Title: The demographic structure of work and intergenerational transfers in an Amazonian population

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Extended abstract:

This paper presents an integrated analysis of the Tsimane' economic subsistence system. Its analyses are guided by a body of evolutionary theory which posits that life history traits, the structure of social relationships, and nature of economic production co-evolve in patterned and predictable ways. This theory gives particular causal imperative to the constraints imposed by the age-schedule of productive efficiency on a species' equilibrium life history and social structure. The paper's principal findings can be summarized as follows.

(1) Mean Tsimane' return rates do not reach their peak until after age 20 across all economic domains. Peak productive efficiency per unit time is achieved earlier in fishing and harvesting than in hunting, likely due to the greater importance of skill-acquisition in determining returns from hunting. Declines in physical condition with aging also hit return rates from hunting earlier and harder than those from fishing or harvesting.

(2) As return rates from hunting far outpace those from fishing for men in their later 20s, 30s, and 40s, men in this period of life specialize in hunting and produce the bulk of fat and protein consumed in the Tsimane' diet. Male time allocation to hunting then declines in parallel with declining efficiency across the 50s, 60s, and 70s. Time allocation to horticulture, on the other hand, increases nearly monotonically across life for both sexes, resulting in peak horticultural production in the 40s, 50s, and 60s. These contributions of men and women aged 40-70 to total productivity within the population are substantial even when mortality is taken into account, due to the relatively high adult survival rates across these ages typical of the Tsimane' and other traditional human populations. Adolescents contribute calories to the household economy principally through fishing and horticulture, though at lower mean return rates than those of adults.

(3) The age-schedule of production was shown to be sensitive not only to changes in the efficiency and cost of productive effort, but also to changes in the consumption requirements of dependent kin through time. These estimated effects of dependent need on producer effort are patterned in accordance with a specialized division of labor within families

(4) As a consequence of the observed age-schedules of productive efficiency and effort across life, males and females are estimated to remain in net caloric deficit until around ages 17 and 23, respectively, confirming the remarkably long duration of human dependency during which energy must be supplied by older, more productive individuals, primarily kin. From the 20s onward, both sexes produce a substantial net surplus, which is channeled to support the growth and development of these younger dependents. Men are estimated to remain positive net producers until their mid-70s, while women in this sample continue to produce a net surplus even into their 80s.

(5) Our investigation of the effects of dependent need on producer effort informs us that while the consumption requirements of dependent kin do motivate higher levels of productivity in adulthood than would be achieved in their absence, they are not primarily responsible for the dominant late-age-biased shape of the production curve that requires such substantial intergenerational subsidization. These analyses do suggest, however, that if not for the depressing effect of small infants on young mothers' productivity, Tsimane' females would likely become net producers in their late teens, around the same age as males, rather than at the observed cross-over point in the early 20s.

(6) A direct analysis of the recipients of Tsimane' subsistence productivity confirms that calories are produced primarily to the benefit of close dependent kin, with adolescents supplying calories to their siblings, mothers and fathers supplying calories to their offspring, and grandparents supplying calories to their adult offspring and grandoffspring. Within Tsimane' extended families, the net flow of calories is consistently downward across generations with two exceptions: men in middle adulthood (from the mid-20s through the 40s) provide a net surplus of meat to both their descendent and ancestral kin; young husbands also provide a net surplus of calories to their parents-in-law, presumably as a manifestation of bride service. Bride service aside, the high productivity of parents and grandparents in their 40s, 50s, and 60s ensures a strong downward flow of carbohydrate calories that help fulfill the dietary need of descendent kin.

(7) Further examination of production in light of Tsimane' demography and familial structure shows that the individual-level pattern of net need early in life and net surplus later in life recapitulates itself at the level of the nuclear family: because young families grow at a rate that outpaces the productivity of parents in their teens, 20s, and 30s, families of young parents tend to sit in a state of net caloric deficit; families of older parents (especially in the range 50-70), on the other hand,

are highly productive, yet have fewer directly dependent offspring. These older families are thus in a prime position to help supply younger families in need.

(8) Finally, our analysis of transfers between families confirm that this pattern of net subsidization does in fact occur at the family level: older families with higher productivity and fewer dependents provide a net surplus to younger, closely related families with lower productivity and more dependents. This is accomplished predominantly through the high horticultural production levels of older families. Since the lion's share of meat, on the other hand, is produced by men in middle adulthood, there is a tendency for net upward flows of meat from middle-aged families to the families of younger and older kin; the older generation, complementarily, provides the bulk of carbohydrates downward. The analysis of inter-family transfers also reveals strong signatures of reciprocity, both in-kind (meat for meat, horticulture for horticulture) and cross-currency (meat for horticulture, and vice versa). We suggest that these results indicate the importance of (a) reciprocal consumption-smoothing and (b) specialization and exchange in the Tsimane' economic system, across and within generations.

This research contributes to research in biodemography and life history theory by demonstrating the ways in which the age-schedule of energy production, demography, and social structure are linked in one traditional human society. Its synthesis of inclusive fitness theory and embodied capital theory proves particularly productive in understanding the equilibrium structure of energy flows between individuals in society, and the effects of close kin on optimal age-schedules of productive effort across life.