the extent that sons of wealthy fathers are wealthy themselves (see above), we would expect men with large networks to have children who have large networks. The fact that this is not the case suggests that personal factors other than wealth play an important part in obtaining partners (particularly among sons where the correlation between wealth and number of partners is lower [$r = 0.32$, $n = 102$, $P < .001$] than it is among the fathers).

Bengaluru in-law networks. A Gini coefficient of 0.468 shows a relatively high degree of inequality for in-law networks in twentieth-century Bengaluru, while a β coefficient of 0.114 ($P = .117$) suggests that network size is only modestly transmitted. These results suggest that those with larger, wealthier social networks are somewhat more effective at achieving large and wealthy social networks for their children but that there are probably other variables at play that limit the importance of this effect. For instance, family and network characteristics may be only one feature of interest in a potential spouse since much emphasis is also placed on individual characteristics (e.g., Shenk 2004, 2005).

General Discussion and Conclusions

The high transmission coefficients of material wealth (mean $\beta = 0.55$, highly significant; shown in table 3) stand in sharp contrast to the much lower coefficients of embodied wealth (mean $\beta = 0.10$, not significant) and relational wealth (mean $\beta = 0.08$, not significant). These estimates indicate that a person born into the top decile with regard to material wealth is more than 80 times more likely to end up in the top decile than is someone born in the bottom decile; the corresponding numbers for embodied wealth and relational wealth are only about 1.9 and 1.7 times more likely, respectively (see Bowles, Smith, and Borgerhoff Mulder 2010; CA+ online supplement). The average Gini coefficient for material wealth shows high levels of inequality (0.57), embodied wealth shows moderate levels of inequality (0.28), and relational wealth shows an intermediate level of inequality 0.46). These patterns suggest that in agricultural societies, highly transmitted forms of wealth may also be more unequally distributed, as is the case for material wealth, but also that relatively high levels of inequality may exist in the absence of high levels of transmission, as appears to be the case for relational wealth.

Strong transmission of material wealth is consistent across the agricultural societies in our sample, even though they are quite distinct in terms of their regions, sizes, and social traits. In fact, most of our agricultural sample excludes urban populations in large state societies that are likely to show the highest levels of inequality, and thus, our analyses may consequently underestimate the degrees of both inequality and transmission of inequality in preindustrial societies. Our findings suggest that an emphasis on heritable forms of material wealth is highly characteristic of agricultural societies and may be an essential part of and motivation for the social features common to intensive agricultural societies (as discussed in the introduction to this paper). The results for embodied capital and relational wealth, on the other hand, are much lower and more inconsistent, suggesting that while they may be moderately important in some cultures they are not as necessary a part of the social complex associated with intensive agriculture.

Why, given what we know about agricultural populations as reviewed above, should material wealth show such a distinctive pattern? We suggest that material wealth is inherently easier to transmit between generations, more subject to customary and legal control of transmission, and, especially in the case of land, central to both the subsistence needs and levels of inequality of the cultures under study. Our data suggest that heritable wealth, and especially wealth in land, may be the key factor in the high and persistent levels of inequality seen in societies practicing intensive agriculture.

It is sometimes argued that intensive agriculture enables social complexity by creating food surpluses that allow for greater concentration of population as well as the freeing of people from subsistence work to pursue other tasks. These changes are thought to both allow for and necessitate an increase in political complexity and hierarchy (e.g., Carneiro 1970, Johnson and Earle 2000; Service 1975); however, the direction of causation is the subject of much debate (Pearson 1957). For example, Boserup (1965) argues that the amount of work involved in intensive agriculture would not be undertaken if it were not made necessary by a large population, while others have argued that geographical circumscription (Carneiro 1970) and/or social inequality (Price 1995; Wolf 1966) are probably necessary to motivate people to do the additional work required.

As discussed above, land limitation is a key feature of intensive agricultural societies. In fact, the rise of intensive agriculture implies a shift from labor limitation (meaning that not all arable land is in use) among horticulturalists to land limitation (implying that all or most arable land is in use) among intensive agriculturalists (e.g., Goody 1976; Harrell

1997; Johnson and Earle 2000). Regardless of the mechanism of causation, when population densities increase to the point where most easily cultivable land is in use, intensive methods of agriculture become both necessary and cost effective (Boserup 1965; Johnson and Earle 2000). When most or all cultivable land is occupied, use rights are likely to be codified through land tenure systems including either direct ownership, or various forms of landlordship with rights to collect rents, either of which can be amenable to rules of inheritance favoring kin (Boserup 1965). Once use rights or ownership of land is codified, land itself becomes a form of heritable wealth, creating the potential for the levels of persistent inequality shown in this paper.

Milanovic, Lindert, and Williamson (2007) examine levels of income inequality in ancient societies based on data gleaned from tax censes, dwelling rents, and other fiscal documents. The authors combine data on 14 ancient and preindustrial state societies, 12 from Eurasia and two Spanish colonies in the Americas, all of which would be classified as intensive agriculturalists under our criteria. The authors report Gini indices on a scale of 0 to 100 (instead of 0 to 1 but interpreted in the same way) ranging from 23.9 for China in 1880 to 63.5 for Nueva España (Spain's colony in Mexico and the surrounding area) in 1790, with the average being 44.1. The levels of inequality reported are very similar to those found in our analyses for material wealth, and in fact the authors show that the inequality patterns seen in their historical samples are quite similar to patterns in modern preindustrial nations from which most of our nonhistorical data sets come.

As discussed above, agricultural populations also show a significant elaboration of rules of inheritance, legitimacy, property transfer, and succession to office, which have been discussed by many authors (e.g., Baker and Miceli 2005; Boserup 1965, 1970; Engels 1942 [1884]; Gaulin and Boster 1990; Goody 1976, 1990; Harrell 1997; Pagel and Meade 2005). Most notably, these include rules that limit inheritance to only one or a category of heirs as well as rules establishing legitimacy of heirship, an important mechanism to reduce the number of heirs likely to inherit. In fact, research on large premodern state societies such as ancient Rome, Soong China, and Tokugawa Japan suggests that early demographic transitions may have been effected by infanticide and the abandonment of children (e.g., Caldwell and Caldwell 2005; Saller 1994). Such practices are thought to have been more frequent among the aristocracy and landed gentry whose power was partly based on wealth, very often wealth in land, and who were therefore motivated to restrict the number of their heirs.

Perhaps perversely, the strong emphasis on material wealth in agricultural societies can also produce a greater disassociation between the RS of parents and children, especially if inheritance rules related to material wealth have strong effects on which children marry and at what ages. For example, many parts of northern and western Europe have had low marriage rates in the last several centuries (Caldwell et al. 2006; Dixon 1978; Guinnane 1997). This phenomenon is usually interpreted as a result of land saturation and restrictive inheritance rules, especially the preferential inheritance of land by oldest sons and the preferential transfer of dowries to oldest daughters (e.g., Boone 1986; Goody 1976).

These considerations may be important in explaining why our β estimates for RS are moderately low and why some of them show no relationship at all. Our higher estimates (0.165–0.213) are consistent with data showing correlations in effective family size of 0.29 between parents and sons and 0.18 between parents and daughters among Hutterites (Pluzhnikov et al. 2007) when social constraints are limited, while our very low estimates appear to be related to high levels of social constraints (such as high rates of nonmarriage) that are likely to have affected some agricultural societies in the preindustrial past. However, it has also been found that RS is more highly heritable after the demographic transition than before it (Bittles, Murphy, and Reher 2008; Reher, Ortega, and Sanz-Gimeno 2008), so by excluding data on RS from societies showing evidence of a demographic transition, we may have limited our sample to societies with lower transmission of RS, thus biasing our averages downward.

Our research has two final implications. First, anthropologists have long used Service's (1962) categorization of societies into bands, tribes, chiefdoms, and states as a practical way of discussing cultural differences in hierarchy and inequality. The empirical basis for these categories, however, was limited to detailed ethnographic observation and involved only limited quantitative evidence (see Johnson and Earle 2000 for a recent and more ethnographically detailed treatment). Our study tests some of Service's key assertions using detailed quantitative data, and our results support some of his generalizations. Most importantly, we find very clear evidence that societies practicing intensive agriculture have high levels of inequality based primarily on forms of material wealth that are easily transmitted between generations and that present a clear basis for the formation and perpetuation of high degrees of social stratification.

Our findings further imply that heritable wealth—and especially wealth in land—may be a more fundamental indicator of social inequality in preindustrial societies than the rise of cities or the formation of early states. Indeed, it may be that the combination of intensive agricultural technologies with heritable wealth is a precondition that allows the elaboration of characteristics such as social complexity, monumental architecture, and urbanization that defines ancient and modern state societies. While high population densities and circumscription certainly can be associated with the rise of inequality, it may be their relationship to land limitation that is key to the high and persistent levels of inequality in material wealth that we see in agricultural societies in both the past and the present.

There are clearly limitations in what can be inferred about the past, and especially the ancient past, from this type of data. We cannot reconstruct the process of change, nor can we be certain how representative the data we use may be of

other agrarian societies. We hope, however, that by including multiple measures from a broad range of historical as well as modern populations, we have been able to obtain reasonable estimates of the transmission of different forms of wealth among intensive agriculturalists. The consistency of our results between societies in our sample, as well as with estimates of α, β, and Gini coefficients from other agrarian societies from different places and time periods, suggests that our findings may very well reflect important patterns in agrarian societies in both the present and the past.

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Intergenerational Wealth Transmission and Inequality in Premodern Societies

Production Systems, Inheritance, and Inequality in Premodern Societies

Conclusions

by Eric Alden Smith, Monique Borgerhoff Mulder, Samuel Bowles, Michael Gurven, Tom Hertz, and Mary K. Shenk

CA+ Online-Only Supplement: Estimating the Inheritance of Wealth in Premodern Societies

Premodern human societies differ greatly in socioeconomic inequality. Despite much useful theorizing on the causes of these differences, individual-level quantitative data on wealth inequality is lacking. The papers in this special section provide the first comparable estimates of intergenerational wealth transmission and inequality in premodern societies, with data on more than 40 measures of embodied, material, and relational wealth from 21 premodern societies representing four production systems (hunter-gatherers, horticulturalists, pastoralists, and agriculturalists). Key findings include (1) the importance of material, embodied, and relational wealth differs significantly across production systems, with material wealth more important in pastoral and agricultural systems; (2) the degree of wealth transmission from parent to offspring is markedly higher for material wealth than embodied and relational wealth; (3) aggregate wealth is transmitted to a higher degree among pastoralists and agriculturalists; (4) the degree of inequality is greater for material wealth; and (5) the degree of intergenerational transmission of wealth is correlated with wealth inequality. Surprisingly, horticulturalists exhibit no greater wealth inequality or intergenerational wealth transmission than do hunter-gatherers, while pastoralists are very similar to agriculturalists. We discuss how these trends may have favored the emergence of institutionalized inequality, as intensified forms of production made material wealth transmission increasingly important.

The papers in this special section apply a uniform analytical approach to a diverse set of premodern societies, production systems, and wealth measures. The theoretical framework and methods are presented in the introductory paper, and the four empirical papers present and discuss the results for each of the production systems. Here we summarize the key findings and emergent patterns, assess what we have learned from this attempt to apply formal theory and consistent quantitative methods to understanding wealth transmission and inequality in premodern societies, and discuss possible avenues for further research.

These essays, and our project in general, offer three main contributions to comparative social science. First, we provide

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data on a large number of societies, measuring many kinds of wealth in a consistent and rigorous fashion. Earlier comparative studies (e.g., Jorgensen 1980; Murdock 1981; Pryor 2005) have relied on qualitative ethnographic assessments of wealth variables at the societal level. Wealth transmission and inequality are typically indicated for a particular society using an ordinal scale, based on the ethnographer's impression rather than on actual measurements. Individual ethnographic studies of premodern wealth transmission (and comparable studies by historians and archaeologists) sometimes present quantitative data, but these are rarely comparable across societies. Recent studies by economic historians have provided valuable quantitative measures of inequality (if not intergenerational transmission of wealth) for many ancient state-organized agricultural and commercial societies (Milanovic, Lindert, and Williamson 2007) but not for the small-scale populations that we study here. By contrast, in this project we have employed a uniform set of methods to analyze quantitative individual-level data on multiple forms of wealth in a wide range of premodern production systems.

Second, this project systematically broadens the definition of wealth in ways appropriate to premodern, nonmonetized economies. As detailed in the preceding papers in this forum, we consider not only standard forms of material wealth such as land, livestock, and household goods but also various forms of embodied wealth (weight, strength, knowledge and skills, and reproductive success) as well as relational wealth (number of network links in various domains, such as exchange, alliance, and cooperative labor). This broader set of wealth measures should enhance our ability to develop an improved understanding of wealth transmission and inequality in premodern societies.

Third, we empirically document and analyze systematic links between production systems, intergenerational transmission of specific types of wealth, and varying degrees of inequality. It is to these linkages that we now turn.

Wealth Transmission

Wealth Classes

The introductory paper in this section (Bowles, Smith, and Borgerhoff Mulder 2010, in this issue) discusses our expectations concerning patterns of intergenerational wealth transmission. For reasons outlined there, we expect the degree of intergenerational transmission to differ markedly among our three wealth classes, with material wealth being more readily transmitted than embodied and relational wealth. Examination of the transmission coefficients (β's) for the three wealth classes, averaged across all production systems, reveals that this is the case: the average β for material wealth (0.37) is three times as great as that for embodied wealth ($\beta = 0.12$) and nearly twice as great as that for relational wealth ($\beta = 0.19$); these differences are both statistically significant ($P < .05$).

Embodied wealth. The 23 estimates of the intergenerational transmission of embodied wealth average 0.12 but range widely (as detailed in the paper on each production system). The highest estimates are for body weight (average $\beta = 0.37$). Most of these estimates come from hunter-gatherer populations; given the widespread food sharing found in many of these populations, access to food is unlikely to account for much of the parent-offspring weight relationship, and genetic variation may play a role (see Smith et al. 2010, in this issue). In contrast, reproductive success (number of offspring surviving to age 5) generally has very low transmission coefficients; β is effectively 0 in three societies, has a maximum value of 0.21 (among Kipsigis, a highly polygynous society where landholdings strongly determine number of wives [Borgerhoff Mulder 1990]), and averages 0.09, similar to low correlations between parental and offspring fertility found in many predemographic transition populations (Murphy 2007). Our measure of reproductive success is, of course, also a measure of fitness, which is not expected to be highly heritable at or near evolutionary equilibrium (Fisher 1958), although certain populations show considerable additive genetic variance in key life-history traits such as fecundity (Pettay et al. 2005). In most cases, knowledge and skill, such as agricultural production among the Pimbwe, proficiency in subsistence tasks and cultural knowledge in the Tsimane, and foraging success among the Ache and Hadza, are only weakly transmitted from parents to offspring; the exception to this is hunting success among the Tsimane ($\beta = 0.38$).

Relational wealth. We have six estimates of relational wealth transmission. To the extent that these are representative, they indicate that intergenerational transmission for this wealth class is moderate, with β averaging 0.19 and ranging widely (0.04–0.34). We suspect that the transmission of relational wealth will depend entirely on the type of network involved. In societies with a high degree of status differentiation, including most with intensive agriculture, the options for improving one's network beyond that of one's parents would seem to be quite limited, whereas in a more "open" social field, an enterprising individual might generate a large network of allies unhampered by the limitations of one's parents in this respect. However, our sample of relational wealth measures is too small and varied to evaluate this argument.

Material wealth. The average β is 0.37 for 14 measures of material wealth, including agricultural and horticultural land, livestock, shares in sea mammal–hunting boats, and household goods. For agricultural land, the degree of transmission is substantial, averaging 0.53 across four populations. Livestock are also highly transmitted across generations in our four pastoral populations, with β's averaging 0.67. These estimates for material wealth transmission in premodern societies equal or exceed the intergenerational transmission of most forms of wealth in industrialized market economies (Charles and Hurst 2003). High transmission levels would

appear to reflect the greater degree to which access to material wealth can be controlled, interacting with cultural norms regarding property rights and inheritance, as discussed in our concluding section. Variability in transmission levels across types of material wealth is likely due to at least two factors. First, wealth types that are subject to economies of scale are likely to show higher β's than wealth types that do not produce increasing returns to investment (Borgerhoff Mulder et al. 2009). Thus we find that some of our highest β's are for livestock wealth, and in a population where both livestock and land are measured (Kipsigis), the β for livestock is almost double that for land. Second, if material wealth is associated with higher fertility (and thus more heirs), wealth will become diluted across generations (resulting in lower estimates of β).

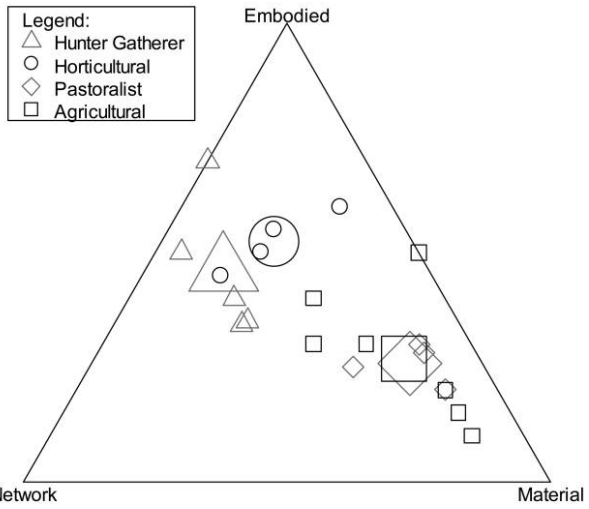

Figure 1. Relative importance of wealth classes (α) for individual populations, averaged for production systems. See text for explanation. The coordinates of each point in this ternary plot sum to 1; thus, the importance of material wealth for any population in the sample is given by the distance from the edge opposite the *Material* vertex, and so on. The larger symbols indicate the averages of each production system. A color version of this figure is available in the electronic edition.

Comparison of Production Systems

Although wealth classes differ in the constraints and opportunities they present for intergenerational transmission, we also expect that the relative importance of these wealth classes will vary across production systems. Ethnographic evidence (some of it summarized in the preceding papers) suggests that hunter-gatherers and horticulturalists depend heavily on strength, knowledge, and social networks to be successful, while making little use of material resources that are not widely available. By contrast, the well-being of a herder or farmer depends heavily on the amount of stock or land under his or her command, and these forms of wealth are scarce (relative to demand), making material wealth a more important influence on livelihoods in these production systems.

We drew on the judgments of ethnographers participating in this project to quantify the importance of each wealth class in each population in the sample, a parameter we label α. This parameter indicates the expected percentage difference in household well-being associated with a 1% difference in amount of a given wealth class, holding other wealth classes constant at the average for that population and requiring these percentage effects to sum to 100%. The values of α—the relative importance of the three wealth classes (embodied, material, and relational)—for each of the 21 societies studied in this project, as well as averages for each production system, are shown in figure 1. They suggest that embodied and relational wealth are relatively important for foragers and horticulturalists, while material wealth is key in pastoral and agricultural populations.

These independently derived judgments are remarkably similar within production systems (see preceding papers for details). They are also consistent with broader ethnographic accounts of how different production systems function (e.g., Johnson and Earle 2000). Subjective judgments of α are, of course, only an interim solution but certainly far preferable to ignoring differences in the relative importance of wealth classes between populations and production systems. In addition, published data from eight agricultural populations in Africa and South Asia allowed a statistical estimate of the relative importance of material capital (a component of α) for agriculturalists. The average estimate of this parameter is 0.56, not significantly different from the average of the ethnographers' estimates for the eight agricultural populations in our project (0.59). And since the sum of α components from the three wealth classes must equal 1, this high value for material wealth importance implies modest values for relational and embodied wealth importance, consistent with our estimates as well.

We use the production system and wealth class α values to calculate weighted average transmission coefficient (β) values for the populations in each production system, as shown in the rightmost entry in each panel of figure 2. These calculations produce markedly different estimates for the four production systems. Specifically, intergenerational transmission of wealth is modest in both hunter-gatherer and horticultural systems (α-weighted average β's of 0.19 and 0.18, respectively) but quite substantial in agricultural (0.36) and pastoral systems (0.43). Indeed, when we compare the β for hunter-gatherers and horticulturalists averaged together with the joint average for agropastoralists, we find a large (0.21) and statistically significant ($P < .001$) difference.

Thus, a key empirical finding of this project is that horticulturalists and hunter-gatherers are quite similar in their patterns of wealth transmission: both transmit wealth at relatively low rates and emphasize embodied and relational wealth over material wealth. In contrast, pastoralists and intensive agriculturalists rely heavily on land, livestock, technology, and other forms of material wealth and transmit this at high rates. Although these findings are consistent with the

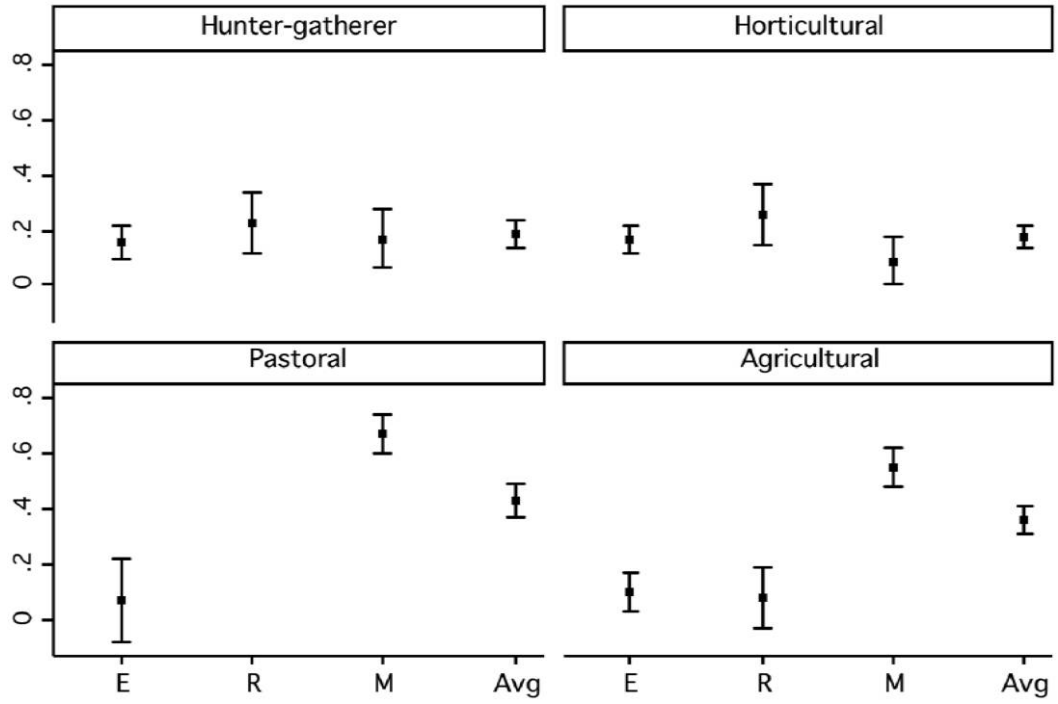

Figure 2. Estimated intergenerational wealth transmission (β) by production system and wealth class, including the importance of the (α)-weighted average for each system. Vertical bars indicate standard errors; α-weighted averages across wealth classes are calculated after weighting each wealth type/production system mean by the α values shown in figure 1. The β for Kipsigis cattle partners is used to estimate the pastoral/relational β as well as for calculating the pastoralist α-weighted average. E = embodied wealth; R = relational wealth; M = material wealth.

conventional wisdom regarding property in different production systems, this is the first time they have been demonstrated empirically using consistent methods on a set of fine-grained quantitative data from multiple populations. In addition, there are several novel aspects to our results.

First, the lack of substantive difference in α-weighted β averages of hunter-gatherer and horticultural populations implies that the greater degree of wealth transmission (and associated inequality) in agropastoral systems is not due to reliance on domesticated plants and animals per se, since horticulturalists also have such reliance. Rather, it likely is due to the more intensive forms of production and the elaboration of property rights associated with animal husbandry and intensive agriculture, an argument we return to in our concluding section.

Second, even the relatively small average β's found among forager and horticulturalist populations are not trivial; they imply that the luck of being born into the top (or bottom) of the wealth distribution confers quite significant advantages (or disadvantages). Specifically, our estimates imply that a child born into the highest wealth decile in hunter-gatherer and horticultural societies is more than three times as likely to end up in the top wealth decile as is a child born into the bottom wealth decile (for details of this calculation, see the CA+ online supplement "Estimating the Inheritance of Wealth in Premodern Societies" in the online edition of *Current Anthropology*). Yet this degree of intergenerational inertia is modest compared to that in pastoral and agricultural societies, where the child from the richest decile is about 16 times more likely to remain there than a child from the poorest decile. For comparison, the degree of intergenerational transmission of wealth in hunter-gatherer and horticultural populations is similar to the intergenerational transmission of monetary income in the Nordic social democratic countries of Denmark, Sweden, and Norway (where β averages 0.18), while the agricultural and pastoral societies are comparable to the United States and Italy (average $\beta = 0.43$), the advanced economies in which inequalities are transmitted most strongly across generations (Björklund and Jäntti 2009).

A third finding is that β for a particular wealth class varies across production systems. Thus, material wealth is weakly transmitted in foraging and horticultural populations ($\beta = 0.13$) but strongly transmitted in agricultural and pastoral populations ($\beta = 0.61$). Similarly, both relational and em-

bodied wealth are transmitted at twice the rate in hunter-gatherer and horticultural populations than in agricultural and pastoral populations (fig. 2), although neither of these differences is statistically significant. Further analysis of the α-weighted average β's shows that 45% of the large (namely, 0.21) and statistically significant difference ($P < .001$) between the average α-weighted β's of the two categories of production systems is accounted for by differences in the α's across the two pairs of production systems, holding the β for each class of wealth at its mean across all production systems. The remaining 62% is due to differences in the β's, holding each α at its mean across all four production systems (for details of this analysis, see the CA+ online supplement). This means that while transmission of a given wealth type is partially determined by its inherent features, transmission is also strongly affected by the production system in which it is embedded.

Finally, our comparative quantitative analysis shows that the more important a wealth class is in a particular production system (as estimated by α), the higher its degree of intergenerational transmission (β). This is clearest in the case of material wealth: in pastoral and agricultural societies, its average importance (α) is 0.60 and the average transmission coefficient (β) is 0.61, while in hunter-gatherer and horticultural populations, $\alpha = 0.18$ and $\beta = 0.13$. Similarly, embodied wealth is about twice as important in hunter-gatherer and horticultural societies as among pastoralists and agriculturalists, and the corresponding average β's are equally divergent (though not significantly so). In fact, the overall correlation between the production system– and wealth class–specific mean α's and β's is quite strong (fig. 3). This finding is consistent with the hypothesis that parents seek to enhance the success of their offspring by differentially transmitting to them the forms of wealth that are most important in that society (e.g., Hartung 1982; Holden, Sear, and Mace 2003). In effect, it appears that parents are making a particular effort to pass on to their offspring those forms of wealth that have the highest marginal value for enhancing well-being.

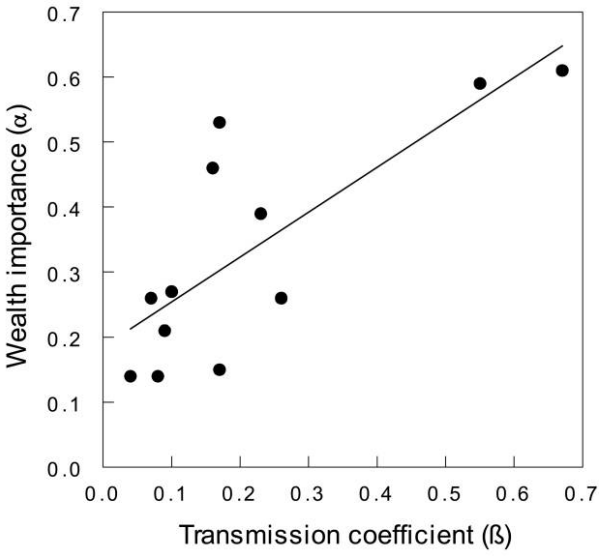

Figure 3. Relationship between the wealth class and production system averages of wealth importance (α) and intergenerational wealth transmission (β). The correlation is positive and significant; $r = 0.78$, $P < .01$.

Wealth Inequality

Are production systems in which wealth is more transmissible also more unequal? To answer this question, we have used the household-level data on various wealth measures in each population to estimate Gini coefficients, a widely used measure of inequality that generates values from 0 (equal wealth) to virtually 1 (all wealth held by a single household). The Ginis for each wealth measure are provided in the preceding papers in this special section; we use these to compute averages for each wealth class in each production system (fig. 4). To calculate an overall measure of wealth inequality for a given production system, we then weight the average inequality of each wealth class in that production system by its importance (α).

These estimates of overall wealth inequality (rightmost entry in each panel of fig. 4) exhibit the same pattern as the β transmission coefficients (fig. 2). Specifically, hunter-gatherer and horticultural populations both exhibit quite modest levels of inequality (α-weighted average Ginis of <0.2), while pastoral and agricultural societies are characterized by more substantial average Ginis (ca. 0.4–0.5). This pattern is due to several causes, but prominent among them is the higher degree of inequality in material wealth that is characteristic of all four production systems (fig. 4); this interacts with the greater importance of material wealth (α) in pastoral and agricultural populations to produce the higher aggregate inequality for these populations.

It is also very noteworthy that the degree of aggregate wealth inequality is no greater in horticultural than in hunter-gatherer populations and is correspondingly almost as high among pastoralists as among agriculturalists. The high Gini for pastoralists counters the commonly held although now contested view that pastoralists are egalitarian (Salzman 1998; Schneider 1979). As discussed by Borgerhoff Mulder et al. (2010, in this issue), the ideological emphasis on egalitarianism, generosity, and leveling mechanisms does not in the end produce an egalitarian distribution of wealth, particularly material wealth.

To put these figures in perspective, the Ginis for foragers and horticulturalists match the lowest values found for modern nations (Denmark's 0.25, Finland's 0.27), while the agropastoral Ginis are comparable to those found in the United States (0.41) and Venezuela (0.48; UNDP 2009; World Bank 2009).

It is worth noting that low Gini coefficients do not mean everyone is the same. Among the Ju/'hoansi, for example,

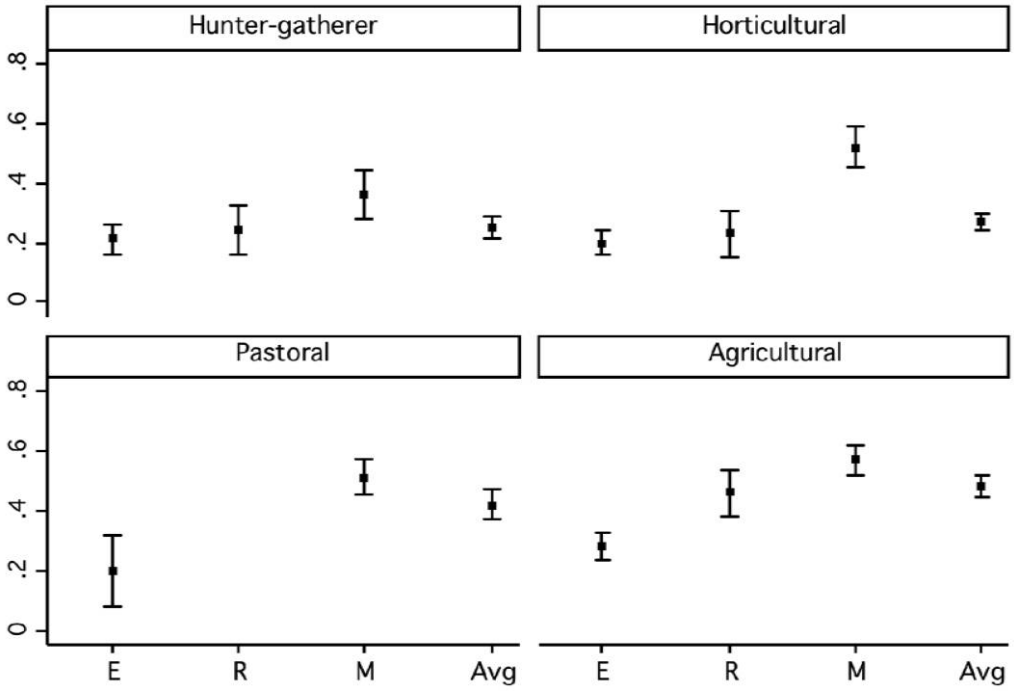

Figure 4. Extent of wealth inequality (Gini coefficients) by production system and wealth class. Vertical bars indicate standard errors; the α-weighted averages for each production system are calculated after weighting each wealth type/production system mean by the α values shown in figure 1. The Gini coefficient for Kipsigis cattle partners is used to estimate the pastoral/relational Gini as well as for calculating the pastoralist α-weighted average. E = embodied wealth; R = relational wealth; M = material wealth.

equality does not mean sameness, and there is a great emphasis on groups having members with very different skills. If one person in a group excels in one niche such as music, healing, or a certain technique of hunting, others will give him or her space and seek recognition in different areas; if one person tries something new and succeeds, there is very little direct imitation (Polly Wiessner, personal communication).

There is a reasonably strong correlation between intergenerational wealth transmission (β's) and wealth inequality (Gini coefficients) for the full set of wealth measures (fig. 5). This is consistent with the arguments linking transmission rates with inequality presented in the lead paper for this section (Bowles, Smith, and Borgerhoff Mulder 2010). It is important to remember that the predicted association between intergenerational transmission and inequality will be attenuated unless the wealth shocks to which individuals are exposed differ across systems. The β-Gini association shown in figure 5 suggests that variation in the magnitude and impact of shocks averages out across our sample of 21 production systems and 43 wealth types. Because we lack empirical data on the magnitude and impact of shocks, and the smaller sample sizes for each production system made the averaging assumption problematic, we did not investigate these relationships within production systems.

Conclusions and Prospects

Summary of Key Findings

The set of papers in this special section advance an explanation of variation in inequality across societies in terms of differential intergenerational transmission of their most important kinds of wealth. They provide theoretical and empirical reasons to support a series of linked claims: (1) the importance of material, embodied, and relational wealth differs significantly across production systems, with material wealth more important in pastoral and agricultural systems; (2) the degree of wealth transmission differs markedly by wealth type, with material wealth more highly transmitted than embodied and relational; as a result, (3) aggregate wealth is transmitted to a higher degree in pastoral and agricultural populations; (4) the degree of inequality is greater for material wealth than for embodied or relational wealth; and (5) the

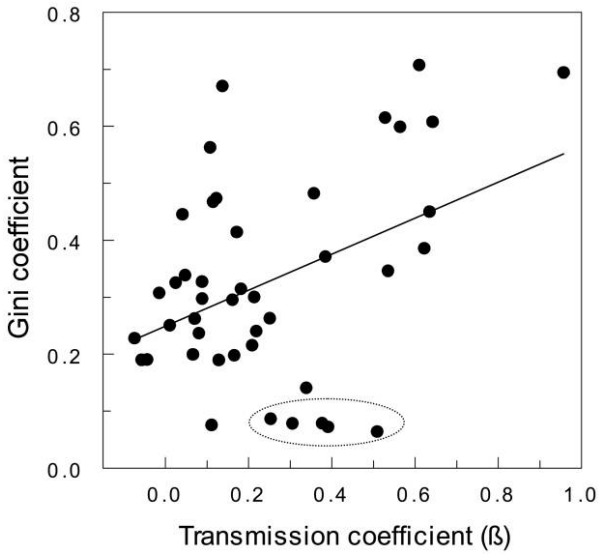

Figure 5. Relationship between inequality (Gini coefficients) and intergenerational transmission (β's) for all wealth measures. Correlation is positive and significant; $r = 0.41$, $P < .01$. The dashed oval contains the points for body weight, which deviate from the overall trend.

degree of intergenerational transmission of wealth is correlated with the degree of inequality of wealth, both within populations (e.g., by wealth measure or wealth class) and across them (e.g., by production system). We thus conclude that over the long run wealth inequality was minor in hunter-gatherers and horticulturalists, at least in part because the modest degree of transmission of the most important kinds of wealth—embodied and relational—limited the accumulation of inequalities from generation to generation. By contrast, in the pastoral and agricultural production systems that displaced many forager and horticultural populations during the Holocene, the high α-weighted β's for material wealth supported substantial levels of persistent (transgenerational) inequality.

Prospects

This project on intergenerational wealth transmission in premodern societies, summarized in this paper and detailed in the preceding four papers on specific populations and production systems, explores new ground in ecological-economic anthropology and comparative economics. Like any exploratory research, it raises more questions than it answers, and it calls out for extension, replication, and critical evaluation. In this final section, we briefly raise some likely directions for such future work.

Wealth complementarity. Much of our analysis turns on the differences in transmission rates (β) and importance (α) between categories of wealth (embodied, material, and relational). However, this does not imply that the levels of each type of wealth held by an individual are uncorrelated or that these wealth classes affect household well-being independently. The Cobb-Douglas production function that underpins our use of α parameters defines aggregate wealth as a weighted product of the levels of each wealth class (the weights being the α's), and as a result, the wealth classes are complements. This means that the marginal product of each type of wealth varies positively with the amount of other types of wealth; for example, an increase in the size of one's herd contributes more to one's aggregate wealth if one is healthy than if one is not. The complementarity of wealth types provides one (among many) reasons to expect the distinct wealth levels to be positively correlated, so that, for example, successful hunters might have both greater reproductive success and larger sharing networks. Further research is called for to explore such complementarities and their role in fostering inequality.

Relational wealth. One of our three wealth classes, relational wealth, accounts for only six (14%) of our 43 wealth measures. This mirrors the underrepresentation of quantitative measures of relational capital in the anthropological literature. Clearly, we need much more data on relational wealth and its ecological and social context. As noted above, we suspect that the transmissibility of relational wealth will depend both on the specific kind of network involved and on the degree of status differentiation in a given society.

Partible inheritance. Wealth types necessarily vary in the extent to which they are partible or impartible, which raises two issues, one concerning estimation of β and another concerning inequality. With regard to the first, specifically, the effects of primogeniture versus an equal wealth division on measuring β, we need to consider potential sample biases and possible associations between wealth and number of inheritors. At one extreme, if all noninheriting sons exit the population, and if there is no correlation between wealth and number of sons, then the β estimate will not be biased. But if rich parents have more sons on average, and they all inherit parental wealth and remain in the population, then β will be overestimated. If only the disinherited sons of the poor emigrate (because disinherited sons of the rich have alternative sources of wealth), then β will be underestimated (because we have overstated the wealth of poor sons by missing those who immigrate). There are, of course, many other combinations, all of which require a more nuanced analysis.

With regard to the implications for inequality, partibility of inheritance may be crucial. Impartible inheritance generates greater variance in second-generation wealth than does partible inheritance, variance that may be important for developing and maintaining inequality. Indeed, a focus on partibility and impartibility may suggest new research questions we do not have room to address here (Paul Leslie, personal communication). For example, do intrafamily inequalities in the transmission of material, somatic, and relational wealth

reinforce one another, or is intergenerational transmission deployed strategically to compensate for such inequalities?

Pastoralism and agriculture. The similarity of pastoralists to agriculturalists in wealth transmission and inequality measures could be due to the fact that several of the pastoralists studied in this project are transhumant pastoralists, and many engage in some farming (as is typical of lower-latitude pastoralists). However, it should be noted that less intensive forms of cultivation, as reflected in the data on horticulturalists, exhibit a very different pattern that emphasizes embodied wealth (especially somatic wealth) and relational wealth over material wealth (figs. 1, 2; see also Gurven et al. 2010, in this issue). Our findings suggest an alternative interpretation for the pastoralist-agriculturalist similarity in wealth and inequality measures, namely, that their primary reliance on certain forms of material wealth is part of a fundamental shift in wealth accumulation and intergenerational transmission, with one result being increased inequality. This is consistent with previous work suggesting that wealth transmission and inheritance may motivate restricted fertility even among high-fertility traditional pastoralists (Luttbeg, Borgerhoff Mulder, and Mangel 2000; Mace 2000). More broadly, this suggests that pastoralists and agriculturalists may reflect two versions of an economic and productive strategy emphasizing material wealth coupled with household or lineage property rights; depending on the regional ecology and competition with other populations, some emphasize pastoralism and others intensive agriculture.

Emergence of institutionalized inequality. Our finding that the overall intergenerational transmission of wealth is no greater in horticultural than in hunter-gatherer populations is provocative. It suggests that, contrary to the many models of the emergence of institutionalized inequality, the domestication of plants and animals per se may not have been sufficient. Instead, persistent inequality may have depended on subsequent developments associated with intensified forms of cultivation and animal husbandry represented by agriculture and pastoral livelihoods. Among these developments, we would argue that increased economic defensibility is critical. Economic defensibility refers to sufficient density and spatiotemporal predictability of resources to repay the costs of territoriality—that is, the defense of property by individuals or kin groups (Cashdan 1992; Dyson-Hudson and Smith 1978). Horticulturalists rely on domesticates, but this production system is characterized by abundance of land relative to labor and, hence, low payoffs to defending property rights at the household level (Harrell 1997). Only when land becomes scarce enough can it repay the social and economic costs of excluding some members of one's group in order to retain long-term control of arable land. This scarcity in turn drives technological and ecological investment such as plowing, irrigation, and terracing, which increase the incentive for control and transmission to descendants.

If plant and animal domestication is not sufficient to stimulate institutionalized inequality, it is also not always necessary. Ethnographers and archaeologists have long noted the existence in various times and places of hierarchical hunter-gatherer societies with marked inequalities in wealth and status (Arnold 1996; Hayden 1994; Kelly 1995; Price and Brown 1985)—cases that are an embarrassment for simplistic correlations of subsistence mode and sociopolitical factors. Although extant hunter-gatherer populations do not include any hierarchical systems and therefore none could be included in our sample populations, the ethnography leaves little doubt that if their β's and Ginis could be measured, they would be substantial. The best-described examples of such hierarchical foragers are the various societies of the North Pacific Rim, from Aleut to Coast Salish. Most focused their subsistence production on rich marine resources, particularly salmon runs; and again, the density and spatiotemporal predictability (hence, economic defensibility) of key resources, enhanced in this case by fish traps and extensive storage, would reward the defense and intergenerational transmission of property rights, favoring the emergence of persistent inequality.

The egalitarian ethos of most hunter-gatherer societies in the ethnographic record (Boehm 2000) and the limited wealth inequalities in our hunter-gatherer estimates are consistent with the view that, at least prior to some 20,000 years ago, economic inequalities between families were quite limited. Although scattered evidence of economic inequality predates the Holocene (Formicola 2007; Pettitt and Bader 2000; Soffer 1989; Vanhaeren and d'Errico 2005), the Holocene saw the emergence of permanent inequality in many populations, eventually culminating in the rise of class societies and the hierarchical ancient states (Ames 2007; Carneiro 1970; Price 1995; Wright 1978). Our model and accompanying empirical evidence suggest that the modest degree of intergenerational transmission of hunter-gatherers' most important kinds of wealth—embodied and relational—limited the accumulation of inequalities from generation to generation. In contrast, the new forms of wealth that resulted from the domestication of plants and animals were highly heritable, as discussed above. As a result, where economic institutions and social norms permitted intergenerational transmission, the inequalities of one generation could be reproduced in the next, accounting (at least in part) for the fact that the pastoral and agricultural production systems that replaced many forager and horticultural societies supported substantial levels of persistent inequality.

In sum, our findings resonate with the argument that controlling access to economically defensible resources such as intensively worked land *or other scarce resource-producing sites* (e.g., salmon streams, livestock herds, trade routes) is a potent contributor to the emergence and persistence of high levels of inequality (Boone 1992). Whatever the fate of this particular argument, we believe rigorous analysis of this and other accounts of the emergence and dynamics of institutionalized inequality in human societies will benefit from use of system-

atic quantitative measures of individual-level wealth transmission such as the ones developed in this project. In addition, theory building and improved understanding of these critical issues will require greater integration of economic and evolutionary approaches, a goal to which we have made a modest contribution here.

Acknowledgments

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Intergenerational Wealth Transmission and Inequality in Premodern Societies

Reply

CA+ Online-Only Supplement: Estimating the Inheritance of Wealth in Premodern Societies

Eric Alden Smith, Samuel Bowles, Tom Hertz, Monique Borgerhoff Mulder, Mary K. Shenk, and Michael Gurven

The papers in this special section provide empirical support for a model of the role of intergenerational wealth transmission in explaining variation in wealth inequality across premodern societies. Our results lead us to conclude that variation in intergenerational transmission rates explain a substantial portion of such inequality, as expected from our model, but do so *in conjunction with other factors*, particularly the types of wealth involved, the nature of the production system, and the social institutions associated with those systems. The commentators variously applaud our efforts, query the importance of intergenerational transmission relative to other factors, and raise questions about our analytical methods and the representativeness of our sample of societies. Here we address the most important challenges raised in the comments and highlight much-needed future lines of research.

We sought to understand some of the determinants of wealth inequality by means of a dynamic model (presented more fully in Borgerhoff Mulder et al. 2009) in which the long-run equilibrium level of inequality depends on just two things. The first is the extent of new inequalities that occur in each generation (windfall gains and losses that in our model are uncorrelated with wealth), measured by σ_λ^2, the variance of the shocks. The second is the extent to which these shocks are passed on from generation to generation, as measured by the inverse of $1 - \beta^2$, which becomes a very large number as β approaches 1. From this model we deduce that long-run inequality is simply the ratio of these two quantities, or $\sigma_\lambda^2/(1 - \beta^2)$. The model is a deliberate simplification designed to capture two important influences on wealth inequality in the very long run in a way that is comparable across many different kinds of economic systems and processes of production. Simplicity and comparability are its virtues: it makes no pretense of capturing all of the influences on this process.

The Role of Shocks

This brings us to an interesting suggestion by Gregory Clark, but first we need to correct a possible misunderstanding. Clark writes that we seek to "measure and explain the degree of social inequality in societies simply by measuring" β (p. 101). In fact, we measure inequality using the Gini coefficient, a statistic that bears no necessary relationship to β; one can imagine a highly unequal society in which positions in the wealth distribution are randomly drawn each generation ($\beta = 0$) or an extremely egalitarian society in which parental wealth is a near-perfect predictor of child wealth. In our data set, for example, inequalities in body weight are very modest, but weight is strongly transmitted across generations. Clark is correct, however, that in explaining the Gini, we do not consider the possibility that the extent of shocks (σ_λ^2) may vary across economic systems. We were unable to explore this possibility in our study as there are no currently feasible measures of the extent of shocks.

But, like Clark, we cannot resist speculating about the nature and extent of these shocks. In addition to the reasons Clark offers for believing that the wealth of farmers and herders may be subject to greater shocks than the wealth of foragers, we would add portfolio diversification: foragers subsist on literally hundreds of species of plants and animals, while agricultural and pastoral subsistence often depends on relatively few. We may test whether σ_λ^2 differs between hunter-gatherer and horticultural economies, on the one hand, and agricultural and pastoral economies, on the other, by taking the logarithm of $\sigma_\lambda^2/(1 - \beta^2)$ to turn this ratio into a sum, which may then be estimated using ordinary least squares regression, as follows:

$$\text{Gini} = a + bH + c\ln[1/(1 - \beta^2)] + \varepsilon, \quad (1)$$

where H is a dummy variable taking the value of 1 for wealth measures from hunter-gatherer or horticultural economies. The estimate of a is a measure of the extent of shocks in the agricultural and pastoral economies and $a + b$ is the corresponding measure for hunter-gatherer and horticultural economies. The parameter c estimates the effect of variations in the extent of intergenerational wealth transmission on the

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degree of inequality. Here is the estimated equation with *t*-statistics in parentheses (all highly significant):

$$\text{Gini} = 0.39 - 0.14H + 0.14\ln[1/(1-\beta^2)]$$
$$(9.09) \quad (-2.73) \quad (2.22) \qquad (2)$$

($R^2 = 0.32$, $n = 43$). The estimates imply that shocks in agricultural and pastoral societies are 56% larger (0.39/0.25–1) than in hunter-gatherer and horticultural populations, consistent with Clark's conjecture.

Transmission Rates versus Mechanisms

Turning from the explanation of the level of inequality to the estimation of the degree of inheritance, we distinguish between the extent of transmission (β, a statistical relationship) and the process of inheritance. The latter, as James Boone points out, is highly heterogeneous, including such disparate processes as material bequests, socialization by parents, and genetic transmission. Boone considers this heterogeneity a problem, while Stephen Shennan considers our statistical concept a clever and "creative abstraction." Richard Waller elaborates on the specifics of how material, relational, and knowledge-based embodied wealth are transmitted, and we find it encouraging that our study, which undoubtedly pushes the quantification of ethnographic data to its limits, corresponds so closely to a historian's interpretation of the ethnographic materials.

To clarify the difference between our measure of overall transmission and the causal processes of inheritance contributing to it, suppose that in a herding economy the wealth of the father (W') is correlated with the wealth of the son (W) both by direct bequest and by virtue of the fact that the father's wealth allows him to provide better nutrition and, hence, more somatic capital (S), to his son (fig. 1).

Thus we have

$$S = a + bW', \qquad (3)$$

$$W = A + BW' + CS, \qquad (4)$$

where a and A are constants, b is the effect of variations in W' on S, and B and C, respectively, are the effects of variations in W' and S, respectively, on W. Substituting the expression for S into equation (4), we have

$$W = A + BW' + C(a + bW') = A + Ca + (B + Cb)W'. \qquad (5)$$

The expression $(B + Cb)$ gives the total effect of parental wealth on offspring wealth, of which B is the direct and Cb the indirect effect.

If by "inheritance" Boone means the literal passing on of things (by bequest, e.g.), then he is surely correct to say that "inheritance is . . . unfeasible unless wealth can be . . . sequestered" (p. 98). But in the above example, a mechanism

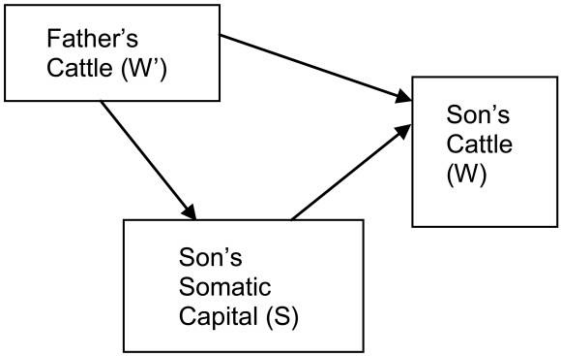

Figure 1. Example of direct and indirect transmission.

other than actual bequest is involved, namely, nutrition, which creates somatic capital (embodied wealth). The indirect effect need not be positive, of course, as is the case (e.g., in our data on the Kipsigis) when greater parental wealth is associated with a larger number of offspring. To see this, just redefine S, above, as number of sons, and note that in this case, C would be negative because the more sons a father with a given amount of wealth has, the less will be the wealth transferred to the son.

Interdependence of Different Wealth Types

We adopt a broad definition of wealth, adding embodied and relational forms to the more conventional focus on material capital. Several commentators point out that different wealth classes are not independent of each other. Thus, Kenneth Ames reminds us of Walker and Hewlett's (1990) hypothesis that those with large kin networks have better dental health, probably as a result of access to a greater range of foods (an interaction of relational and embodied wealth), Dan Bradburd describes how Komachi (and many others) use wealth to build social connections, and vice versa, and Mark Flinn observes how hard it may be to tease apart power and resources.

We agree that our classes of wealth are interdependent, but that does not mean they cannot be measured and the effects of their variation studied. There are two very different kinds of interdependence to be considered. First, the contribution of one kind of wealth to an individual's well-being may depend on the level of some other kind of wealth; and second, how much wealth of one type an individual has may be the result of having other kinds of wealth.

With respect to the first, our model does *not* assume independence of wealth types but, rather, a relationship of complementarity, such that the marginal effect of a larger herd, for example, increases with the number of political supporters. Thus, the effect on well-being of any one kind of wealth a family has depends on their holdings in other kinds of wealth. This complementarity may help determine the degree of transmission, but we see this as a strength of our approach rather than a flaw.

To explicate this more fully, consider our definition of a

household's wealth: any attribute that contributes to its well-being as measured by consumption levels, social status, or other ends that are valued in the particular society. To take account of many kinds of wealth simultaneously, we define the importance of each class of wealth as follows. Let E, M, and R be positive numbers representing the amount of a household's embodied, material, and relational wealth. The well-being of the household, W, is a weighted product of these classes of wealth, the weights being the relative importance of each wealth class in the production system in which the household lives:

$$W = \gamma E^e M^m R^r, \tag{6}$$

where γ is a positive constant and the exponents e, m, and r (the weights) are the derivatives of the logarithm of well-being with respect to the logarithms of the three respective wealth classes or, equivalently, the percent difference in well-being associated with a percent difference in the amount of each class of wealth.

The weighted product is preferred (to the weighted sum, e.g.) because it implies, plausibly, that the wealth classes are complements; that is, the contribution of each class of wealth to individual well-being is enhanced by the extent of the other classes of wealth. This is the first sense in which wealth classes are interdependent. We do not know, of course, if we have correctly captured the nature and extent of the interdependencies as we have not yet estimated an equation like (6) explicitly. This is among our current research projects.

The second kind of interdependence concerns the process by which an individual acquires wealth; for example, a well-connected person may find it easier to acquire a large herd. Thus, in the above example the material wealth of the father contributes to the embodied wealth of the son, which in turn contributes to the material wealth of the son. This is true in many cases, and it may help explain the degree of transmission. But it is not a criticism of our methods as long as our estimate of β is an unbiased estimate of the effect of a parental wealth shock on the wealth of the offspring. If figure 1 correctly captures the causal relationships involved, then an unbiased estimate of β is achieved by regressing son's wealth against father's wealth, as we do. In this case, were we to include a separate control for the son's somatic capital (S), this would introduce a negative bias into our estimate of β, one that netted out the indirect consequences of the father's wealth.

But suppose that S represented the son's herding skills acquired from the dad and consider the effect of the loss of the father's herd through theft. This shock would eliminate the direct bequest of cattle but need not prevent the indirect transfer of skills, so instead of a fraction ($B + Cb$) of the shock being passed on to the son, only B would be passed on, so our estimate would be upward biased by an amount Cb/B. This type of bias will arise for any attribute that is correlated between generations and is conducive to achieving higher wealth but is not a direct *consequence* of parental wealth. Because we cannot fully specify all the factors and causal relationships that are at work in these many societies, we cannot rule out the possibility that some of our estimates of β may be biased.

In any case, the commentators' concerns about the lack of independence among wealth types point to plenty of new territory to explore with respect to examining the implications of these interactions. In situations where success in acquiring one kind of wealth, such as a large group of friends, strongly favors acquisition of material goods or robust health, the extent of inequality may be much greater than in a situation where each family or individual has a chance to prosper in their pursuit of any wealth type, irrespective of their success or failure in acquiring other wealth types. We also think that the uncoupling of material and relational wealth might provide insights into the intriguing question raised by Robert Kelly as to why the social-leveling mechanisms observed in many hunter-gatherer and simple horticultural populations stop working so effectively in pastoralists and farmers. Perhaps there is a tipping point where welfare losses resulting from the diminished popularity of a hoarder are eclipsed by the benefits of material accumulation, a point more easily reached when material and relational wealth are relatively independent. These are questions we will be examining empirically in some of our more complete data sets.

Are Wealth Transmission and Inequality Correlated?

Both Clark and Frederic Pryor are concerned that a central implication of our model—that there should be a positive relationship between the degree of intergenerational transmission (as measured by β) and the level of inequality (as measured by the Gini coefficient)—is not borne out in our data. (We do not share Pryor's concern that many of our estimates are not significantly different from 0 since there is no reason to discount a reasonably precisely estimated value of β merely because it is close to 0: some forms of wealth are simply not transmitted across generations.) Clark states that the (β, Gini) correlation we document (which is 0.41 when calculated over the 43 population-specific and wealth type–specific estimates) is very weak. This objection falls into the glass half-empty category; it is not clear how high this figure would have to be to validate our expectation since the correlation depends on the variability across the 43 observations in the realized variance of the idiosyncratic shock term (σ^2_λ). Given this, we would expect the (β, Gini) correlation to rise when the 43 observations are aggregated into their 12 cell means (as in tables A4 and A5 in the CA+ online supplement "Estimating the Inheritance of Wealth in Premodern Societies" in the online edition of *Current Anthropology*) since this averaging should remove some of the noise contained in σ^2_λ. This is, in fact, what we observe: the correlation rises to 0.51 when calculated over the 12 wealth class– and economic

system–specific averages. At a still higher level of aggregation, the correlation between the α-weighted β's for each production system and their α-weighted Gini coefficients is 0.90, a result that achieves statistical significance at the 10% level despite resting on only four observations. The fact that there is a statistically significant and nontrivial relationship between intergenerational transmission and inequality, observed at all three levels of aggregation, is strong validation of the central prediction of our model.

But Pryor notes that there should also exist a positive relationship between the β's and the Gini coefficients *within* each production system as well as in the aggregate, and this generalization is valid (though it might be difficult to test given that we have an average of only 11 observations per production system). As Pryor shows, this is the case for pastoral and agricultural but not for hunter-gatherer and horticultural systems, where the relationship is actually negative. But this surprising result is driven entirely by the five observations on body weight, which were available only for a few hunter-gatherer and horticultural populations. When a dummy variable is included that flags these few cases, the coefficient on β as a predictor of the Gini is almost exactly 0 and has a large standard error in these two production systems.

The reason body weight is an outlier is that, while it is strongly transmitted across generations, it simply cannot be very unequally distributed. Unlike material wealth or social ties, body weight is physically constrained to lie in a fairly narrow range. One can have 10 times as many cows as the next herder but not weigh 10 times as much! More important for our model, an adverse shock can eliminate 90% of one's herd, while an individual experiencing an adverse health shock with a similar weight loss would not survive and, hence, would not be in our sample. In terms of our model, this physical constraint on overall variability translates into a lower value of σ_λ^2 for this form of wealth and, hence, a lower Gini for any given value of β. Its Gini coefficients are thus some 20 points lower than those for non-body-weight forms of wealth, reflecting both the physiological limits on body size and the sharing of food among families in the societies in question mentioned by both Pryor and Clark. Nonetheless, the lack of a positive relationship among hunter-gatherers and horticulturalists between Gini and β, even taking account of this peculiarity of the wealth measure, is puzzling and deserves further attention.

Pryor offers three possible explanations. The first two of these strike us not so much as alternatives to but restatements of our model. He argues that an ergodic stochastic model of the intergenerational transmission process would "show that the distribution of wealth asymptotically approaches an equilibrium that depends on the various societal rules specified in the model" (p. 112). This is the basis of our reasoning as well, with β being the parameter that captures the effects of all the "various societal rules" at work, including those "nondemographic societal rules" that Pryor emphasizes in his second numbered paragraph and which he notes are discussed in several of the production system–specific papers. Pryor thinks that "the inheritance rule, not the calculated β, is the key variable to examine" (p. 112). But inheritance rules are difficult to directly quantify in ways that are comparable across wealth types and production systems and are only relevant to some sorts of wealth. Our β's are not an alternative to examining these rules but, rather, a way of examining the effects of these rules along with other influences on intergenerational transmission in a manner that allows quantitative comparisons.

Pryor's third point is that foraging and horticultural societies engage in more redistribution, which should reduce wealth inequality properly measured. This, along with Clark's related observation on the differences in the magnitude of shocks across production systems, recommends a more explicit modeling of the effect of societal institutions and norms and how these interact with the nature of wealth in sustaining inequality in the long run. We are currently engaged in this project.

More direct evidence that influences other than the extent of intergenerational transmission are at work comes from our summary table (table A5 in the CA+ online supplement). Averaging the α-weighted β's for the hunter-gatherer and horticultural populations, on the one hand, and the farming and herding populations, on the other, the values of $1/(1-\beta^2)$ are 1.04 and 1.18, respectively, implying 14% greater wealth inequality in the latter than the former, assuming that σ_λ^2 does not differ across populations and that the model is correct. But wealth inequality (measured by the α-weighted Gini coefficients) is 77% greater in the latter.

Clark's comment that the model does not illuminate the persistence of class or racial or other group inequality is well taken, though his suggested solution appears a bit mechanical; he simply assumes that "upper-class parents have upper-class children" (p. 102).

What to Measure and How

Our method for the derivation of α (our measure of the relative importance of each wealth type) concerned some commentators. We based α values for each population in the project on the judgment of the participating ethnographer or historian and calculated average values of α for various sets of societies based on these. We view quantification of ethnographic information as a critical first step in testing our model. In addition, we remind readers that as a comparative check, we calculated values of α for material wealth using published quantitative data on one horticultural, two pastoral, and seven small-scale agricultural populations not in our sample, and these were extremely close to our own ethnographic estimates for comparable populations in our project sample (summary in the concluding paper in this special section [Smith et al. 2010*a*] and further details in the section "Sta-

tistical Estimation of m: α Value for Material Wealth" in the CA+ online supplement). Moreover, even with the unrealistic assumption that α values are equal across wealth types, we found that β differed by wealth type and production system.

Shennan wonders why we do not discuss the evolutionary implications of reproductive success (RS) and rightly points out that number of children is a poor measure of RS from an evolutionary perspective. As discussed in our introductory paper (Bowles, Smith, and Borgerhoff Mulder 2010, in this issue), we use RS not as a fitness measure but, rather, as an "indicator of somatic wealth, capturing an individual's ability to produce and successfully raise offspring" (p. 9). From this perspective, there are many justifications for using number of children as an outcome measure. First, children can be viewed as direct indices of parental somatic wealth. Pregnancy and lactation are highly calorically demanding, and children require a significant investment in time and effort spent in caretaking. Number of surviving children thus indexes a parent's physical condition, knowledge, and working capacity, including parental ability to handle trade-offs between reproduction and subsistence work or other obligations. Children can also serve as indicators of parental wealth whenever they contribute to household wealth production (e.g., Kramer 2005; Kramer and Boone 2002). In most traditional societies, children, especially daughters, also yield important help with the care of younger siblings (Kramer 2005; Mace and Sear 2005). Children may also serve as a key means of generating relational wealth since durable alliances can be created through marriage, fostering, or adoption. In sum, we fully acknowledge that reproductive success can be viewed as both a form of wealth and an outcome of it. In treating RS as a form of wealth, we highlight one perspective, while in future work we intend to highlight the other by directly examining the relationship between wealth and fitness.

Bradburd suggests that relational wealth may be poorly measured by number of ties. We agree with this assessment. Although we have used number of ties as a measure of network in several cases, in others we had the data—and sometimes went to great lengths—to weight each tie by a measure of quality. For example, each tie in the Bengaluru network data was weighted using the ratio of each network member's income relative to that of the network node. This reduced the β estimate to 0.114 (SE = .073; $P = .117$) compared to the estimate of 0.218 (SE = .060; $P = .000$) derived from unweighted data but produced an estimate that better captures the value of one's network ties.

Production Systems and Population Sample Bias

Our ability to make inferences about wealth inequality and inheritance typical of a given type of production system was inevitably limited by the sample of populations for which sufficient quantitative multigenerational wealth data existed. Kelly and others question how useful the production system categories (forager, pastoralist, horticulturalist, farmer) are at tracking causality. We acknowledge that our reliance on the traditional typology of production systems is imperfect because causal factors do not map neatly onto such a typology, but we defend it as a useful starting point. Bradburd suggests that we could perhaps learn more about the role of intergenerational transmission in contributing to inequality by conducting a conventional cross-cultural study of the ways in which wealth is generated, transferred, maintained, and dispersed. Presumably, he is thinking of using a comparative database like the Human Relations Area Files or the Outline of Cultural Materials (http://www.yale.edu/hraf/; Murdock et al. 2006). Such a study would be a useful complement to ours but runs into the usual kinds of problems—relatively limited information (and/or codes) on inheritance, the near-absence of data on the transmission of relational and embodied wealth, and reliance on normative statements rather than behavioral observations.

With regard to possible bias in the set of populations included in production system category and the sets of measures used, we were obviously limited by cases for which the kinds of data required to apply our model were available. Bradburd is concerned that inferences about horticulturalists are biased given our sample of four relatively egalitarian horticulturalist populations. However, larger samples indicate that the great majority of horticultural societies are egalitarian (see Gurven et al. 2010, in this issue, table 1). In addition, our sample is informative in demonstrating that domestication alone does not lead to increases in wealth inequality. The critique is nevertheless quite valid and can even be generalized: any typology used to categorize populations will be a generalization with many exceptions illustrating a wide range of variation. Similarly, we could not obtain intergenerational wealth data on complex hunter-gatherers, who exhibit extensive property rights and nonegalitarian social relations, as noted by Ames; nevertheless, our sample includes Lamalerans and Meriam (populations with corporate kin groups holding property rights of various kinds), enhancing the range of variation in the forager sample.

We addressed the problem of production system sample bias in two ways. First, we reclassified societies (Ache as horticulturalists and Kipsigis as pastoralists) and reran our analyses by production category, and we found no significant change in average β from our previous analysis (table A7 in the CA+ online supplement). Second, each of the papers in this issue discusses results and evaluates conclusions in light of the sample bias of analyzed cases. Thus, Gurven et al. (2010) discuss island horticulturalist populations and other more hierarchical societies for which requisite data were not available, and Smith et al. (2010*b*, in this issue) do the same for hunter-gatherers. Even though the horticulture chapter only includes quantitative analysis of four societies, our initial working hypothesis would be that more transegalitarian horticultural populations will show higher β for the limited resources (e.g., land) that likely would also exhibit higher α. Finding such a horticultural population that looks more like

an agricultural population in terms of β and/or α would help focus attention on the social institutions or ecological factors that produce such a result.

Still, the concerns raised in this regard by Bradburd, Kelly, and others are valid. We have plenty of ideas about the causes of inequality, and in our ongoing research, with a larger sample and more data, we will use more specific explanatory variables, paralleling the work of Henrich et al. (2004) in their study of cross-cultural variability in notions of fairness. By analyzing the effect of various possible independent variables, we should be able to move beyond the typological approach of production system variation. In addition, study of the variation in wealth inheritance among societies with similar production systems may further illuminate the roles of norms and institutions and other factors.

Multiple Determinants

Ambitious papers that seek generalizations from comparative data inevitably favor some hypotheses or explanatory factors and ignore others. How do we justify what is *not* included as an explanation for inequality? Håkansson (1998, 2004) begs for more attention to regional economic exchange networks. World system theorists attribute much of economic inequality to exchange, trade, and competition occasioned by such dynamics beyond the borders of the population of interest, and rightly so—regional dynamics can indeed spur intensification, wealth accumulation, and political centralization, but they do so *through their effects on the wealth types we study*. Thus, as Håkansson found, the nineteenth-century East African ivory and cloth caravans extended preexisting trade networks and increased the value of marketable goods, providing a stimulus for agricultural intensification, accumulation of livestock, political centralization, and, one might assume, increased inequality. This happened through increasing the value of livestock—in our terms, raising the α value of material wealth in pastoralist systems. Thus, we do not see world systems theory as providing an *alternative* to our own explanation for the emergence of inequality.

Flinn draws attention to another potentially omitted dimension, the role of differential power in generating inequality. This is a question with which many, from Max Weber onward, have grappled. Is power just another form of wealth, is it derived directly from relational wealth (e.g., an individual's centrality in a network), or is it an entirely independent (and overlooked) dimension, possibly equivalent to status? These are wonderful questions but not ones that our research was designed to address, and until comparable empirical measures of status from multiple populations are available, we cannot determine the intergenerational transmission of status.

Bradburd objects to our statement (in the essay on hunter-gatherers by Smith et al. [2010*b*] in this special section) that "it is much harder to construct institutions to transmit social ties and knowledge than to do so for material wealth" (p. 31). His objection appears to be that ownership, wealth transmission, and so on require social institutions; we of course agree, and the quoted statement in no way implies otherwise. It simply claims that it is relatively difficult to construct institutions to delineate ownership of (and control over) certain kinds of wealth. More important, examples of the ways in which our analyses help reveal the importance of social institutions in shaping wealth transmission and inequality are discussed throughout the set of papers in this special section.

Consequences of Agricultural Intensification

Thomas Håkansson argues that we overstate the relationship between intensive agriculture and political complexity, as well as the relationship between complexity and the scarcity of arable land due to population pressure. This point is somewhat peripheral to our argument, which addresses economic inequality, not political complexity, and we believe that the relationship between complexity, power hierarchies, centralization, and inequality lies beyond the purview of this paper. We certainly agree with Håkansson that "intensive cultivation is often present in the archaeological record before the emergence of political centralization" (p. 105). Our sample of agricultural societies bears this out: three of the eight intensive agricultural societies in our sample—the Khasi, the Kipsigis, and the Yomut—have limited internal political complexity and are only peripherally involved in the politics of the modern state societies in which they are located.

Similarly, we discuss scarcity of land as a potentially important factor in the evolution of wealth inequality. Our proposal, however, is that once land becomes a scarce defensible resource, the potential exists for the emergence of significant inequality in wealth. This does not mean that land must be scarce due to population pressure, but only relative to effective demand. We agree with Håkansson that various forms of landscape modifications such as terracing, soil creation, or irrigation may exist in the absence of population pressure, but we argue that such modifications produce inequalities in land productivity that increase motivations to sequester land, thereby contributing to persistent wealth inequalities.

Origins of Inequality

Several commentators, particularly Boone and Kelly, are disappointed that our model (and resulting analysis) is not more comprehensive—that we do not directly tackle "the formation of social inequality." Our model, however, is clearly not designed to address this broad question; rather, it analyzes the stability or perpetuation of wealth inequality given certain material and socioeconomic constraints. We argue that degree of intergenerational wealth transmission (i.e., the correlation of offspring wealth with parental wealth, however instantiated) in conjunction with random economic shocks drives

wealth inequality to some long-run equilibrium value. We further propose that different types of wealth vary in their degree of transmissibility and that this (coupled with institutional and other factors) can help explain why societies vary so much in their observed levels of wealth inequality. This framework then allows us to discuss some of the questions that concern Boone and Kelly, but these inferences and speculations (found near the end of the four papers on production systems as well as in the concluding paper) are not direct consequences of the model per se.

However, let us briefly consider what Kelly poses as a key problem: given the "fierce egalitarianism" enforced through "leveling mechanisms" said to be characteristic of ancestral hunter-gatherers, what can we say about "why the leveling mechanisms stopped working" (p. 109)? One possibility is that new forms of material wealth made self-insurance through storage more feasible, reducing the importance of relational wealth. An example of this comes from Cashdan's (1985) comparison of !Kung groups with and without cattle, demonstrating how, when the option to reduce risk through private means becomes available, people do hoard, and this becomes more socially acceptable. Another reason that leveling mechanisms stopped working, or at least became attenuated, might be that the social creation of new forms of material wealth generated opportunities for controlling and thereby directly and indirectly transmitting inequalities in wealth. We sketch out a scenario along these lines in the concluding paper (as well as varieties of it in the other papers) but do not claim originality or direct derivation from our wealth-transmission model. It will require much future research to see if the dynamics of wealth transmission formalized in our model do indeed fruitfully interact with social and ecological factors in the manner suggested by such a scenario.

Conclusions

Kelly expresses disappointment that the main findings of this project are neither remarkable nor new. Ultimately this judgment is a matter of opinion rather than of fact or logic. However, we are skeptical that our findings merely corroborate received wisdom. For example, Kelly cites our finding that material wealth is more conducive to inequality than other forms as unsurprising, yet this is disputed in other commentaries and elsewhere in the literature. We have not encountered many publications that argue—let alone quantitatively demonstrate—that foragers and horticulturalists are virtually indistinguishable in their patterns of wealth inheritance and inequality or even that foragers lacking complex sociopolitical structures (as is the case with our sample) show levels of wealth inheritance and inequality persistence that are similar to those found in many industrialized societies. Similarly, our demonstration that pastoralists show levels of wealth inequality as high as densely populated farmers calls into question the widely held view of egalitarian pastoralists. Of course, these are preliminary findings, affected by possible bias in the sample of populations and other limitations as discussed above. But they surely constitute more than a simple corroboration of what everybody already knew about cross-cultural variation in wealth inheritance.

In conclusion, we thank the commentators for their often incisive comments on the set of papers in this special section. Given space constraints, we have not been able to address every comment, and in particular have mostly ignored those that endorse our efforts and findings and amplify their possible significance. We are pleased that most commentators perceive originality and explanatory value in our approach. We look forward to incorporating many of their suggestions in future research we are currently developing.

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Supplement from Tom Hertz, Adrian Bell, Patrizio Piraino, and Suresh Naidu, "Estimating the Inheritance of Wealth in Premodern Societies: CA+ Online Supplement to the Special Section"

(Current Anthropology, vol. 51, no. 1, p. 000)

Statistical Methods

Basic Specification and Unit of Analysis

The objective is to calculate a dimensionless statistic that quantifies the resemblance between the wealth holdings of the parental generation (F_1) and their offspring (F_2). Many such statistics are possible, but the one that allows for a clear algebraic link to the dynamics of inequality, as modeled in equations (1)–(3) in Borgerhoff Mulder et al. (2009), is the elasticity of F_2 wealth with respect to F_1 wealth, which we call β. This statistic is applicable to any kind of wealth whose amount is a nonnegative continuously measured quantity, regardless of its scale or the nature of its distribution, as required. It is important to stress that this statistic is descriptive, not structural: it is a measure of intergenerational association and does not specify the causal pathways accounting for the association.

To estimate this statistic, we drew upon the large literature that studies intergenerational associations in earnings or income, as summarized, for example, by Solon (1999). The standard econometric specification used in that body of research is to model the natural log of the F_2 outcome (in our case, various forms of wealth) as a linear function of the natural log of the F_1 outcome, with polynomial controls for age at measurement in both F_1 and F_2. We also control for gender in F_2, yielding the following baseline specification, which was estimated using ordinary least squares regression (OLS):

$$\ln(W_{F_2}) = \delta + \beta \ln(W_{F_1}) + \lambda_{F_2}(F_2 \text{ age}) + \lambda_{F_1}(F_1 \text{ age}) + \tau(F_2 \text{ male}) + \pi(\text{other controls}) + e.$$

Here W_{F_2} and W_{F_1} are wealth outcomes in the two generations, δ is the regression intercept, β is an intergenerational elasticity, λ_{F_2} and λ_{F_1} are vectors of coefficients that apply to their respective polynomial terms in F_2 and F_1 age, τ is the effect of F_2 gender, π is a vector of parameters associated with situation-specific control variables described below, and e is the regression error term.

The unit of analysis for all such equations was the individual or the household in F_2; in other words, the sample size is dictated by the number of children studied, not the number of parents. As a result, parents with multiple children appear multiple times on the right-hand side of the equation. (The consequences of this for the estimation of standard errors are discussed below.)

In order that our estimates be as comparable as possible across wealth classes and populations, we sought to make as few modifications to this baseline specification as possible. Still, additions and modifications were necessary in some cases, for the reasons described next. The precise procedures used for each data set are detailed in table A1. Our goal was to make the minimal deviation from the baseline specification that was needed to ensure that our estimates would be (*a*) *unbiased*, that is, representative of the average child's relation to her parents; (*b*) *robust* to small changes in the sample or the specification; and (*c*) reasonably *precise*, with consistently estimated standard errors.

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Table A1
Details of estimation of β

Population	Researcher	Wealth type	Class	Elasticity (β)	SE	SE type	P value	N (F_2)	Model	F_1 measure	F_2 measure	Controls	Outlier effects
Hunter-gatherer:													
Ache	Hill	Hunting returns	Embodied	.081	.273	Conventional, not clustered	.768	49 (2,915 trips)	Levels, with measurement error correction	Age- and year-corrected lifetime average kg of meat per trip, father	Age- and year-corrected lifetime average kg of meat per trip	None: age and time corrections done in first stage	Not influential
Ache	Hill	Weight	Embodied	.509	.128	Robust, clustered on HHID	.000	137	Levels, elasticity at means	Midparent weight	F_2 weight	Quadratic in midparent and F_2 age, sex, single parent controls	Not influential
Hadza	Marlowe	Weight	Embodied	.305	.076	Robust, clustered on HHID	.000	227	Levels, elasticity at means	Midparent weight	F_2 weight	Quartic in midparent age, quadratic in F_2 age, sex, single parent controls	Not influential
Hadza	Marlowe	Hunting-gathering returns	Embodied	.047	.193	Robust, clustered on HHID	.808	33	Levels, elasticity at means	Midparent total kilocalories/day from hunting and foraging, all food sources	Total kilocalories/day from hunting and foraging, all food sources	Quartic in midparent and F_2 age, sex, single parent controls; mother-daughter digging omitted because they dig together	Not influential
Hadza	Marlowe	Grip strength	Embodied	−.044	.050	Robust, clustered on HHID	.386	196	Levels, elasticity at means	Midparent right-hand grip strength	Right-hand grip strength	Quadratic in midparent and F_2 age, sex, single parent controls	Not influential
Ju/'hoansi	Wiessner	Social networks	Relational	.208	.114	Bootstrapped, clustered on HHID	.067	26	Logs, with mean correction	Log of sum of parents Hxaro partners	Log of Hxaro partners	Quadratic in midparent and F_2 age, sex (single parent controls greatly reduced precision)	Not influential
Lamalera	Nolin	Reproductive success	Embodied	.161	.174	Robust, clustered on HHID	.355	121	Levels, elasticity at means	Midparent reproductive success	Reproductive success	Quadratic in midparent and F_2 age, sex (all two-parent households)	Not influential
Lamalera	Nolin	Quality of housing	Material	.218	.099	Robust, clustered on HHID	.027	121	Levels, elasticity at means	Mokken Scale of house construction	Mokken Scale of house construction	Quartic in midparent age and F_2 age, sex (all two-parent households)	Not influential
Lamalera	Nolin	Boat shares	Material	.122	.093	Robust, clustered on HHID	.190	121	Levels, elasticity at means	Household's shares in ownership of fishing boats	Household's shares in ownership of fishing boats	Quadratic in F_2 age, sex (all two-parent households)	Removal of single most influential observation raises β to .185
Lamalera	Nolin	Food-sharing partners	Relational	.251	.052	Bootstrapped, clustered on HHID	.000	119	Logs, with mean correction	No. households the focal household gives food to or receives food from	No. households the focal household gives food to or receives food from	Quadratic in midparent and F_2 age, sex (all two-parent households)	Not influential
Meriam	E. Smith	Reproductive success	Embodied	.088	.247	Robust, clustered on HHID	.722	91	Levels, elasticity at means	Midparent reproductive success	Reproductive success	Quadratic F_2 age, sex, single parent controls	Not influential
Horticultural:													
Dominicans	Quinlan	Land	Material	.137	.140	Conventional, not clustered	.327	62	Levels, with measurement error correction based on reliability estimate of .7, from dual reports	Landholdings (fathers)	Landholdings (sons and daughters)	F_2 age and sex	Positive elasticity driven by a single outlier, which is confirmed to be correct (a wealthy father-son pair); without this point, estimate is negative (but insignificant)
Gambia	Sear	Weight	Embodied	.391	.041	Robust, clustered on HHID	.000	1,274	Levels, elasticity at means	Midparent weight	Weight	Quartic in midparent and F_2 age, sex, single parent controls	Not influential
Gambia	Sear	Reproductive success	Embodied	.088	.086	Robust, clustered on HHID	.309	967	Levels, elasticity at means	Midparent survival adjusted RS5	Survival adjusted RS5	Quadratic in midparent and F_2 ages, sex, F_1 and F_2 birth years, single parent controls, village controls, controls for type of censoring	Not influential
Pimbwe	Borgerhoff Mulder	Farming skill	Embodied	−.015	.097	Robust, clustered on HHID	.875	217	Levels, elasticity at means	No. months family is without maize	No. months family is without maize	Quadratic in midparent and F_2 age, sex, single parent controls, linear controls in hectares of land planted in both generations	Not influential
Pimbwe	Borgerhoff Mulder	Weight	Embodied	.377	.096	Robust, clustered on HHID	.000	148	Levels, elasticity at means	Midparent weight	Weight	Quartic in midparent and F_2 age, sex, single parent controls	Not influential
Pimbwe	Borgerhoff Mulder	Reproductive success	Embodied	−.057	.107	Robust, clustered on HHID	.592	599	Levels, elasticity at means	Midparent RS5, survival adjusted	Survival adjusted RS5	Quadratic in midparent and F_2 age, sex, single parent controls	Not influential
Pimbwe	Borgerhoff Mulder	Household and farm utensils	Material	.107	.318	Bootstrapped, clustered on HHID	.735	283	Logs, with mean correction	Log value of midparent wealth (household and farm utensils) averaged across multiple surveys	Log value of household and farm utensils averaged across multiple surveys	Quartic in midparent and F_2 age, sex, single parent controls	Not influential
Tsimane	Gurven/ Schniter	Knowledge of skills	Embodied	.111	.094	Robust, clustered on HHID	.240	181	Levels, elasticity at means	Average of parents' % of skills possessed (different skill sets for men and women)	% skills possessed (different skill sets for men and women)	Quadratic in F_2 age, sex, single parent controls, village controls	Not influential
Tsimane	Gurven	Grip strength	Embodied	.070	.042	Robust, clustered on HHID	.094	490	Levels, elasticity at means.	Midparent grip strength	Grip strength	Quartic in midparent and F_2 age, sex, single parent controls	Not influential
Tsimane	Gurven	Weight	Embodied	.253	.069	Robust, clustered on HHID	.000	383	Levels, elasticity at means.	Midparent weight	Own weight	Quadratic in F_2 age, sex, single parent controls (parental age controls had no effect)	Not influential

Tsimane	Gurven	Hunting returns	Embodied	.384	.130	Weighted least squares	.003	26 (203 trips)	Levels, weighted by son's no. trips (weighted least squares); elasticity at means	Rate of return (father)	Rate of return (son)	Quadratic in father's and son's ages, village dummies	Result highly sensitive to outliers; dropping the most positively influential point reduces elasticity to .004; removing the most negatively influential point raises elasticity to .593
Tsimane	Gurven	Reproductive success	Embodied	.128	.073	Bootstrapped, clustered on HHID	.079	849	Two-part model: reproductive success in logs, adjusted to arithmetic mean	Log midparent reproductive success	Log child reproductive success	Quartic in midparent and F_2 age, sex, single parent controls	Not influential
Tsimane	Gurven	Household wealth	Material	.024	.071	Bootstrapped, clustered on HHID	.731	110	Logs, with mean correction	Log average of parents' wealth = value of household objects	Log wealth	Quadratic in midparent and F_2 age, sex	Removal of most influential observation lowers elasticity to −.002
Tsimane	Hooper	Labor cooperation network ties	Relational	.181	.106	Robust, clustered on FID	.086	67	Levels, elasticity at means	No. individuals from remote communities who helped father in field	No. individuals from remote communities who helped son in field	Quadratic in father's and son's ages	Not influential
Tsimane	Hooper	Allies in conflict	Relational	.338	.103	Robust, clustered on HHID	.001	45	Levels, elasticity at means	Peer interviews: relative ranking of who would have more allies in a conflict (father)	Peer interviews: relative ranking of who would have more allies in a conflict (son)	Quadratic in F_2 age (F_1 age immaterial)	Not influential
Pastoral:													
Datoga	Borgerhoff Mulder	Reproductive success	Embodied	.066	.060	Robust, clustered on HHID	.274	133	Levels, elasticity at means	Father's RS5, survival adjusted	F_2 RS5, survival adjusted	Quadratic in father's age and own age, sex	Not influential
Datoga	Borgerhoff Mulder	Livestock	Material	.622	.127	Conventional	.000	135	Levels, with measurement error correction	Father's livestock	Own livestock	Quadratic in father's and F_2 age, sex	Four high and four low outliers roughly offset each other; data are valid
Juhaina Arabs	Fazzio	Camels (milk)	Material	.535	.226	Bootstrapped, clustered on FID	.018	21	Logs, with mean adjustment	Camel milk collected by father	Camel milk collected by child	Quadratic in F_2 age, sex	Not influential
Sangu (Ukwaheri)	McElreath	Cattle	Material	.957	.424	Bootstrapped, clustered on FID	.024	108	Levels, elasticity at means	Father's livestock holdings	Child livestock holdings	Quadratic in F_2 age, sex	Two wealthy fathers drive this result, but they are valid data; without them the elasticity is −.04; we used bootstrapped standard errors to emphasize this lack of precision; these are 70% larger than conventionally estimated standard errors
Yomut Charwa	Irons	Patrimony (livestock)	Material	.564	.167	Robust, not clustered	.001	22	Levels, elasticity at means	Father's patrimony	Son's patrimony	None	Not influential
Agricultural:													
Bengali	Leonetti	Reproductive success	Embodied	−.074	.057	Bootstrapped, clustered on MID	.191	382	Logs, with mean adjustment	Mother's reproductive success	Son reproductive success	Quadratics in F_1 and F_2 ages	Not influential
Bengaluru	Shenk	In-law networks	Relational	.114	.073	Bootstrapped, clustered on HHID	.117	249	Logs, with mean adjustment	Parents' average in-law network size	Son's and daughter's in-law network size	Sex (age insignificant)	Not influential
East Anglians	Clark	Reproductive success	Embodied	.171	.150	Robust, clustered on FID	.255	200	Levels, elasticity at means	Father's reproductive success	Reproductive success	Quadratics in father's and son's ages; linear in son's decade of death	Not influential
East Anglians	Clark	Estate value (mostly land)	Material	.642	.073	Bootstrapped, clustered on FID	.000	210	Logs, with mean correction and selection correction	Log father's estate value	Log son's estate value.	None; age-at-death and decade-of-birth corrections immaterial	Not influential
Khasi	Leonetti	Reproductive success	Embodied	.165	.045	Robust, clustered on MID	.000	650	Levels, elasticity at means	Mother's reproductive success	Daughter's reproductive success	Quadratics in mother's and daughter's ages	Not influential
Kipsigis	Borgerhoff Mulder	Reproductive success	Embodied	.213	.106	Robust, clustered on FID	.044	270	Levels, elasticity at means	Father's survival adjusted RS5	Survival adjusted RS5	Linear terms in F_1 and F_2 age, sex	Not influential
Kipsigis	Borgerhoff Mulder	Land	Material	.357	.041	Conventional	.000	270	Levels, with measurement error correction	Father's landholdings	Own landholdings	Quadratic in children's ages, sex	Not influential
Kipsigis	Borgerhoff Mulder	Livestock	Material	.635	.098	Conventional	.000	270	Levels, with measurement error correction	Father's livestock	Own livestock	Quadratic in children's ages, sex	Not influential
Kipsigis	Borgerhoff Mulder	Cattle partners	Relational	.041	.139	Robust, clustered on FID	.767	102	Levels, elasticity at means	Father's cattle partners	Child's cattle partners	Quartic in father's and children's ages, sex	Not influential
Krummhörn	Beise	Land	Material	.610	.043	Robust, clustered on FID	.000	1,602	Levels, elasticity at means	Father's land	Child's land	Quadratic in F_2 year of birth, sex	Not influential
Skellefteå	Low	Reproductive success	Embodied	.010	.028	Robust, not clustered	.714	2,515	Levels, elasticity at means	Midparent reproductive success	Son's reproductive success	Quadratic in F_2 age, single parent controls	Not influential
Yomut Chomur	Irons	Patrimony (land)	Material	.528	.147	Robust, not clustered	.000	58	Levels, elasticity at means	Father's patrimony	Son's patrimony	None	Removal of three most influential observations (two positively, one negatively affecting slope by >1 SD) reduces elasticity to .266 (SE = .117)

Note. SE = standard error; FID, HHID, and MID = identified by father, household, and mother, respectively; RS5 = estimated number of offspring surviving to age 5. In the "Researcher" column, the researcher listed is the primary researcher who provided the ethnographic or historical data set used to generate the estimates of β. For further background, see Smith et al. (2010) for hunter-gatherer populations, Gurven et al. (2010) for horticultural populations, Borgerhoff Mulder et al. (2010) for pastoral populations, and Shenk et al. (2010) for agricultural populations.

Functional Form

The logarithmic functional form is preferred for use with data that are highly skewed, as is generally true of material wealth types, because it is more robust to extreme values and often yields more precise estimates than a model estimated in levels. It was used whenever practicable. The main obstacle to its use occurs when there are a nontrivial number of zeros in the F_1 data, since one cannot take the logarithm of 0. A common, but ill-advised, solution to this problem is to add an arbitrary constant to all observations prior to taking logs. This was rejected in our case because in some data sets the estimated elasticity was extremely sensitive to the arbitrary constant. Moreover, the widely different scales of our many measures meant that no single value stood in the same relation to the nonzero data in all cases.

We chose instead to work in levels, as opposed to logarithms, for measures with large numbers of zeros in F_1. In such cases, the reported elasticity is the elasticity at the mean of all independent variables. In a few cases this led to estimates that were heavily influenced by a small number of outliers; these cases are noted in table A1. Our measurement error–corrected results were also based on regressions in levels (see below).

Cases in which there were zeros in F_2 but not F_1 were handled either by working in levels or by using a two-part model in which the first part consists of a probit equation to separate the zero from the nonzero outcomes and the second part is an OLS regression in logarithms. The parameters from these two models can then be combined into a single elasticity (Hertz 2010).

Elasticities that are based on logarithms (such as the term β, in the equation above) are elasticities of the conditional *geometric* mean of the F_2 outcome with respect to the F_1 variable, while models in levels produce elasticities of the conditional *arithmetic* mean. For comparability across these two specifications, we transformed the log-derived elasticities (whether from the basic single-equation specification listed above or from a two-part model) into elasticities of the arithmetic mean, following the methods described by Hertz (2010).

Whenever possible, we compared linear and logarithmic estimates, and we found that, in general, our final elasticities were robust to the choice of functional form. This was especially clear when the data were not skewed (e.g., the anthropometric data).

Treatment of Gender in F_1 and F_2

In some societies, a particular wealth type may pertain only to men (e.g., estate values in East Anglia in the sixteenth–nineteenth centuries). In these cases, the relevant elasticity is clearly that between fathers and sons, and F_2 gender controls are not needed. In other cases, the form of wealth may be owned by both men and women, and, provided that both parents' wealth measures are separately ascertainable, one could calculate father-son, father-daughter, mother-son, and mother-daughter elasticities separately. Given the importance of gender in determining both wealth levels and inheritance practices, there is every reason to expect that these four elasticities might differ. On the other hand, this results in a proliferation of statistics for each society and wealth type (whereas our goal is to synthesize results for comparative purposes) and reduces the sample size for each estimate (which reduces the precision of the estimates). In such cases, we chose instead to pool sons and daughters and to include an indicator variable for their gender. Since the gender of offspring is not, in general, strongly correlated to parents' wealth, this pooling should yield an elasticity that is an average of the son-specific and daughter-specific values.

For F_1, if both father's and mother's wealth were measured, we chose to use either their sum or their average, depending on which quantity best captured our concept of "household or parental status." For the anthropometric measures, the "midparent" value, or average value, was used. Ownership of most forms of household material wealth was not differentiated by gender, and so these are effectively sums, as are our measures of parental network partners in the case of the Ju/'hoansi and the Lamelera.

A complication is that even if a given type of wealth may be owned by both mothers and fathers, not all households will contain both parents, either because of permanent separation, death, or temporary absence; moreover, in polygynous households, children of the same man might be mapped to different mothers. We dealt with these cases by including indicator variables that flagged those households with only the father's information and those with only the mother's information. These variables were often quite important, and their inclusion serves to reduce an important source of omitted variables bias. For example, mother-only households will have lower than average F_1 weight, and yet conditional of this lower weight value, the offspring should be expected to have higher than average weight since their weight is, in fact, also causally determined by that of their missing father.

Age Controls

In most cases, we used quadratic polynomials in the age of the child and in the average age of the parents. In some of the smaller samples, quadratic age controls led to counterintuitive or extremely steep age profiles, and linear controls proved more plausible. In larger samples, on the other hand, we often augmented the quadratics to quartic polynomials, which can provide a better fit and higher precision. In other cases, F_1 age controls were entirely immaterial and were dropped. In any event, in the great majority of cases, the final elasticity estimates did not depend strongly on the choice of age controls. Most analyses also specified a minimum age for F_2, which was determined based on the nature of the wealth measure and the distribution of the data. Details appear in table A1.

Other Controls

For data that were drawn from historical records, we were often able to include a time-trend term, to try to disentangle age effects from time effects; examples include the Ache and Gambian data sets. Finally, in two cases (Tsimane skills and hunting returns) we also included village indicators. The logic here was that if some villages are, say, located near rivers, so that everyone fishes, while others are not located near rivers, then the association between fishing ability in F_1 and F_2 is overstated if the village controls are omitted and if fishing skills are socially acquired and not inherited per se.

Data Cleaning and Robustness to Outliers

Prior to analysis, all data were inspected for implausible values such as children who were too close in age to their biological parents (or older) and implausible anthropometric outliers; such cases were corrected where possible or they were dropped. Outliers in material wealth measures were also investigated on a case-by-case basis: the anthropologist who collected the data was consulted and, more often than not, could attest to the validity of these extreme values. In the final column of table A1, we flag the few estimates that were substantially sensitive to outliers and report the results obtained after dropping some of the most influential cases. These were identified by visual inspection and by checking their DFBETA test statistics (StataCorp 2007), with special attention paid to those cases whose omission would alter the point estimate by more than .75 SE in either direction.

Standard Errors

In most cases we use heteroskedasticity-robust standard errors (White 1980), under the presumption that the data were subject to heteroskedasticity of unknown form. These were also calculated to take account of clustering at the level of the parental household; in other words, to account for the likely correlation among unobservable factors for children of the same parents or households. This generally resulted in larger standard errors reflecting the loss of precision due to the intracluster correlation.

For the hunting returns data, we worked with averages over many hunting trips, generating heteroskedasticity of *known* form, which we handled using weighted least squares (i.e., by weighting the averages by the number of hunting trips they represent). The exception was the Ache hunting data, for which a single observation representing an extremely high number of trips stood as an influential outlier. In that case, the efficiency gain of correcting for heteroskedasticity did not seem to justify introducing what appeared to be a significant source of bias, and weighted least squares was not used.

As noted, results based on logarithmic measures were transformed to apply to the arithmetic mean, for comparability with the levels-based elasticities. In these cases, and in the two-part model, standard errors are bootstrapped, sampling with replacement from among the parental clusters. Last, we used conventional standard errors for those estimates that we were able to adjust for the effects of measurement error.

Sample Selection Bias

Many of the data sets are village-based surveys and are thus closer to a census than to a random sample. However, they are often limited by who is present in the household and so may be subject to biases related to nonrandom outmigration. We were not able to address this in a systematic way due to the lack of instruments to predict migration. One way to view our results is to state that they pertain to the dynamics of wealth

transmission among those who do not leave their parents' village. One particular form of sample selection bias that we could and did address related to the bequest data from East Anglia. There the sons of low-wealth parents were less likely to leave wills, but by truncating the sample at a minimum parental wealth threshold, we obtain a data set of father-son *pairs* that has roughly the same wealth distribution as the full sample of fathers. Note that this amounts to selection on an independent variable and not a dependent variable: it corrects for an unrepresentative sample and should not introduce any new source of bias if the intergenerational relationship is truly a linear one.

Measurement Error Bias

Classical (random) errors in the measurement of parental wealth will normally attenuate the estimated intergenerational elasticity (i.e., bias it toward 0). The best way to prevent this problem is to start with well-measured data in the first place. In this regard, our reliance on experts with extensive field experience and knowledge of their populations is important, as is the fact that in several cases (e.g., the Gambian data, which are drawn from a long-running panel study), we were able to collapse multiple measurements into a long-run average. We are generally confident in the quality of our anthropometric data and do not believe that correcting for residual measurement error would raise our estimate of the transmissibility of somatic wealth appreciably.

Perhaps the hardest forms of wealth to measure are the material outcomes, which sometimes involved aggregating different items using estimated prices, or were based on recall, not observation. Even in carefully executed studies such as the Panel Study of Income Dynamics, the reliability of log annual earnings falls in the range of .70–.85 (Bound et al. 1994; Duncan and Hill 1985). If our material wealth data are of equivalent reliability, then we might expect that correcting for measurement error would raise our material wealth β's (which were, on average, already higher than for the other two wealth classes) by about 20%–40%.

There were five cases in which we had repeated measures of the same quantity and could thus make an explicit correction for measurement error. The first of these was the data on Ache hunting returns, where the presence of some hunters with many trips to their credit allows us to estimate the reliability of the data when fewer trips are recorded. We estimated that the average reliability of the data was .68, and we corrected our elasticity to reflect this, using the standard algorithm for adjusting a regression coefficient under the assumption that a single regressor is mismeasured, with classical measurement error and known reliability (Greene 2003). The second case was the Dominican land data, where measurement error estimates are based on comparing dual reports from community members. In the latter case, we found that male landholdings were estimated with a reliability of .70, and we corrected our estimates accordingly, while female landholdings were estimated with such a high degree of error as to be unusable.

The final three cases are the Datoga and Kipsigis cattle data and the Kipsigis land data, for which multiple annual measurements were available. The correlation between such measurements is an estimate of reliability; it was .75 for cattle holdings in both populations and .93 for Kipsigis land wealth. Given that four of our five measurement error–corrected results apply to material wealth, it is important to note that none of the qualitative findings reported in the paper were altered by the measurement error correction.

Statistical Estimation of m*: α Value for Material Wealth*

As noted in the introduction (Bowles, Smith, and Borgerhoff Mulder 2010, in this issue) and other papers in the forum, our estimate of the relative importance of each wealth class to the production of economic well-being (α) is based on expert assessments. However, for material wealth, we were able to validate these estimates econometrically, using three data sets to estimate the relative importance of material wealth in agricultural production.

The first is an agropastoralist population (Nyaturu) in Tanzania observed half a century ago. (Our estimates are calculated from the Cobb-Douglas production functions estimated in Massell 1963.) We estimated α for material wealth as the sum of the estimated exponents for cattle and land divided by the sum of these two estimates plus the coefficient for labor, so that the resulting exponents summed to 1 (from eq. [2], estimated on p. 37 in Massell 1963). This value is .76, implying that the sum of the α's for embodied and relational wealth is .24. We have no way to assess if these data are representative, but the production system of the Nyaturu is very typical of East African agropastoral societies (Schneider 1979). Taken at face value, this statistical estimate suggests that our ethnographers' estimates for the α's in agricultural (.59) and pastoral (.61) societies could even be a bit on the low side. Correcting this underestimate (if that is what it is) would, of course, strengthen our results.

Our second α estimate is for seven grain- and rice-growing areas in India during the 1950s and is derived from production function estimates in Bardhan (1973). Our estimate is the coefficient on acres tilled minus the coefficient on man-days of labor per acre, divided by the coefficient on acres (all in natural logarithms). There are a total of eight estimates from grain-farming areas for material wealth (land) that average .68. Combining this estimate with the results from the Tanzanian grain growers, the average is .69, exactly the mean of the ethnographers' estimates for our five grain-growing agricultural populations. The ethnographic and Indian econometric estimates agree that the α for land is less in rice-growing areas, though here the correspondence is not exact. The econometrically based estimates of α for the four Indian rice-growing areas average .33 compared with our ethnographic estimates (from three rice areas also in India) of .41. Were we to use the econometrically estimated α's, the average for all agricultural populations would be .57 rather than the .59 we obtained from our ethnographers.

Estimates of m for pastoral and horticultural production come from a third source, a single study (Berhanu, Colman, and Fayissa 2007) of the Borana people in southern Ethiopia who are seminomadic pastoralists engaging in some horticultural production. The estimated $m = .84$ for pastoral production is the estimated exponent of total livestock units (TLUs) in a Cobb-Douglas production function (the dependent variable is the total value of pastoral production). The estimated $m = .23$ for horticultural production is the sum of the exponents for land and oxen inputs in agricultural production adjusted to take account of decreasing returns to scale.

Aggregation of β and Gini Estimates by Wealth Class and Production System

The β estimates for each wealth class that appear in figure 2 of the concluding paper (Smith et al. 2010, in this issue), as well as in table A5, are simple averages of the underlying β's for that wealth class and production system (as listed in table A1 as well as in papers in the special section). Their standard errors are estimated using a regression of the elasticities against a full set of 12 dummy variables, one for each cell. This amounts to assuming that the estimated elasticities are homoskedastic, that is, drawn from a common population. While this is a strong assumption, in this application it is also a conservative one: it yields larger standard errors than alternative methods (such as White's robust estimator) and thus does not tend to exaggerate the precision of our estimates or of differences between them.

To calculate averages of β within or across populations, these cell means were combined using the "importance weights," which are the α terms described above. The full array of estimates of α, by population and wealth type, are provided in table A2. Note that we averaged these weights across populations in each production system. Identical methods were used to produce averages of the Gini coefficients (see below).

Table A2
Populations, wealth classes, wealth-class-specific estimates of α, and averages across production systems

Population	Embodied	Relational	Material
Hunter-gatherer:			
Hadza	.70	.30	.00
Meriam	.40	.40	.20
Ju/'hoansi	.35	.40	.25
Ache	.50	.45	.05
Lamalera	.35	.40	.25
Average	.46	.39	.15
Horticultural:			
Gambia	.55	.25	.20
Tsimane	.45	.40	.15
Pimbwe	.60	.10	.30
Dominica	.50	.30	.20
Average	.53	.26	.21
Pastoralist:			
Yomut Charwa	.20	.10	.70
Datoga	.25	.25	.50
Sangu (Ukwaheri)	.30	.10	.60
Juhaina Arabs	.28	.10	.62
Average	.26	.14	.61
Agricultural:			
Bengali	.30	.20	.50
Khasi	.40	.25	.35
Kipsigis	.20	.10	.70
Yomut Chomur	.20	.10	.70
England	.50	.00	.50
Skellefteå	.10	.10	.80
Krummhörn	.15	.10	.75
Bengaluru	.30	.30	.40
Average	.27	.14	.59

Estimates of Inequality (Gini Coefficients)

Population and wealth type–specific Gini coefficients were calculated using the maximal sample of individuals, including all available F_2's, F_1 mothers, and F_1 fathers, with no duplicates, for whom wealth and age data were available (with appropriate minimum-age criteria). There was no requirement that wealth data be simultaneously available in two generations. Thus, many more observations were used in the calculation of the Gini inequality estimates than were used for calculating the intergenerational elasticities.

The Ginis were age adjusted by regressing the raw data against a quadratic in age and saving the residuals from this regression. These were then added to the predicted value at age 50. In some cases, the age on which the data were centered was raised or lowered by, at most, 10 years, to prevent 0 values from being adjusted into negative numbers. (When negative numbers were unavoidable, they were recoded to 0.) Ginis were then calculated on these age-adjusted data, and their standard errors were bootstrapped using 100 replications. All results and sample sizes are listed in table A3. Ginis were weighted and averaged in the same way as β's (described above; see table A4 here as well as fig. 4 in Smith et al. 2010).

Whenever the intergenerational elasticities were calculated using village dummy variables (as described above), village dummies were also included in the age-adjustment regression. In these cases, both the intergenerational transmission measures and the inequality measures become within-village estimates.

Table A3
Gini coefficients for 43 wealth types (and sample sizes for both generations)

Population	Wealth type	Gini	SE (Gini)	*N* (F_1 + F_2)
Ache	Hunting returns	.237	.014	147
Ache	Weight	.064	.003	297
Hadza	Weight	.079	.002	485
Hadza	Hunting-gathering returns	.339	.018	179
Hadza	Grip strength	.191	.006	451
Ju/'hoansi	Social networks	.216	.028	44
Lamalera	Reproductive success	.296	.012	560
Lamalera	Quality of housing	.241	.007	610
Lamalera	Boat shares	.474	.010	611
Lamalera	Food sharing partners	.263	.010	611
Meriam	Reproductive success	.298	.024	145
Dominicans	Land	.671	.024	315
Gambia	Weight	.073	.001	2,355
Gambia	Reproductive success	.328	.010	1,935
Pimbwe	Farming skill	.308	.011	507
Pimbwe	Weight	.079	.003	395
Pimbwe	Reproductive success	.190	.005	1,041
Pimbwe	Household and farm utensils	.563	.012	614
Tsimane	Knowledge of skills	.076	.004	265
Tsimane	Grip strength	.263	.006	1,249
Tsimane	Weight	.087	.002	1,033
Tsimane	Hunting returns	.371	.037	40
Tsimane	Reproductive success	.190	.005	1,288
Tsimane	Household wealth	.326	.020	361
Tsimane	Labor cooperation network ties	.315	.014	234
Tsimane	Allies in conflict	.141	.008	130
Datoga	Reproductive success	.200	.018	186
Datoga	Livestock	.386	.037	189
Juhaina Arabs	Camels (milk)	.346	.037	33
Sangu (Ukwaheri)	Cattle	.694	.052	130
Yomut Charwa	Patrimony (livestock)	.599	.042	44
Bengali	Reproductive success	.228	.006	729
Bengaluru	In-law networks	.468	.189	499
East Anglians	Reproductive success	.415	.016	381
East Anglians	Estate value (mostly land)	.608	.022	387
Khasi	Reproductive success	.198	.004	1,138
Kipsigis	Reproductive success	.301	.015	425
Kipsigis	Land	.482	.036	426
Kipsigis	Livestock	.450	.019	425
Kipsigis	Cattle partners	.446	.021	181
Krummhörn	Land	.708	.008	1,887
Skellefteå	Reproductive success	.251	.002	6,238
Yomut Chomur	Patrimony (land)	.615	.028	113

Table A4
Gini coefficients by production system and wealth class

Production system	Embodied	Relational	Material	α-Weighted average
Hunter-gatherer:				
α	.46	.39	.15	
Gini	.21	.24	.36	.25
SE (Gini)	(.05)	(.08)	(.08)	(.04)
P value	.00	.01	.00	.00
Horticultural:				
α	.53	.26	.21	
Gini	.20	.23	.52	.27
SE (Gini)	(.04)	(.08)	(.07)	(.03)
P value	.00	.01	.00	.00
Pastoral:				
α	.26	.14	.61	
Gini	.20	na	.51	.42[a]
SE (Gini)	(.12)	na	(.06)	(.05)
P value	.10	na	.00	.00
Agricultural:				
α	.27	.14	.59	
Gini	.28	.46	.57	.48
SE (Gini)	(.05)	(.08)	(.05)	(.04)
P value	.10	.00	.00	.00
Average across all production systems:				
α	.38	.23	.39	
Gini	.22	.31	.49	.35
SE (Gini)	(.04)	(.05)	(.03)	(.02)
P value	.00	.00	.00	.00

Note. The *P* values test whether the true Gini coefficient is 0 for that cell. na = not available.
[a] The Gini for Kipsigis cattle partners is used in the Pastoral/Relational cell for the calculation of the α-weighted average across wealth classes.

Decomposition of Population Differences in α-Weighted β's

The decomposition summarized in table A5 and discussed in the concluding paper (Smith et al. 2010) was calculated as follows. First, we averaged the three values of α reported for hunter-gatherers with the three values reported for horticulturalists and likewise for the β's. We then used the average α's to weight the average β's. Next, we did the same for the pastoral and agricultural populations, thus reducing four production systems to two. The difference between these two resulting α-weighted β's can then be decomposed as follows:

$$\alpha_1\beta_1 - \alpha_0\beta_0 \equiv \bar{\alpha}(\beta_1 - \beta_0) + \bar{\beta}(\alpha_1 - \alpha_0),$$

where the 1 subscript refers to the pastoral and agricultural societies and 0 to the other two production systems. The term $\bar{\alpha}$ is the grand mean of the α's for all four production systems and likewise for $\bar{\beta}$. Thus, the first term captures the effects of differing β's across the paired production systems, holding the α's at their means across production systems, while the second holds the β's fixed at their means across production systems and captures the contribution of differences in the α's across production systems. This is a variant of the Oaxaca-Blinder decomposition technique that is commonly used to study male-female wage differentials (Blinder 1973; Oaxaca 1973).

Table A5

β coefficients by production system and wealth class

Production system	Embodied	Relational	Material	α-Weighted average
Hunter-gatherer:				
α	.46	.39	.15	
β	.16	.23	.17	.19
SE (β)	(.06)	(.11)	(.11)	(.05)
P value	.01	.04	.12	0
Horticultural:				
α	.53	.26	.21	
β	.17	.26	.09	.18
SE (β)	(.05)	(.11)	(.09)	(.04)
P value	0	.02	.31	0
Pastoral:				
α	.26	.14	.61	
β	.07	na	.67	.43[a]
SE (β)	(.15)	0	(.07)	(.06)
P value	.66	0	0	0
Agricultural:				
α	.27	.14	.59	
β	.10	.08	.55	.36
SE (β)	(.07)	(.11)	(.07)	(.05)
P value	.66	.47	0	0
Average across all production systems:				
α	.38	.23	.39	
β	.12	.19	.37	.29
SE (β)	(.05)	(.06)	(.04)	(.03)
P value	.01	0	0	0
	Embodied − material	Relational − material		
Differences by wealth class in averages across production systems:				
$\Delta\beta$	−.25	−.18		
SE ($\Delta\beta$)	(.06)	(.07)		
P value	0	.02		
Average of hunter-gatherer and horticultural production systems:				
α	.49	.33	.18	
β	.17	.24	.13	.19
SE (β)	(.04)	(.07)	(0)	(.03)
P value	0	0	.07	0
Average of pastoral and agricultural production systems:				
α	.26	.14	.60	
β	.08	.08	.61	.40
SE (β)	(.08)	(.11)	(.05)	(.04)
P value	.33	.47	0	0
Difference between hunter-gather/horticultural and pastoral/ agricultural systems:				
$\Delta\beta$	.09	.17	−.48	−.21
SE ($\Delta\beta$)	(.09)	(.13)	(.08)	(.05)
P value	.34	.21	0	0
	Embodied − material	Relational − material		
Average of hunter-gatherer and horticultural production systems:				
$\Delta\beta$	.04	.11		
SE ($\Delta\beta$)	(.08)	(.10)		
P value	*.62*	*.27*		
Average of pastoral and agricultural production systems:				
$\Delta\beta$	−.53	−.53		
SE ($\Delta\beta$)	(.10)	(.12)		
P value	0	0		

Note. The first panel presents the average values of β for each production system and wealth class, along with their α-weighted averages across wealth classes (final column) and their unweighted averages across the four production sytems. The *P* values test the hypothesis that the true values of β for each cell are zero. In the second panel, the *P* values test whether embodied and relational β's are significantly different from material β's. The third panel compares the two paired systems and reports the difference in their α-weighted average β's (−.21), as discussed in the text; the *P* values test the hypothesis that this difference is zero. The final panel compares embodied to material wealth and network to material wealth for each pair of production systems. na = not available.

[a] The elasticity for Kipsigis cattle partners is used in the Pastoral/Relational cell for the calculation of the α-weighted average across wealth classes.

Relationship between β Values and the Probability of Attaining High and Low Positions in the Wealth Distribution Conditional on Parents' Position

How much intergenerational inequality does a given value of β indicate? To answer this question, we estimate the ratio of the probability that an offspring whose parent is in the top decile (or quintile) of the distribution of wealth will also end up in the top decile to the probability that the offspring of a parent in the bottom decile will end up in the top decile. We call this the inequality of life chances ratio (denoting it as ρ), as it measures the degree to which one's parents' wealth predicts one's own attainments as an adult. Assuming that the two generations' wealth have the same variance as would be true at the stationary distribution (so that the β is equal to the intergenerational correlation coefficient), we can create a 10×10 transition matrix (each entry of which, w_{ij}, gives the probability that the offspring of a parent in the ith decile will end up in the jth decile), from which we can calculate the middle column in table A6.

Table A6
Conversion of β values to inequality of life chances ratio (ρ)

β	ρ Deciles	ρ Quintiles
0	1.0	1.0
.05	1.4	1.2
.10	1.9	1.5
.15	2.6	1.8
.20	3.6	2.2
.25	5.0	2.8
.30	7.2	3.5
.35	1.6	4.4
.40	16.2	5.7
.45	25.9	7.6
.50	43.9	10.3
.55	80.2	14.7
.60	163.3	22.1
.65	386.6	35.8
.70	1,146	64.9
.75	4,839	140.3
.80	37,450	407.1
.85	881,747	2,083
.90	11,300,000	41,434
.95	. . .	. . .

Thus, if the average β is about what we find for horticultural and hunter-gatherer populations (say, .2), the son of the wealthy top decile is 3.6 times more likely to end up where his parents were (top wealth) than the son of someone whose parents were in the bottom decile.

1. A value of β close to 0 does not indicate an egalitarian system of intergenerational transmission. Small β's are associated with quite substantial values of ρ.

2. "Small" differences in β are associated with huge differences in ρ.

3. The ρ for quintiles (bottom and top fifths of the population) are, of course, less dramatic but, nonetheless, are impressive.

4. By either the decile or quintile measure, our hunter-gatherer and horticultural α-weighted β's demonstrate a substantial level of intergenerational inequality when measured by the comparison of the conditional probabilities of getting ahead for the offspring of top and bottom parents.

5. Pastoral or agricultural intergenerational inequality is much greater (4.5 times by the decile ρ measure, twice by the quintile ρ measure).

6. For $\beta = .95$, the probability that the son of the poorest decile will attain the top decile is so small that the

ρ cannot be reliably calculated. And for $\beta = .90$, the (decile) number is 11,300,000. The numbers for very high β's are subject to some error (especially for the decile case) because the denominator of the ratio is almost 0 (no chance of getting to the top at all), so small differences in that number make a large difference in the ratio.

Robustness Checks

Sensitivity of Weighted Averages of β to an Alternative Classification of Societies by Production System

We investigated the sensitivity of our main findings to a possible reclassification of societies across production systems. Two possible alternatives were selected as being worthy of consideration, namely, reclassifying the Ache as horticulturalists and the Kipsigis as pastoralists. (Although we do not believe that either of these reclassifications is truly justified, the question of the sensitivity of our results to these choices remains an important one.) In table A7, we implement this reclassification and replicate all components of table A5, reporting the mean β's by production system and wealth class as well as the α-weighted means of the β's for each production system. Note that reclassifying these two societies alters both the β's and the α's, since the α's for each cell are derived from averages across estimates for the societies in that cell.

As table A7 shows, this reclassification has virtually no effect on our estimates. The cell means of β for each production system and wealth class are not appreciably altered, and neither are the α-weighted averages.

Table A7

Sensitivity of α-weighted averages of β to an alternative classification of societies by production system

Production system	Embodied	Relational	Material	α-Weighted average
Hunter-gatherer:				
α	.45	.38	.18	
β	.11	.23	.17	.17
SE (β)	(.07)	(.11)	(.11)	(.05)
P value	.11	.04	.12	.00
Horticultural:				
α	.52	.30	.18	
β	.19	.26	.09	.19
SE (β)	(.04)	(.11)	(.09)	(.04)
P value	.00	.02	.32	.00
Pastoral:				
α	.25	.13	.62	
β	.14	.04	.61	.42
SE (β)	(.11)	(.15)	(.06)	(.05)
P value	.20	.79	.00	.00
Agricultural:				
α	.28	.15	.57	
β	.07	.11	.59	.38
SE (β)	(.08)	(.15)	(.09)	(.06)
P value	.38	.46	.00	.00
Average across all production systems:				
α	.37	.24	.39	
β	.13	.16	.37	.29
SE (β)	(.04)	(.07)	(.04)	(.03)
P value	.00	.02	.00	.00
	Embodied − material	Relational − material		
Differences by wealth class in averages across production systems:				
$\Delta\beta$	−.24	−.20		
SE ($\Delta\beta$)	(.06)	(.08)		
P value	.00	.01		
Average of hunter-gatherer and horticultural production systems:				
α	.49	.34	.18	
β	.15	.24	.13	.18
SE (β)	(.04)	(.08)	(.07)	(.03)
P value	.00	.00	.07	.00
Average of pastoral and agricultural production systems:				
α	.26	.14	.60	
β	.10	.08	.60	.40
SE (β)	(.07)	(.11)	(.05)	(.04)
P value	.13	.48	.00	.00
Difference between hunter-gather/horticultural and pastoral/ agricultural systems:				
$\Delta\beta$	.05	.17	−.47	−.22
SE ($\Delta\beta$)	(.08)	(.13)	(.09)	(.05)
P value	.54	.21	.00	.00
	Embodied − material	Relational − material		
Average of hunter-gatherer and horticultural production systems:				
$\Delta\beta$	.02	.11		
SE ($\Delta\beta$)	(.08)	(.10)		
P value	.78	.27		
Average of pastoral and agricultural production systems:				
$\Delta\beta$	−.50	−.52		
SE ($\Delta\beta$)	(.08)	(.12)		
P value	.00	.00		

Note. This table replicates table A5, after reclassifying the Ache as horticulturalists and the Kipsigis as pastoralists. See notes to table A5 and discussion in text.

Effects of Using Econometric Estimates of m *for α-Weighted β's and Ginis*

We explored the effect of using the econometric estimates of m^* described above. Because we lack separate estimates for the embodied versus the relational wealth classes, these were combined, and their sum $(e + r)$ was set to $1 - m^*$. Data limitations also required that we apply the estimate of m for horticulturalists to hunter-gatherers as well. The results are in tables A8 and A9. The effect is to increase somewhat the differences in α-weighted β's between the hunter-gatherer and horticultural populations on the one hand and the agricultural and pastoral populations on the other; the weighted average Ginis are virtually unaffected.

Table A8
Sensitivity of α-weighted average β estimates to using econometric estimates of m

Production system	Embodied and relational	Material	α-Weighted average
Hunter-gatherer:			
α	.77	.23	
β	.18	.17	.18
SE (β)	(.05)	(.10)	
P value	.00	.11	
Horticultural:			
α	.77	.23	
β	.19	.09	.16
SE (β)	(.04)	(.08)	
P value	.00	.29	
Pastoral:			
α	.16	.84	
β	.07	.67	.57
SE (β)	(.15)	(.07)	
P value	.65	.00	
Agricultural:			
α	.43	.57	
β	.09	.55	.36
SE (β)	(.05)	(.07)	
P value	.10	.00	
Average across all production systems:			
α	.53	.47	
β	.13	.37	.24
SE (β)	(.04)	(.04)	
P value	.00	.00	

Note. Estimation method is identical to table A5, but the econometrically derived estimates for α are used (see text for discussion).

Table A9
Sensitivity of α-weighted average Gini estimates to using econometric estimates of m

Production system	Embodied and relational	Material	α-Weighted average
Hunter-gatherer:			
α	.77	.23	
Gini	.22	.36	.25
SE (Gini)	(.04)	(.08)	
P value	.00	.00	
Horticultural:			
α	.77	.23	
Gini	.20	.52	.27
SE (Gini)	(.03)	(.07)	
P value	.00	.00	
Pastoral:			
α	.16	.84	
Gini	.20	.51	.46
SE (Gini)	(.12)	(.06)	
P value	.10	.00	
Agricultural:			
α	.43	.57	
Gini	.33	.57	.47
SE (Gini)	(.05)	(.05)	
P value	.00	.00	
Average across all production systems:			
α	.53	.47	
Gini	.24	.49	.36
SE (Gini)	(.03)	(.03)	
P value	.00	.00	

Note. Estimation method is identical to table A4, but the econometrically derived estimates for α are used (see text for discussion).

Statistical Determinants of Intergenerational Transmission and Inequality

We also conducted a more detailed econometric exercise, treating the estimated elasticities and Gini coefficients as dependent variables and the wealth classes and the population's production system as independent variables. We estimated the following four equations with ordinary least squares:

$$\hat{\beta}_{wp} = c + \delta^{am} A_p M_w + \delta^{h} A_p + \delta^{m} M_w + \varepsilon_{wp}$$

$$\hat{\beta}_{wp} = c + \delta^{am} A_p M_w + \delta^{m} M_w + \phi_p + \varepsilon_{wp}$$

$$\hat{G}_{wp} = c + \delta^{am} A_p M_w + \delta^{h} A_p + \delta^{m} M_w + \varepsilon_{wp}$$

$$\hat{G}_{wp} = c + \delta^{am} A_p M_w + \delta^{m} M_w + \phi_p + \varepsilon_{wp},$$

where w denotes wealth class, p denotes population, M_w denotes an indicator for material wealth, A_p denotes a binary indicator for the population being agricultural or pastoral (as opposed to hunter-gatherer or horticultural), and ϕ_p denotes a population-specific average transmission coefficient, which we estimate with a set of dummy variables (fixed effects). The constant term is denoted c. The standard errors are heteroskedasticity robust but not clustered on population type (this is conservative; clustering the errors by population would lead to more significant results, perhaps due to within-population negative correlation in the error terms across wealth types). Results are reported and discussed in Borgerhoff Mulder et al. (2009).

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