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Changes in adult well-being and economic inequalities: An exploratory observational longitudinal study (2002–2010) of micro-level trends among Tsimane', a small-scale rural society of Indigenous People in the Bolivian Amazon

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ABSTRACT

Knowing what happens over time to the lifeways of people in contemporary small-scale non-industrial societies of the rural Global South matters because it helps assess changes in the quality of life of underrepresented groups. It has been hard to answer the question because longitudinal information is rarely collected in such settings. A longitudinal dataset of nine years (2002–2010) from a horticultural-foraging society of Indigenous People in the Bolivian Amazon (Tsimane') is used for an exploratory analysis of micro-level trends in indicators of well-being and economic inequalities. We selected 13 Tsimane' villages (from ~ 100) that varied in proximity to town and surveyed all households in each village. ~ 240 households were followed yearly to estimate trends of 21 outcomes (e.g., income, sociality, macronutrients). For each economic outcome, annual and all-years-combined Gini coefficients were estimated for the entire sample across the 13 villages. We show a rise in total asset wealth, a change in asset composition (less traditional wealth, more commercial wealth), higher monetary value of foods eaten, and better-perceived health, but a decline in caloric and protein consumption and no marked gender differences in objective or hedonic measures of well-being. Economic inequalities were non-trivial and showed no marked trend but varied between years; asset inequality varied less than income inequality. We document the value of longitudinal, locally grounded indexes of well-being to obtain a granular view of micro-level changes in well-being and the possible use of inequality in the consumption of calories and macronutrients as a valid proxy for income inequality in rural areas of the Global South with tenuous links to the market economy.

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1. Introduction

The past two decades have seen a sharp increase in the number of quantitative studies about quality of life of people in small-scale, non-industrial societies of the rural Global South (hereafter, *small-scale societies*), including hunter-gatherers, pastoralists, fishers, and horticulturists, because the studies can help reveal what is universal and idiosyncratic to each society (Henrich, 2022). We use the term well-being as an umbrella term for quality of life, a good life, or life satisfaction without implying the specialized meaning the term well-being has acquired in different academic disciplines (Section 1.2). In this article, we report the results of an exploratory study of micro-level trends in quality of life in one such society over a nine-year period.

Among empirical researchers of small-scale societies, the interest in change has taken the form of quantitative analysis of how aspects of the outside world, such as globalization, modernization, development, or the market economy, correlate with changes in aspects of human well-being. For example, using cross-sectional data on time allocation, researchers have documented a decline in leisure time between hunter-gatherer and industrial societies (Bhui et al., 2019; Sahlins, 1972). In another cross-sectional study, researchers found that sociality increased with greater participation in the marketplace (Henrich et al., 2010) while others have found that participation in the market economy correlated with a poorer diet, worse health, and greater inequality in material wealth (Donders & Barriocanal, 2020; Mattison et al., 2023).

With few exceptions dealing with changes in local ecological knowledge (reviewed in Aswani et al., 2018) or health (Shephard & Rode, 1996; Weitz et al., 2014), most quantitative studies have relied on cross-sectional information to infer change, and have done so owing to the scarcity of panel (longitudinal) datasets from small-scale societies. Two reasons explain the scarcity. First, small-scale societies are numerically small, mobile, and live in hard-to-reach places. National statistical agencies ignore them. Even the World Bank's Living Standards Measurement Study, a leading international study established in the early 1980 s to collect comparable household socioeconomic data on human welfare from the Global South, has only once (to our knowledge) collected information from a small-scale society, probably due to the high costs of collecting such data and the difficulties of applying a money metric to measure welfare in societies that often lack formal markets or prices (Jerven, 2011; Tucker et al., 2015). Second, most research on contemporary rural small-scale societies comes from bio-cultural anthropology, a discipline with a weak tradition of collecting panel data (Gravlee et al., 2009). Cross-sectional data are adequate to compare end-states, but the analysis of change among living human populations requires using the same protocol to collect information from the same entities over time (Deaton, 1985).

Here, we start filling the gap by using a yearly panel dataset (2002–2010) from a highly autarkic society of Indigenous People in the Bolivia Amazon (Tsimane') to undertake an exploratory analysis of micro-level trends in 21 indicators of well-being. The broad aim raises two questions: *[1]* what do we expect to learn from the analysis? and *[2]* how do we define and measure well-being?

1.1. Expectations

Most past quantitative research on the effects of the outside world on small-scale rural societies has focused on the effect of participation in the market economy on selected outcomes, like sociality, health, or economic inequality. Results from this line of research are problematic because individual, household, and community participation in the marketplace reflect endogenous choices and the role of other confounders, which means that inferences about causality are not trustworthy. In addition, to assess changes in well-being from exposure to the market economy — or from larger processes like modernization, globalization, or development — requires a control group that remained at arms' length from the marketplace; to our knowledge, prior studies (including ours) lack a control group.

Although one could build on Western intellectual contributions to test the hypotheses that greater participation in the market economy or modernization increases sociality (Hume, 1793, p. 121), anomie (Durkheim, 2005 [orig. 1897]), consumerism (Veblen, 1899, pp. 68-101), the division of labor (Smith, 1884 [orig. 1776], p. 5), or economic inequality (Marx, 1920 [orig. 1867], pp. 823–826, 838–848; Vol. 1), research results would be questionable for the reasons noted. Faced with these challenges, a prudent way forward is to explore micro-level trends, leaving for future researchers the task of identifying the aspects of the outside world that changed well-being and social exclusion of people in small-scale rural societies of the Global South (Marlier & Atkinson, 2010).

1.2. Well-being: Definitions and measurements

The second concern is how to define and measure well-being. Inherent disagreement exists on these topics because *a)* well-being as a stand-alone construct is a recent field of study (Kahneman et al., 1999), *b)* it carries different meanings across academic disciplines, and *c)* it spans many dimensions (Benjamin et al., 2020). We next address five related questions about well-being that inform our approach.

[i] Approaches to defining and measuring well-being in anthropology, economics, and psychology

Anthropology. With few exceptions (Fischer, 2014; Mathews & Izquierdo, 2008), anthropology has avoided studying well-being as a comprehensive construct or acknowledging its subjective side (other than emotions), and focused instead on specific aspects of quality of life, such as diet, sociality, health, and leisure time. Although there is still no theory or methods in anthropology to study well-being in its totality, there is growing recognition in anthropology that well-being requires a multidimensional perspective (Page-Reeves, 2022).

Economics. Starting in the 1970's, interest in economics began to shift from equating well-being with GDP or income to including other aspects besides GDP or income (Oman, 2021, pp. 35-47). Thanks to the work of Sen (1999), economists began pairing well-being with people's subjective value of their *functioning* (Sen's term), or what people think most important in life, plus quantifiable measures of material conditions such as income, even if material conditions play a small or no role in peoples' views of the good life. Material conditions count because they provide the "general-purpose means" — *capabilities* or *freedoms* in Sen's scheme — deployed to meet loftier ends (Robeyns, 2005; Sen, 1999, p. 14). To obtain a fuller grasp of well-being, economists have added non-monetary aspects such as leisure and mortality (C. Jones & Klenow, 2016) and some have borrowed measures of subjective well-being from psychology (DeNeve & Sachs, 2020; Stone & Krueger, 2018). Unlike anthropologists who analyze well-being at the level of the individual, economists often aggregate data and analyze it at the country level.

Psychology. Whereas anthropologists and economists entered the study of well-being indirectly through specific aspects like leisure, diet, or income, psychologists entered the field by directly asking people to rate their happiness (see review below). Over the years, psychologists have gone beyond happiness to add satisfaction with various domains in life and other indicators of subjective well-being (Oishi & Westgate, 2022) while acknowledging that material conditions overlap with, or predict, subjective well-being (Diener, Oishi, & Tay, 2018).

In sum, beginning from separate places, the three disciplines have converged on the need to take a fuller view of human well-being composed of subjective and material aspects. The UNDP's latest development agenda reflects this trend by acknowledging the importance of a comprehensive set of indicators to assess progress in quality of life (UNDP, 2023). At present, the UNDP comprises 17 indicators bearing on Sen's capability approach, including such things as monetary poverty, food, health, inequality, schooling, natural resources, consumption, and

climate change. In spirit, though not in detail, our approach mirrors the growing trend of conceptualizing well-being as an expanding bundle of traits but differs from the UNDP and other approaches in development by being location specific. This said, not all development programs stress subjective well-being (Venkataraman, 2013).

[ii] Who defines well-being and identifying its determinants

Depending on the question posed, researchers from outside the community, study participants or both play a role in defining well-being. The definition of researcher dominates if the interest lies in assessing well-being cross-culturally. Marlier and Atkinson (2010, p. 288) say that in such cases the criteria should have an "agreed normative interpretation" and be clearly and easily "interpretable in an international context." At first sight, examples of such criteria would include years or schooling or levels of monetary income (e.g., monetary poverty) because more schooling or more monetary income could be taken as signs of improved well-being. However, these canonical indicators would have little meaning to people in highly autarkic settings whose human capital takes the form of knowledge of the local environment (rather than years of schooling or academic skills) and who do not need to rely as much on money because they consume what they produce. On the other hand, the definition of study participants dominates if one wishes to understand quality of life from their perspective. An indicator of well-being meaningful to local people such as social drinking would lack a clear normative interpretation since too much drinking could lead to alcoholism; more is not necessarily better as it is with human capital. Irrespective of who defines well-being, the choice of predictors typically relies on theories from the behavioral or natural sciences and the judgment of researchers (Das et al., 2020; Diener et al., 2018) though some researchers ask study participants to identify perceived causes of hedonic well-being (Reyes-García et al., 2021).

[iii] How to measure subjective and objective well-being?

Currently, the most comprehensive method for evaluating subjective well-being relies on survey questions that ask study participants to rate themselves in three areas: *[a]* evaluative measures ask people to judge their entire life or aspects of their life (e.g., income), *[b]* experiential or hedonic measures ask people about their positive and negative feelings (e.g., happiness, anger) at the time of the interview or in the recent past, and *[c]* eudaimonia measures ask people how far they feel their life has meaning or purpose. Answers are rated with a numeric scale (e.g., 0 = not satisfied; 10 = very satisfied) (Stone & Krueger, 2018). All this information provides a comprehensive measure of subjective well-being, but the collection of such data in non-Western societies is challenging because of translation (Lomas, 2019). Objective measures of well-being like income or wealth come from survey responses, while measures of health come from survey responses and direct measurements by researchers. Economic outcomes are typically estimated with monetary values.

[iv] Should the indicators of well-being be combined or treated separately?

Indicators of subjective well-being are analyzed separately when indicators cannot be collapsed into one variable (Decancq et al., 2009). This type of analysis allows researchers to see how different indicators change. In contrast, other researchers prefer to combine answers into an index (Benjamin et al., 2020) if there is evidence that the separate dimensions of well-being reflect a latent trait (Winther et al., 2015), which is more likely to happen when indicators have an "agreed normative interpretation". By aggregating, a summary index reduces measurement errors (Krueger & Schkade, 2008) and false positives, streamlines the description of results, and enhances the use of results in policy (Marlier & Atkinson, 2010; Alkire et al., 2022; UNDP 2021).

[v] Where do economic inequalities fit in?

Economic inequalities are an indirect indicator of well-being because they tend to predict lower life satisfaction (Cheung, 2018) and worse subjective and objective health among individuals across many societies, including small-scale rural societies (Jaeggi et al., 2021; Pickett & Wilkinson, 2015; Undurraga et al., 2016; Undurraga et al., 2010), with some notable caveats (Ngamaba et al., 2018; Reyes-García et al., 2019). We limit the analysis of inequality to economic outcomes rather than to social or health outcomes because inequality of economic outcomes such as income or wealth have taken a central place among academics and policymakers.

In sum, there is still debate about what is well-being, who defines it, how to measure it, and whether to use an index or use its parts separately.

2. Specific aims

We use a yearly panel dataset (2002–2010, inclusive) from a highly autarkic society of Indigenous People in the Bolivian Amazon (Tsimane') undergoing increasing exposure to the market economy, globalization, Westerners, modernization, development initiatives, and governmental programs (hereafter the six processes are referred to collectively as the *outside world*) to achieve three specific aims:

[1] Offer an embracive portrait of well-being or quality of life that includes *(a)* subjective and objective dimensions of well-being measured with *(b)* survey questions and physical measurements. To identify perceived predictors of subjective well-being, we asked study participants to indicate what had made them happy or sad (see below). Answers were used to identify the objective measures of well-being that predicted or overlapped with subjective well-being. For instance, food was identified as an evaluative measure of subjective well-being, and through surveys, we measured many aspects of household food consumption. For one evaluative dimension, health, we use survey responses and objective measurements identified by our research team.

[2] Present a novel approach to measure income inequality in small-scale rural societies increasingly engaged with the outside world as an indirect indicator of well-being. Biocultural anthropologists have been gaining a better understanding of the material inequalities and diet of people in small-scale societies. However, little is known about income due to the complexity of defining and measuring income in societies without formal prices. We argue that inequality in calories and macronutrient (proteins, fat, carbohydrates) intake could be a promising approach of measuring objective income inequality because *(a)* in small-scale rural societies, food consumption, expenditures, and income correlate highly due to Ernst Engel's Law that food consumption dominates aggregate household consumption among money-poor people (Clements & Si, 2018; Kaus, 2013; Seale & Regmi, 2006; Zimmerman, 1932) and *(b)* the approach sidesteps the difficulties of imputing prices to foods in societies without a price-setting market. Measures of inequality in the calories and macronutrients people eat in a highly autarkic rural society should allow one to get near the true distribution of unseen, hard-to-measure income of the society and could be added to other objective indicators of well-being. (For brevity, we sometimes use the term *macronutrients* for calories, proteins, fat, and carbohydrates). To be clear and not oversell our point: There is a large literature on country income inequality and nutritional status of individuals (reviewed in Alao et al., 2021) and a literature on inequality in monetary food expenditures (reviewed in Sassi et al. (2022), but a slimmer literature (most of it in India) on formal measurements of nutritional inequalities per se, such as estimates of Gini coefficients of energy or macronutrient intake (Bell et al., 2021;

Kharkwal & Malhotra, 2020; Liu et al., 2023; Singh, Kumar, & Singh, 2016), and none of these studies underscore the role of energy and macronutrient inequality as proxies for hard-to-measure income inequality in rural settings of the Global South.

[3] Make the clean and coarse datasets and documentation of the panel and ancillary studies freely available to the public to redress the glaring gap in longitudinal datasets from small-scale societies of the Global South (Appendix A).

3. Tsimane' Amazonian panel study (TAPS) and the setting

The culture, human biology, health, psychology, and economy of Tsimane' have been analyzed by researchers from the Tsimane' Health and Life History Project (Gurven et al., 2017) and by researchers from the Tsimane' Amazonian Panel Study (TAPS) (Leonard et al., 2015; Mulligan et al., 2022). This study centered on Tsimane' living along the river Maniqui, department of Beni, an area we call the homeland. Prior studies with all nine years of TAPS data have focused on a few outcomes and show *(a)* increased consumption of cooking oil and pasta, adult body mass index (BMI; body weight in kg/standing height in m^2), and prevalence of overweight and obesity (Bethancourt et al., 2019), *(b)* less convivial traditional drinking (Rosinger & Bethancourt, 2019), and *(c)* catch-up growth among stunted children (Undurraga et al., 2018; Zhang et al., 2016).

We depart from these studies by putting well-being at the center stage of the analysis and by examining time trends of many indicators at the same time, particularly foundational indicators of objective well-being like income, macronutrients, and material inequalities that so far have received no attention in longitudinal studies of small-scale societies. Furthermore, we go beyond earlier studies using TAPS data by providing a panoramic instead of a narrow view of well-being limited to a single indicator, like convivial drinking or food consumption. And what makes the endeavor important is how it relates to the polarized views about changes in the quality of life of people in highly autarkic small-scale rural societies from increasing dealings with the outside world. As we show elsewhere (Bauchet et al., 2020), some observers from the Enlightenment to the present have seen greater anomie, consumerism, inequality, and squalor while others have seen material prosperity and greater life satisfaction. Where is the nuanced middle ground?

At the time of our research, Tsimane' numbered 17,000 people (INE, 2015) and lived in over 100 villages, mainly in the department of Beni. Almost nothing is known about Tsimane' before the twentieth century because they lived in or retreated into the backlands of the Bolivian Amazon beyond the reach of Westerners. At the turn of the twentieth century, two foreigners — Pauly, an Argentinian engineer and explorer, and Nordenskiöld, a Swedish anthropologist — visited Tsimane' along the river Maniqui and penned what they saw. In the ethnographic sketch of the outcomes (Appendix B), we sometimes turn to their works to highlight what has changed over the past century. During the mid-1950's, Protestant missionaries from the United States settled permanently along the river Maniqui to proselytize Tsimane' and to set up the first rural schools for them (Kempf & Kempf, 2017). Tsimane' began to settle in villages with schools, a shift from their historical semi-nomadic way of life. Notwithstanding the shift toward more permanent residence, Tsimane' at the time of our research were one of the world's most economically self-sufficient, small-scale, nonindustrial, contemporary rural societies. A comparative study of 15 such societies ranked Tsimane' next to last in contact with the market economy, with an average of 7 % of all household calories bought in the market (Henrich et al., 2010).

During the study, the influence of the outside world on the homeland of Tsimane' deepened. The Bolivian government established national programs to transfer cash for old-age pensions (2002) and to promote school attendance (2006) and preventive health care among pregnant women and children under two years of age (2009). Delivery of public health services increased. Vaccination campaigns in villages became routine, and the government, non-government institutions, and foreign institutions began to supply other health services to Tsimane' besides vaccinations. Government officials visited Tsimane' villages to issue birth certificates and national identification cards, which Bolivian citizens need to access governmental services. Around 2001, the Bolivian government began to build schools in Tsimane' villages that previously had no schools; the intervention increased the tendency to adopt a sedentary lifestyle. Representatives of political parties and local officials visited villages to garner support for the municipal and national elections of 2002, 2005, and 2009. Road infrastructure improved, and solar panels were placed in village schools to provide light and run electronic teaching equipment. Toward the end of the study, the national electric grid reached villages near towns while telephone towers were erected in parts of the Tsimane' homeland so people could use cellular telephones in villages within the covering radius of the towers. During the last year of the study (2010), 3 % of adults in the sample owned telephones and 3 % owned televisions. Real (inflation-adjusted) fares to towns fell yearly by 4 % during 2002–2010, making it easier for Tsimane' to travel to town and for merchants to stop by villages to trade.[1] During the study, adult Tsimane' men increased the number of days working for loggers, cattle ranchers, and Andean highlanders who had encroached on the homeland of Tsimane', often dwelling in settlements next to Tsimane' villages. Real cash earnings from these jobs rose by 8 % per year while rice and maize sales fell, each by ~ 2.5 %/year. The frequency of purchases also rose; every year Tsimane' adults bought 3 % more durable assets and were 2.4 percentage points more likely to buy apparel. Starting in 2004, the chances an adult would not spend cash the past fortnight fell by 5.8 percentage points per year. In the past three decades, 10 % of Tsimane' emigrated from the department of Beni, some to settle in cities and rural towns, some to settle in distant villages with more wildlife in other departments.

The sketch highlights two points relevant to this article. It provides evidence of the many concurrent events engulfing the sample of Tsimane' studied and underscores the difficulties of isolating the effect of markets, outside institutions, migrations, environmental degradation — as shown by Tsimane' moving farther away to have access to more wildlife — or development on well-being in our study.

4. Approach to define and measure well-being

Building on the previous discussion of well-being or quality of life, we follow a pragmatic, eclectic approach to define it. Our approach relies on subjective and objective aspects (predictors) identified by study participants and our research team. These dimensions were assessed by answers to survey questions and physical measurements by our research team. We analyze indicators separately but test whether using one or more summary indicators is justified.

Before discussing specifics, we note one criterion used to select outcomes as it limits what we can say about changes in the main analysis. The outcomes had to have been measured every year from 2002 until 2010 because this made micro-level yearly trends comparable. Nevertheless, we bring in information collected occasionally or from ancillary studies to complement the main analysis (sections 9, 5.1).

[1] During the 2007 survey, adults had travelled an average and median of 12 and 6 times to the regional towns in the past year; by 2010, mean and median values for the same recall period and destination had risen to 19 and 12. Survey answers about travel frequency collected before 2007 cannot be used because they were coded very different and could not be meaningfully recoded to compare frequencies. Before 2007, we asked about frequency of travel to only one town (San Borja) and coded answers as "Never", "Once a year", or "Once a month". Starting in 2007, we asked about the number of times the respondent had travel to any town.

4.1. Measures of subjective well-being

During the first two years of the study (2002–2004), we asked adults (age $\geq$ 16y) an open-ended question about all the events that had made them happy the past week, and, separately, about all the events that had made them sad in the past week. Respondents could list as many events as they wished. Appendix C contains a verbatim summary of what made respondents happy or sad. The initial questions about the causes of happiness and sadness had strengths and shortcomings.

Strengths. First, the Tsimane' language has words for happiness and sadness, so the use of these words was easily understood by study participants (Godoy et al., 2010), especially when limiting the recall to the past week. Second, the use of an open-ended question posed to each villager (who were often by themselves without bystanders listening) made it easier for respondents to express their true feelings. A more public participatory approach through focus groups could have been used but posed its own challenges (Sim & Waterfield, 2019), such as confidentiality and peer pressure. Third, the happiness-sadness dichotomy resembles the utilitarian pleasure-pain continuum but is a convenient albeit blunt entry point into what people value or eschew. As such, answers could be read as measures of evaluative well-being or their predictors. For instance, if food emerges as a salient reason for sadness or happiness, satisfaction with food must be a valid evaluative proxy of subjective well-being, and the measure of foods eaten must be a blunt but reasonable correlate of the evaluative measure. This line of thinking is in line with Dressler's (2020) concept of cultural consonance, which has been examined among Tsimane' (Reyes-García et al., 2010), but not with food. Fourth, we found that despite their autarky, Tsimane' valued many of the same things valued by people in the rural Global South (Alkire, 2002, p. 190). Like other people in the rural Global South, Tsimane' cherished social relations, food, shelter, and some material prosperity but did not mention the environment, knowledge, supernatural beliefs, or religion, all important to Tsimane' (Huanca, 2006).

Shortcomings. We did not measure all relevant variables. *[1]* The initial approach should have been followed by the same questions every year about the degree to which respondents were satisfied with their food, shelter, social relation, and all the other principal reasons for their happiness or sadness; the improved approach would have allowed us to estimate directly changes in evaluative well-being and spot new expressions of well-being. Although we asked about evaluative measures of food, clothing, health, and sociality, and about hedonic measures of well-being in the form of experiences with positive (happiness) and negative emotions (anger, fear, sadness) in the past week, we did not do so every year, so we exclude these measures from the main analysis. *[2]* Asking people about what made them happy or sad does not get at views about the provision of public services that contribute to well-being. Village political leaders, the municipal government, and the governing body for most Tsimane' villages (Tsimane' Council) play a role in defending territorial rights against encroachers, mismanaging natural resources by logging firms, crime, and the quality of schools and public health services. *[3]* Last, we did not ask about eudaemonic measures of well-being.

Given the open responses and limited by these shortcomings, for the main analysis we are left with two indirect measures of evaluative well-being: number of reported bed-ridden days the past fortnight and frequency of convivial drinking of a home-brewed beverage (*chicha*) that Tsimane' use to display sociality. These are measures of well-being because Tsimane' mentioned that convivial drinking of *chicha* made them happy, while poor health made them sad. Drinking *chicha* was the fourth most important reason for happiness after events like a good fish catch or being in the company of family, while poor health was the leading reason for sadness (Appendix C). The measures we obtained are indirect because they do not capture how satisfied respondents were with their health or with their *chicha* consumption; instead, they measure the frequency of the events. Nevertheless, both measures capture canonical aspects of well-being. Indeed, recent international research points to perceived morbidity and sociality as crucial components of subjective well-being (Das et al., 2020; Krueger & Stone, 2014; Lee et al., 2017; Waldinger & Schultz, 2023). In Appendix B we discuss the importance of *chicha* as a social glue.

4.2. Measures of objective well-being

Under this rubric, we include objective measures of foods eaten (expressed in monetary value, macronutrients, and calories), privately owned physical asset wealth, monetary income, aspects of horticulture that capture the amount of food available to the household to eat, barter, sell, or to make *chicha*, and body-mass index (BMI).

4.3. Final selection criteria

Based on our ethnographic understanding of Tsimane' and the data available to estimate yearly trends for all nine years of the panel, we include outcomes that met one or two additional criteria. *(i)* They reflected an indicator of well-being identified by Tsimane'. For example, Tsimane' identified poor health as a reason for sadness, and to capture health, we measured body-mass index and asked about the number of days respondents, or their dependents had been bedridden the past fortnight. Several aspects of horticultural production were included because Tsimane' frequently mentioned that the quality of their fields (and by implication of crop production and food) made them happy or sad. (*ii*) The outcomes helped Tsimane' attain or deal with some of the reasons that made them happy or sad. Cash income and asset wealth are examples. Almost no respondent mentioned cash income as a reason for either sadness or happiness, yet Tsimane' need money to pay for things they care about, such as food they have learned to value but cannot produce (e.g., pasta) and health services (even from local curers). Same with asset wealth — almost no respondent mentioned an asset surplus or deficit as a cause of mirth or dejection, but they value dugout canoes, livestock, and metal tools; these they use to travel, farm, fish, and hunt. Most assets provide both food (e.g., eggs from poultry) and lump sums of cash for emergencies (e.g., from the sale of livestock or rifles).

5. Data collection, preparation, and analyses

Before collecting information, we obtained IRB approval from Northwestern University (732–002, 732–007, 732–016, STU000007), the Tsimane' Council, and study participants.

5.1. Data collection

Every dry season (May-September) during 2002–2010 a team of Bolivian and international researchers and Tsimane' assistants gathered information on 21 outcomes among all households of 13 Tsimane' villages along the river Maniqui (Table 1). We trained Tsimane' assistants in data collection and collaborated with them to ensure they translated the questions accurately when the respondent could not understand Spanish. Gathering data during the same time of the year erased the effects of seasonality on survey responses. We selected villages because they varied in proximity to the principal urban hub of the area (the town of San Borja). Villages in the study were one hour to one day away by car or outboard motor from San Borja and had a median of 19 households (standard deviation, SD = 6).

The selection of villages raises the question of how representative our sample was of the Tsimane' population. To answer the question, we turn to a randomized-controlled trial (RCT) done in 2008–2009 in 40 villages beyond the 13 villages of the panel study. We restrict the comparison to data from the baseline survey of the RCT (2008) and the 2008 yearly survey of the panel study because the trial changed outcomes by the endline survey (2009). We did not measure all the outcomes of the panel study in the RCT because the aims of the two studies differed, but some outcomes were measured in the same way, and those are the ones

Table 1
Definition and measurement of variables recorded annually among Tsimane' households used for the main analysis /1/, 2002 (baseline)-2010.

Variable	*Definition and measurement*
Horticultural production:	*Current conditions of household farmlands*
Forest	Hectares (ha) of old-growth and fallow forest cleared for horticulture in past year
Plots	Number of forest plots cleared for horticulture in past year
Plantains	ha of farmlands under plantain cultivation
Manioc	ha of farmlands under manioc cultivation
Economic flows:	*Monetary value of inflows to the household in past two weeks /2/*
Income	Monetary income from wage earnings and sale of local goods
Barter	Monetary value of goods received in barter
Autarky	Binary variable if an *adult* had not earned money or bartered (yes = 1; no = 0) /3/
Economic stocks, wealth:	*Monetary value of 22 physical assets owned by the household at the time of the survey /2/*
Total	Total value of traditional, commercial, and livestock assets
Traditional	Goods made by Tsimane' women or men from local plants: canoe, mortar, cotton bag, wooden quern, set of bows and arrows
Commercial	Commercial goods from the market: axe, bicycle, cooking pot, cutlass, hook (fishing), knife, mill (hand), mosquito bed net, fishing net, radio, rifle, shotgun, watch
Livestock	Domesticated animals raised at home: cow (or bull), duck, hen (or chicken), pig
Sociality:	*Episodes of sociality among adults in past week /3/*
Gifts	Mean number of gifts given by *adults* in a household
Chicha	Mean number of days *adults* in a household drank *chicha*
Food:	*Monetary value and nutritional composition of 21 own and market foods consumed by the household in the past week*
Value	Own: manioc, rice, maize, plantain, wildlife (birds, fish, game [mainly mammals]), eggs, chicken, duck, pork. Market: beef, cow head, jerky, canned sardines, oil, lard, white granulated sugar, flour, pasta, bread. /2/
Dietary Consumption:	The number of kilocalories of energy and grams of protein, fat, and carbohydrates of each of the 21 foods consumed was obtained by using the conversions and methods in Flores et al. (1971) and Bethancourt et al. (2019). Macronutrients = protein, fat, and carbohydrates, but in the text, we sometimes use the term *macronutrients* to cover energy as well
Energy	
Protein	
Fat	
Carbohydrates	
Health:	*Reported health in the past two weeks for all people in the household and body-mass index (BMI) of adults at the time of the survey*
Bedridden	Number of days the person was bedridden in the past two weeks
BMI	Measure of body-mass index of adults at the time of the survey /3–5/

Table 1. Definition and measurement of variables recorded annually among Tsimane' households used for the main analysis /1/, 2002 (baseline)-2010. - continued.
Notes:
(1) Unless indicated otherwise, the value of all variables refers to mean amounts per person in the household. Amounts per person came from dividing the sum of the value of the outcome in the household by the number of people living in the household at the time of the yearly survey.
(2) The monetary values in all tables are in *bolivianos*. Nominal monetary values were converted to inflation-adjusted (real) values using Bolivia's Consumer Price Index, retrieved from the World Bank on May 1, 2022: https://data.worldbank.org/indicator/FP.CPI.TOTL?locations = BO. Wealth was measured at the individual level among all adults in the household but, in addition, a household-level measure was estimated by adding the wealth of individuals, plus the wealth of children, who often own poultry. For the main analysis we use household-level measures of wealth, but for the analysis of gender differentials (Table 3) we use individual measures of wealth. We used our prior ethnographic observations during 1999–2001 to select the 22 assets that we measured. We tried to make sure the assets measured covered goods owned by better-off and less well-off households, by women and by men.
(3) Adults were people age $\geq$ 16 years old at the time of the survey, or younger if they headed a household.
(4) Except for BMI (body-mass index; weight [kg]/standing height[m^2]) all other outcomes come from self-reports of adults about themselves, their children, or their households. Parents provided answers about bedridden days of children. For data on variables collected at the level of the household, we relied on one household head for the answers. Men typically answered questions about horticulture and asset wealth and women answered questions about food consumption. The methods to measure BMI are described in Rosinger et al. (2013).
(5) BMI. Analysis of BMI excludes pregnant women and is done separately for women and men.

discussed next.

The analysis shows similarities and differences. *Demography*. Villages in the panel study were larger (19 household/village) than villages in the RCT (14 households/village), but total household size (~6 people) and the percentage of nuclear households were similar in the two studies (~75 %). 23 % of the sample of women 14y $\leq$ age $\leq$ 50y in the panel study reported being pregnant in 2008 compared with 19 % in the RCT. Women in the panel study seemed more vulnerable to environmental stresses for they were 6 % more likely than women in the RCT study to give birth during the dry season. *Horticulture*. Here no differences appear. Households in both samples cleared the same number of plots (~1) from the forest and the same area of forest (1 ha) and put the same area under manioc cultivation (0.1 ha), the principal ingredient to make *chicha*. *Monetary earnings*. Although adults in both samples worked for the same number of employers (1) in the past week and sold many of the same farm and forest produce, they differed in the number of days worked, earnings, and what they sold. Adults in the panel study worked mostly for cattle ranchers, whereas adults in the RCT study worked for a mix of smallholders, traders, and loggers. Households in the panel study sold mainly plantains and thatch palm from the forest, whereas households in the RCT study sold mainly rice. In the past 1–2 weeks, adults in the longitudinal study worked three times more days and earned three times more money than their peers in the RCT study. Villages in the panel study paid higher real wages. *Shocks*. Illness was the most common adverse shock in both studies, but people in the RCT study were five percentage points more likely to have experienced any shock the past year and experienced 3.3 % more shocks than study participants in the RCT. In short, the evidence suggests that Tsimane' in the longitudinal study had a stronger toehold in the market economy but were like other Tsimane' in other areas.

A household in the panel study had a mean and median of six people (SD = 2.7), evenly split between adults (defined as people $\geq$ 16 years of age) and children or people < 16 years of age. The sample during the baseline year (2002) had ~ 240 households (Appendix D). Other than the measurement of BMI, the measurement of other outcomes came from answers to survey questions. We followed the protocol of Lohman et al. (1988) to measure BMI. A portable Seca stadiometer was used to measure standing height to the nearest 0.1 cm and a Tanita BF-522 W scale was used to measure body weight to the nearest 0.1 kg.

We used three surveys to gather information about individuals, households, and communities (villages and towns). *(1)* Surveys about individuals centered on monetary earnings (income), barter, sociality, and perceived health. Questions about monetary earnings, barter, and sociality were addressed to all household members $\geq$ 16 years old or younger if they headed a household. Questions about self-perceived health were addressed to all adults; the female household head was asked to judge the health of dependents under 16 years of age. *(2)* The survey about household traits had questions to assess area deforested, areas and crops under cultivation, asset wealth, and food consumption. Questions about food consumption were addressed to the female household head and questions about horticulture were addressed to the male household head. *(3)* Questions about villages and towns dealt with prices, which we used to estimate the monetary value of foods eaten and asset wealth. We addressed questions about village prices to one or more village leaders and questions about town prices to shopkeepers in two towns of the study area (San Borja and Yucumo).

Three recall periods were used: *(a)* one week for questions about

foods eaten and sociality, *(b)* two weeks for questions about monetary earnings, barter, and perceived health, and *(c)* the past year for questions about forest clearance. Questions about asset wealth and areas under cultivation with plantain or manioc referred to conditions at the time of the survey.

5.2. Data preparation

We transformed data in several ways.

(1) Prices from villages and towns were imputed to the quantity of assets owned or foods eaten. We first relied on current village selling or buying prices. If these prices were missing, we imputed the median price from the sample of villages that had the price, and if the good had not been bought or sold in any village for the past three months, we imputed the current price of the good in towns to the commodity without a price.
(2) To estimate time trends of monetary values, we converted current nominal monetary values to inflation-adjusted values using Bolivia's Consumer Price Index (Table 1). To convert the national currency (*bolivianos*) into United States dollars (USD), we used the unofficial foreign exchange rate currency in the two towns of the study. For transparency, we report monetary values in USD and *bolivianos* when discussing results. During the study, the average yearly foreign currency exchange rate was 7.47 *bolivianos*/USD (SD = 0.42).
(3) Excluding BMI and sociality, when the question or physical measurement referred to an adult, we added the amount reported by each adult in the household and divided the sum by the total number of household members at the time of the survey, which yields an average value per person in the household. BMI values refer to the average BMI of adult (non-pregnant) women and adult men in the household at the time of the survey. Sociality indicators refer to the average for adults in a household. We did not use adult equivalents to estimate household size because many adult Tsimane' do not know their age (Gurven et al., 2007).
(4) To explore micro-level trends of outcomes which had some zero values, reduce the influence of outliers, and ease the interpretation of results, we changed the value of household averages with the inverse hyperbolic sine transformation.
(5) We do the main analysis using the household as the unit of analysis for three reasons. *(a)* Two dimensions of well-being (horticulture and food consumption) were measured at the household level. *(b)* Tsimane' subsistence puts the household at the center stage of most daily horticultural activities. *(c)* The computation of Gini coefficients is typically done with the household as the unit of observation owing to data availability. Therefore, cross-cultural comparisons of economic inequalities are facilitated by analyzing inequality at the household level (Hruschka et al., 2017; Killewald et al., 2017).
(6) We used the Gini coefficient to measure economic inequalities. As has long been recognized (Atkinson, 1970), there are several methods to estimate economic inequality, each with advantages and disadvantages (Bowles & Carlin, 2020; Woolard-Mayfour & Hruschka, 2022). Nevertheless, we used the Gini coefficient because it facilitates cross-cultural comparisons as it has become the indicator of choice in many fields. It can range from zero (complete equality) to one (complete inequality); the latter would happen if, for instance, one household owned all the assets of the group.

5.3. Analyses

Main analysis. The main analysis proceeds in three steps. First, we assess the correlations between outcomes to assess if they reflect latent variables and whether the creation of one or more indexes is warranted. Second, we describe the 21 outcomes at baseline. Third, we use bivariate regressions with survey year as a predictor to explore micro-level time trends of outcomes, aware we are not controlling for confounders that would happen with any nested observational dataset. With many outcomes analyzed simultaneously, the likelihood of finding false positives rises. To protect against this mistake, we report levels of statistical significance of micro-level time trends after adjusting for false discovery rates (Jones et al., 2019) (Appendix E and Table 2, columns 2 and 4).

Robustness analysis. We did three robustness checks. *(1)* We controlled for fixed traits of villages to remove some of the noise from these types of confounders (e.g., village-to-town distance). In addition, we took two steps to assess if the analysis of inequality was sensitive to the measurement of inequality. *(2)* Besides estimating yearly Gini coefficients for each economic outcome for all households, we computed a grand Gini for each outcome using all households and years combined and did so as a check for the study's short duration and modest yearly sample size of households (~240). *(3)* We used the coefficient of variation instead of the Gini to judge if results changed by the method to compute economic inequality.

Extensions. Gender. The main analysis and the robustness analysis gloss over gender disparities in the household, an important aspect of disaggregation in the analysis of well-being (Marlier & Atkinson, 2010). To address the shortcoming, we unbundle some household-level data and compare micro-level trends of indicators that were measured at the individual level among adult women and men but that we aggregated to the household level in the main analysis. These indicators included the monetary value of goods obtained in barter, monetary earnings, the monetary value of privately owned material assets, sociality (gifts given and convivial drinking of *chicha*), bedridden days, BMI, and body-fat measured with the sum of four skinfolds (triceps, biceps, subscapular, suprailiac), the latter an indicator of energy availability stored in the human body. *Hedonic measures.* We analyze trends in four emotions (fear, sadness, anger, happiness) that we omitted in the main analysis because they were not measured every year.

6. Quality checks and limitations

Quality checks. We tried to reduce measurement errors by using the same questions and field staff every year, but errors nonetheless arose. Some measurements had random or systematic mistakes. There was rounding or digit heaping around multiples of five in the last digit of whole numbers in answers to questions about cash earnings and the last digit of whole numbers in answers to questions about the cash value of goods obtained in barter. There were also biases from forward telescoping and omissions. When asking about barter, bedridden days, and monetary income, we first asked for the amounts the week before the interview and, subsequently, for the amounts two weeks before the interview. Reported values for the past week were higher than reported values for two weeks ago. For example, respondents were 13–15 percentage points more likely to say they had sold goods the past week than two weeks ago. Reported answers about the area of forest cleared for horticulture coincided with field measurements by our research team (Vadez et al., 2003). We excluded extreme height, body weight, and skinfold values for all ages, following thresholds recommended by WHO (1995). The sample of households remained relatively stable during the study, but adults entered and left the panel. Of the 633 adults present in the baseline year (2002), 4.42 % left permanently after 2002 and 38.23 % were surveyed every year until 2010; the rest (57.35 %) were surveyed a mean and median of six times during the remaining seven years (2003–2009).

Limitations. *(1)* In a panel study with branching questions, respondents might have learned that saying "no" to initial forking questions saved them time from having to provide details about the event. For instance, in answer to the question, "How many days were you bedridden the past week?", saying "none" would have saves time among seasoned respondents from having to answer follow-up questions about

Table 2
Micro-level trends in household levels and economic inequality of well-being indicators: 2002 (baseline)-2010.

Outcomes	[A] Levels – households			[B] Inequality (Gini)	
	Baseline	%Δ/year. Village fixed effect: No	Yes	Baseline	%Δ/year
	(1)/a/	(2A)/b/	(2B)/b/	(3)/c/	(4)/d/
Horticulture:					
Forest	0.179	0.40	0.40	0.459	−0.5
Plots	0.298	−0.60	−0.60	0.359	0.5
Plantain	0.112	−0.80***	−0.80***	0.512	1.7
Manioc	0.021	0.01	0.10	0.735	1.6
Economic flows:					
Income	4.650	2.30	2.60	0.670	0.4
Barter	0.337	−0.40	−3.00	0.717	1.3
Autarky	0.061	1.00*	1.00	Not applicable	
Economic stocks, wealth:					
Total	886	4.20***	4.30**	0.412	1.1
Traditional	228	−5.2**	−4.80*	0.419	1.5
Commercial	503	7.60***	7.70***	0.452	0.2
Livestock	155	−6.30**	6.80	0.693	2.1
Sociality:					
Gifts	0.085	−0.01	−0.10	Not applicable	
Chicha	0.060	−0.10	−0.10		
Food value:					
Value	6.860	7.40***	7.40***	0.476	−1.2
Food consumption:					
Calories	3025	−1.40*	−1.4**	0.304	−1.6
Proteins	91	−2.30*	−2.30**	0.373	−1.7
Fat	49	0.10	0.10	0.477	−1.1
Carbohydrates	545	−1.20	−1.20*	0.304	−2.0
Health:					
Bedridden	0.131	−0.80***	−0.80***	Not applicable	
BMI-women	23.143	0.40**	0.50		
BMI-men	23.364	0.20	0.20		

Table 2. Micro-level trends in household levels and economic inequality of well-being indicators: 2002 (baseline)-2010. – continued.
Notes:
Table 1 has definition of variables and how we measured them. For Autarky, the number in column 1 represents the share of adults who were autarkic, and the number in column 2 represents the percentage-point change per year in the likelihood of being autarkic. *, **, and *** significant ≤ 10 %, ≤5%, and 1 %≤. Values have been adjusted for false discovery rates.
(a) Values come from column "Mean" of Appendix D. All values refer to household means, except for macronutrients; those values refer to median amounts per household during the baseline year.
(b) Values come from Appendix E. Other than Autarky, values capture the percentage change per year. Since Autarky took the value of one or zero, the value is read as a percentage-point change for each additional year.
(c) Values come from the year 2002 in Appendix F, Part 1.
(d) Values come from column "%Δ/year" in Appendix F, Part 1. Regression coefficients, standard errors, and p values for this column come from Appendix F, Part 3. P values have been adjusted for false discoveries.

ailments, symptoms, and cures. Some of the improvements in perceived morbidity discussed later could reflect panel conditioning. *(2)* The brief duration of this exploratory study does not allow us to estimate non-linear trends confidently.

7. Main analysis: Descriptive results of baseline

[7.1] Testing for latent variables.

To test for latent variables, we computed Chronbach's alpha to assess whether all the socioeconomic and health outcomes or a subset of variables captured latent variables (Appendix G). Alphas ranged from a high of 0.64–0.65 for horticultural variables or for all socioeconomic and health variables (0.63), down to 0.18 (sociality) or 0.15 (health). The results fall below the modest reliability threshold of 0.70 recommended in some of the literature (e.g., Nunnally & Bernstein, 1994; Peterson, 1994) and reflect the reality that most of the items measured distinct aspects of well-being (Lance, Butts, & Michels, 2006). However, the four macronutrients reflected a reliable latent variable (alpha = 0.90). For these reasons, we provide a granular analysis of change in well-being, but occasionally bring in the principal component factor index to describe changes in the total socioeconomic and health indicators or the four macronutrients consumed.

7.1. Baseline (2002) conditions – Levels of socioeconomic and health outcomes

Deforestation. Because Tsimane' are principally subsistence horticulturists, the yearly area of forest a household clears approximates the area cultivated and is therefore a valid proxy for aggregate yearly agricultural sales and unseen income from consuming what households grow. In 2002, 93 % of households had cleared forest for horticulture. Households did not scatter plots to protect crops against localized losses from pests, predators, diseases, or floods. In 2002, a household cleared an average of 1.5 plots and a median of one forest plot (SD = 0.86). The total forest area cleared by a household amounted to 0.9 ha composed of fallow forest plus old-growth forest (SD = 0.8 ha). Adjusted by household size, deforested areas in 2002 averaged 0.17 ha per person (Table 2).

Monetary income. Tsimane' had low monetary income. Table 2 suggests that daily cash income per person measured with monetary earnings from wage labor and from sale of farm and forest goods was USD 0.65 (4.65 *bolivianos*), below the World Bank's daily international poverty line for Bolivia of USD 1.9 per person (World Bank, 2022a). To put the figure in context: In 2002, an employer spent 5.8 *bolivianos* in a mid-day meal for a Tsimane' hired to prepare pasturelands or to cut and transport logs from the forest. Thus, with 4.65 *bolivianos* a Tsimane' could have bought 80 % of a lunch meal. The average reported daily

monetary value of goods received in barter per person was also low, USD 0.04 (0.33 *bolivianos*). During 2002, 67 % of adults (n = 611) had not bartered during the two weeks before the interview, and 6.1 % of households were autarkic, meaning no adult in the household had bartered or earned cash the past fortnight.

Asset wealth. Tsimane' households had modest amounts of privately owned assets; most of these assets were not expensive. Thirty percent of adults reported they did not own footwear, 42 % of women did not own hens, and a quarter of adults did not own fishhooks. When they owned an asset, they owned one, as they did in Nordenskiöld's days a century ago (Appendix B). In 2002, the average monetary worth of wealth in privately owned physical assets reached 886 *bolivianos* per person, equivalent to USD 126. To ground this figure, consider the following: If a Tsimane' were to sell all their assets worth 886 *bolivianos* they could buy enough food to eat for 129 days (886 *bolivianos*/6.86 *bolivianos* in self-reported per capita daily value of food consumption). Fifty-seven percent of asset wealth was stored in commercial goods (503 *bolivianos*), followed by wealth in goods crafted from local plants (26 %; 228 *bolivianos*), and livestock (17 %; 155 *bolivianos*). These estimates do not capture net worth because they omit debts.

Sociality. Sociality was modest. Most adults said they did not bestow gifts or consume *chicha* in the previous week. Sixty percent of adults said they had not given a gift the past week, and those who did reported offering few gifts (mean = 1.5; median = 1 gift). Three-quarters of adults had not consumed *chicha* the week before the interview, and those who drank it reported doing so on one day. What effect did *chicha* drinking have on feeling happy or sad? For the week before the interview, we estimated the association between the number of days an adult reported having consumed *chicha* and whether they felt happy or sad. The estimates come from the seven years in which we measured the two emotions (2002–2006, 2009–2010). Drinking *chicha* was associated with an increase in the chances of feeling both happy and sad; the likelihood of feeling happy increased by 4.6 percentage points per day of drinking while the probability of feeling sad also increased, but by a slightly lower amount (3.3 percentage points per day of drinking).[2] The net effect of drinking was positive but small. The mixed effects of *chicha* drinking could come from *(a)* alcohol having both stimulant and sedative effects on the same person (Hendler et al., 2013), *(b)* happy and sad people drinking for different motives, or *(c)* both of these reasons.

Food. Each day, an average Tsimane' reported eating food worth ~ USD 1 (6.86 *bolivianos*) in the form of calories (median = 3025 kcal), carbohydrates (median = 545 g [g]), proteins (median = 91 g), and fat (median = 49 g). The intakes meet international recommendations (Kraft et al., 2018, p. 1187). Measured through the average monetary value of daily food consumed per person reported in the surveys (6.86 *bolivianos*; ~1 USD), Tsimane' were better off than measured through the average daily cash earned per person (4.65 *bolivianos*; USD 0.65), but still far below the USD 1.9/day per person international poverty line.

Health. In the baseline sample of children and adults (n = 1453), the average Tsimane' had been bedridden a total of 1.6 days the past two weeks (median = 0; SD = 3.8). The average BMI of adult men and non-pregnant adult women in a household was similar (men = 23.36 [SD = 2.1]; women = 23.14 [SD = 2.6]). Using the BMI of all adult men and all adult non-pregnant women surveyed during each year of the study (observations = 4907) and following WHO (2000) definitions of weight groups, we found that 2 % of adult Tsimane' were underweight (BMI < 18.5), 75 % had a healthy BMI (range: 18.5–24.99), 20 % were overweight (range: 25–29.99), and 3 % had obesity (BMI ≥ 30).

7.2. Baseline conditions (2002) - Gini coefficients of economic inequalities at baseline and mean yearly Gini coefficients of economic inequalities during 2002–2010

The histograms in the two parts of Figure 1 summarize the Gini coefficients of economic inequalities at baseline (Figure 1A and Table 2 [column B3]) and the average yearly Gini coefficients across the nine years of the study (Figure 1B). The histograms resemble each other, though some outcomes moved a bin or two from Figure 1A to Figure 1B. We focus on Figure 1B in the discussion that follows because it comes from a larger sample of observations while reflecting the ranking of economic inequalities at baseline. In addition, the mean yearly Gini coefficients of Figure 1B resemble the grand Gini (Appendix F, Part 1, penultimate column), so we are safer characterizing economic inequalities among Tsimane' using the mean yearly Gini coefficient of outcomes.

Figure 1B shows four noteworthy results. *[1]* There is much variation among Gini coefficients for different outcomes, from very high inequality with Gini coefficients of 0.75 for the monetary value of goods received in barter during the past two weeks, area under manioc cultivation, and monetary value of livestock wealth, down to Ginis of about 0.3 for the intake of three macronutrients (proteins, carbohydrates, calories) consumed the past week. *[2]* Other than livestock wealth and macronutrient intakes, flow variables related to barter and cash income had higher Gini coefficients (~0.6) than stock variables related to asset wealth (Gini ~ 0.4). *[3]* Conclusions about the amount of wealth inequality versus income inequality hinge on how they are measured, with the range of Gini values overlapping. Traditional, commercial, and total wealth of the privately-owned assets we measured were more equally distributed (Gini ~ 0.4) than livestock wealth (Gini = 0.7). Income was more equally distributed if we equated income with the area of forest cleared for horticulture or with the monetary value of foods eaten (Ginis ~ 0.4) than if we equated income with cash earnings (Gini = 0.6). *[4]* The Gini coefficients of two proxies for income (consumption) — *(a)* area deforested and *(b)* consumption of proteins, calories, and carbohydrates — were similar, with Gini coefficients near 0.4.

Variation in Gini coefficients among different outcomes has implications for how one characterizes the economic inequality of a small-scale society. If one uses aggregate asset wealth (grand Gini = 0.42; Appendix F, Part 1), Tsimane' are more egalitarian than two other contemporary rural societies where Gini coefficients for material wealth have been estimated: Dominicans (Gini = 0.67) and Pimbwe (Gini = 0.56) (Gurven et al., 2010, p. 58). Putting aside the validity of comparing Gini coefficients of asset inequality between industrial and nonindustrial economies (and the possible fragility of Gini coefficients with small samples), Tsimane' have much less asset inequality than five industrial nations reported by Cowell et al., (2018,p. 336) — Italy (0.60), UK (0.66), Finland (0.68), United States (0.80), and Sweden (0.89) — and less asset inequality than China (0.81) or India (0.86) (Davies et al., 2017). These results suggest that Tsimane' society is egalitarian in privately owned total asset wealth, perhaps because most assets measured were inexpensive and available to most households.[3]

The story differs with income. The grand Gini coefficient of Tsimane' income inequality measured with monetary earnings or with area deforested reached 0.63 and 0.41, respectively. The World Bank computed Gini coefficients of income inequality for 82 countries for 2010, the last year of the panel study. The mean and median Ginis for these countries were 0.36 and 0.33. These Gini coefficients of income

[2] The results come from two separate ordinary least square regressions with binary outcome variables for whether the respondent had felt happy or sad, and, in both regressions, included as a predictor the number of days the respondent had consumed *chicha*. The recall period for both outcomes and for the predictor referred to the seven days before the interview. The regressions were run with robust standard errors clustered by village-year. The regression with happiness as an outcome had a p value of 0.001 (n=4198) and the regression with sadness as an outcome had a p value of 0.02 (n=4197). P values were not adjusted for false discovery.

[3] In analyses not shown we find a generally positive correlation between the price of an asset and the Gini coefficient of the asset.

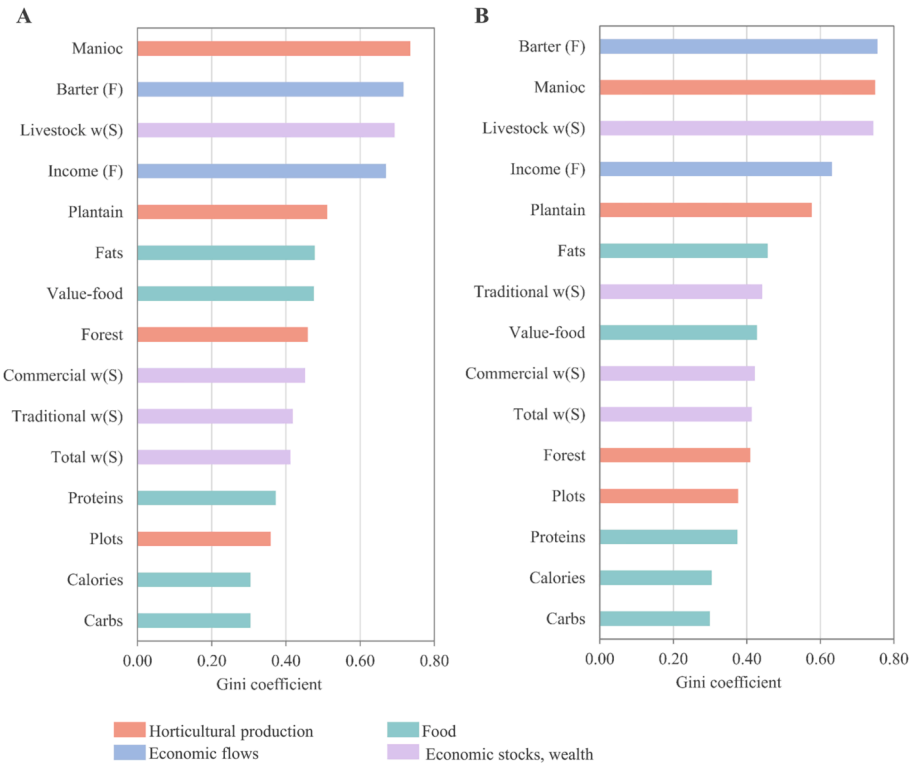

Figure 1. Gini coefficients a) at baseline and b) yearly mean (2002–2010). Figure 1A comes from the column for the year 2002 in Appendix E (Part 1), and the histogram in Figure 1B represents the yearly means in Appendix E (Part 1). The variables are defined in Table 1, with slight alteration in the name of variables in the histograms. For clarity, a "w" was added as a suffix to the types of asset wealth; S = stock. F = flow.

inequality would put Tsimane' — if they were a country — as one of the most unequal societies in the world, on a par with South Africa (Gini = 0.63) if one measured income with cash earnings, or as a moderately unequal society (Gini ~ 0.41) if one measured yearly income with area deforested. Either way, Tsimane' would still be in the top 25 % of unequal societies, with 61 of the 82 countries in the World Bank dataset having Gini coefficients below 0.41 (World-Bank, 2022b). The comparisons are not ideal but underscore the chief point that what economic inequality we use and how we measure inequality can lead to different conclusions about the economic disparities of a small-scale society.

8. Main analysis: Micro-level trends in outcomes measured at the household level

Table 2 (column 2A) suggests that during the study, 10 of the 21 indicators measured at the household level did not change, and the indicators that did change showed that quality of life got better in some respects and worse in others. *Unchanged*. Examples of indicators that did not change include area and number of forest plots cleared, monetary earnings, monetary value of goods received in barter, and sociality. *Better*. The real value of wealth in commercial assets and total wealth, and the real monetary value of food consumption increased yearly by an average of 7.6 %, 4.2 %, and 7.4 % per person. During 2002–2006 and 2009–2010, we asked adults how satisfied they were with their diet and found that only 4 % of adults felt they had eaten poorly the past week; the share of dissatisfied respondents shrank from 7 % during 2002–2004 to 2 % during 2009–2010. The likelihood of being bedridden in the past two weeks fell by 0.8 %/year. In surveys done during occasional years, we found Tsimane' reported improved self-perceived health. The share of adults rating their health as "poor" declined from an average of 21 % during 2002–2003 to 6 % during 2009–2010. Last, each year saw a one-percentage point increase in the likelihood an adult would be autarkic, meaning they had not earned cash or bartered in the past fortnight. Despite the greater presence of the outside world in the village economy, many people did not need to barter, work for wages, or sell goods to earn cash, probably due to household pooling of resources and governmental transfers. *Worse*. The inflation-adjusted monetary value of wealth in goods made from local plants (traditional wealth, as defined in Table 1) and wealth in livestock declined by 5.2 % and 6.3 % per year. The result shows Tsimane' were changing how they held asset wealth, away from traditional article and livestock toward commercial goods. *Per capita* caloric and protein consumption declined by 1.4 % and 2.3 % per year, as did the area under plantain cultivation (0.8 %/year).

We did not use a summary index to capture socioeconomic aspects of well-being because of the low cutoff value for Chronbach's alpha (Appendix G). However, here we report the trend for *(a)* the index of all socioeconomic and health variables and *(b)* the index for energy and macronutrients (protein, fat, carbohydrates) consumption. Each of the two indexes is expressed as a principal component factor. Each year saw an improvement of 0.01 SD in the index of all socioeconomic and health variables ($p = 0.09$; $n = 1685$) and an improvement of 0.02 SD in energy + macronutrient intake ($p = 0.078$; $n = 2261$). Both total well-being (socioeconomic + health) and macronutrients consumption improved by a small amount; the coefficients suggest that after a decade, total well-being and macronutrient intake would improve by only 0.1 SD to 0.2 SD.

9. Main analysis: Micro-level trends in economic inequality

We find no evidence of changes in inequality (Table 2, column 4). Although we cannot speak about trends in inequality with confidence because we have only nine data points, we can describe the variability of Gini coefficients across years. In Figure 2, we show the inter-annual coefficient of variation (CV) of Gini coefficients for each outcome during 2002–2010. Figure 2 highlights three points. First, Gini coefficients varied considerably over time, from low CV values of 0.04 for the number of forest plots cleared, monetary value of goods received in barter, or total asset wealth to high CV values of 0.8 or above for calories

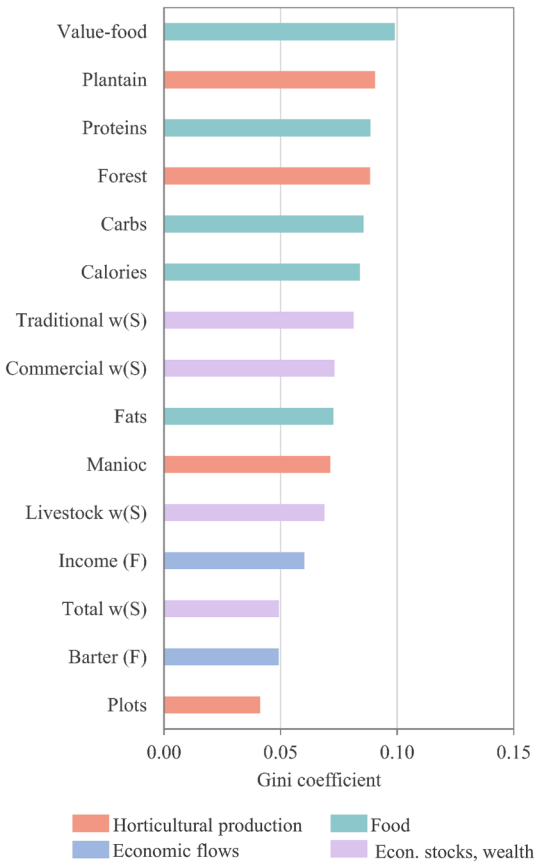

Figure 2. Inter-annual coefficient of variation of Gini coefficients, 2002–2010. The coefficient of variation was computed by dividing the standard deviation by the mean yearly Gini coefficient of each outcome from Appendix E (Part 1). See notes to Figure 1 for the conventions followed to name the bins of the histogram.

and most macronutrients eaten, monetary value of foods eaten, and wealth in assets Tsimane' make from local plants. Second, Gini coefficients for asset wealth varied less between years (CV range 0.05–0.08) than Gini coefficients for the two forms of income — area deforested (CV = 0.08) and food consumption (CVs ~ 0.07–0.09). Third, the inter-annual variability in inequality in the more inclusive form of asset wealth (total wealth, CV = 0.049) was lower than the inter-annual variability in the inequality of smaller asset bundles, such as wealth in livestock (CV = 0.069), wealth in goods made from local materials (CV = 0.081), or wealth in commercial articles (CV = 0.073). Not all inequalities changed in the same way; some were more stable.

A snapshot of inequality could yield an unrepresentative picture of longer-run realities because some Gini coefficients varied significantly over a short time. For example, a study among Tsimane' of area deforested by households — as a proxy for income — done in 2004 (Gini = 0.44) would find a 29 % larger dispersion in income than a study four years later (Gini 2008 = 0.34) (Appendix F, part 1). Using total asset wealth instead of smaller asset bundles reduces variability and the need for repeated measures, but even then, differences in Gini coefficients between years, though more modest, would still be misleading about the longer-run situation. For instance, a study of total asset wealth in 2009 would find a 16 % higher Gini (0.44) than a study done three years earlier (Gini 2006 = 0.38) (Appendix F, part 1).

10. Robustness

[a] Village fixed effects. Besides the growth rate of livestock wealth, results from the main analysis did not change after controlling for fixed traits of villages (Table 2, column 2B). Changes in livestock wealth became statistically insignificant after conditioning for village fixed effects. *[b] Method to compute inequality*. The amount of inequality was sensitive to the method used to compute inequality. The ranking of outcomes by their economic inequality using the Gini coefficient (Figure 1B) differed from the ranking when using the coefficient of variation (Appendix F, Part 2), probably because the coefficient of variation is more sensitive to outliers, which is more likely to happen with small samples (Bendel et al., 1989). In the main analysis (Figure 1B), the monetary value of barter transactions, livestock wealth, monetary income, and area under manioc cultivation had the most inequality; none of these outcomes was among the most unequally distributed resources when using the coefficient of variation.

11. Extensions

Gender. In Table 3 we compare growth rates of selected well-being indicators between women and men. The results provide some evidence of a gender bias in favor of men. Yearly growth rates in the monetary value of barter transactions, total asset wealth, and traditional wealth were higher for men than women (by 5.7 %, 4.3 %, and 6 %). The number of gifts offered grew by 1.1 % per year more for men than for women. Only with commercial wealth did the yearly growth rate for women meaningfully surpassed the growth rate for men: 3.3 % per year more for women than men. Compared with men, women's BMI and adiposity grew yearly by 0.3 % and 0.6 % more, but the effect sizes were small. We found no gender differences in the growth rates of monetary income, monetary value of livestock, *chicha* consumption, or self-reported morbidity.

Hedonic measures. In Table 4, we show growth rates of hedonic measures of well-being, including information on differences between adult women and men. The most noteworthy finding is the lower likelihood of feeling negative and positive emotions or a trend toward emotional neutrality. As the variable *Year* shows, from one year to the next, an adult woman reported being *(a)* less fearful, sad, and angry (5.5, 5.5, and 4.9 percentage points) but also *(b)* less happy (6.9 percentage points). The other noteworthy finding is that the trend in hedonic measures for men was like that of women, as suggested by the modest statistically significant results for the interaction term between the variables *Male* and *Year*.

12. Discussion

This study contributes to research on well-being or quality of life, and inequality. Before turning to the two topics, we discuss reasons for the micro-level trends that were unambiguous; these were trends in *(a)* the composition of asset wealth, *(b)* diet, *(c)* monetary value of foods eaten, *(d)* perceived health, *(e)* plantain cultivation, and *(f)* gender differences.

12.1. Reasons for unambiguous trends

(a) Changes in the composition of asset wealth (reduction in traditional wealth; increase in commercial wealth) reflect intentional choices by Tsimane' in how they wanted to hold wealth. For example, instead of using bows and arrows to fish or hunt, or cotton bags to carry goods, Tsimane' shift to use commercial fishing nets, metal hooks, rifles, shotguns, or backpacks, in part because these commercial goods are cheaper and last longer than goods made from plants.

(b) In energy and macronutrient consumption we see declines in calories and proteins. The first could reflect a trend toward less physical activity — and correlative lower demand for calories — from a more sedentary lifestyle (Section 3 and Rosinger et al., 2013) and the second could reflect greater defaunation (Fernández-Llamazares et al., 2017).

Table 3
Differences in yearly growth rates of well-being indicators between adult (age ≥ 16y) women and men: 2002–2010.

	(1)	(2)	(3)	(4)	(5)	(6)
Variables:	Income	Barter	Autarky	Total	Traditional	Commercial
Male*year	−0.034	0.057**	−0.002	0.043***	0.060**	−0.033**
	(0.029)	(0.020)	(0.003)	(0.011)	(0.020)	(0.016)
Year	0.019	−0.063***	0.011***	0.024***	−0.065***	0.117***
	(0.019)	(0.012)	(0.002)	(0.007)	(0.012)	(0.014)
Male	70.852	−113.634**	3.258	−86.056***	−119.994**	67.863**
	(58.629)	(40.066)	(6.289)	(21.401)	(39.679)	(32.799)
Constant	−35.669	127.595***	−22.464***	−40.137***	136.190***	−229.223***
	(37.374)	(24.734)	(4.502)	(14.638)	(23.488)	(27.590)
Observations	5,397	5,397	5,598	5,376	5,376	5,376
R-squared	0.138	0.012	0.009	0.237	0.012	0.331
	(7)	(8)	(9)	(10)	(11)	(12)
Variables:	Animals	*Chicha*	Gifts	Bed	BMI	Body Fat
Male*year	0.040	0.004	0.011*	−0.011	−0.003***	−0.006*
	(0.032)	(0.005)	(0.006)	(0.011)	(0.001)	(0.003)
Year	−0.044	−0.011***	−0.010	−0.034***	0.005***	0.014***
	(0.021)	(0.003)	(0.004)	(0.008)	(0.001)	(0.002)
Male	−79.476	−8.019	−21.913*	22.358	6.187***	10.709
	(64.183)	(10.767)	(11.718)	(22.137)	(2.395)	(6.674)
Constant	91.633**	21.358***	20.820**	69.720***	−6.006***	−23.816***
	(41.847)	(6.768)	(8.310)	(15.566)	(1.918)	(5.013)
Observations	5,376	5,273	5,397	5,522	4,907	5,198
R-squared	0.001	0.040	0.003	0.012	0.005	0.374

Note: Definition of outcomes are the same as in tables 1-2, with one exception: We added the sum of four skinfolds as a measure of subcutaneous body fat store, necessary for immune function. Other than Autarky (1 = autarkic, 0 = otherwise), all other outcomes are logged. Only indicators measured at the individual level are included. Regressions are OLS with robust standard errors clustered by study participants. P values of variables are adjusted for false discovery rates; *, **, and *** significant ≤ 10 %, ≤5%, and 1 %≤.

Table 4
Comparison of yearly micro-level trends in hedonic measures of well-being between adult (age ≥ 16y) women and men: 2002–2006, 2009–2010.

	(1)	(2)	(3)	(4)
Variables:	Fear	Happy	Sad	Angry
Male*year	0.013**	0.004	−0.007	0.008*
	(0.005)	(0.005)	(0.005)	(0.004)
Year	−0.055***	−0.069***	−0.055***	−0.049***
	(0.003)	(0.004)	(0.003)	(0.003)
Male	−27.131**	−8.608	13.322	−16.750
	(9.770)	(10.236)	(10.220)	(8.934)
Constant	111.641***	138.892***	111.556***	99.061***
	(7.012)	(7.368)	(6.954)	(6.331)
Observations	4,077	4,077	4,076	4,077
R-squared	0.092	0.167	0.107	0.095

Note: Outcomes are binary variables, with names = 1 if respondent reported having experienced the emotion in the past week, and zero otherwise. All other notes are the same as in Table 3.

(c) The rise in the real monetary value of foods eaten reflects a growing propensity to acquire food. During 2004–2010, the chances an adult would buy food in the past fortnight rose by 1.4 percentage points per year; during 2002–2010, the likelihood an adult would barter for food rose yearly by 1.8 percentage points. From 2002 to 2010, the diet changed away from wildlife and crops grown by Tsimane' toward processed foods from the marketplace, principally cooking oil and pasta (Bethancourt et al., 2019). Unfortunately, our price data is too spotty to assess the role of relative food prices in diet trends.

(d) Improvement in perceived health reflects the spread of public health services (Section 3), a rise in real cash expenditures in medicines and health services by households (5 %/year during 2004–2010), and panel conditioning (Section 6).

(e) Many factors explain the reduction in plantain cultivation but a simple one is the growing preference to cultivate rice, a leading cash crop and an appreciated food. During 2002–2010 the total area under plantain cultivation for a household declined by ~ 8 %/year, while the area under rice cultivation rose by ~ 1 %/year. In addition, the probability of eschewing plantain cultivation during this period rose by 2.3 %/year, whereas the probability of not growing rice remained flat at 0.1 %/year.

(f) Trends in gender differentials defy an easy explanation. From one year to the next, men were more likely to accumulate traditional assets and to barter and were less likely to accumulate commercial asset; one might have expected the opposite because men have a stronger foothold in the market economy, have more schooling, and are more likely to speak the national language (Spanish). It is possible that men were acquiring more household commercial articles that got assigned to women. Compared with women, men had barely discernible yearly reductions in BMI and body fatness and the same likelihood of feeling happy or sad over time. The weak evidence for gender differences in rates of change suggests that Tsimane' women have maintained strong decision-making power in their household. Women are empowered through the support of kin, strong respect in Tsimane' households for the private property each spouse brings to a union, and cooperation in horticulture (Bauchet et al., 2021).

Like other Indigenous Peoples in the Amazon, Tsimane' have seen their share of intrusion from missionaries, oil firms, gold panners, drug traffickers, loggers, cattle ranchers, and colonist smallholders from the Andean highlands (Reyes-García et al., 2012), but not in the extreme form seen in other parts of the Amazon. Until recently, Tsimane' have been able to protect themselves by living in remote places and, when necessary, fighting back or retreating farther into the backlands. Under these conditions, exposure to the outside world goes along with a small bundle of micro-level changes, barely perceptible taken together, as shown by the 0.01SD/year change in the index of socioeconomic and health dimensions measured (Section 8).

12.2. *Well-being*

This article contributes to *(i)* longitudinal studies of well-being or quality of life, *(ii)* studies of well-being in small-scale societies, and *(iii)* studies of deprivation in the rural Global South.

Longitudinal studies of well-being. The past two decades have seen

many case studies and cross-cultural studies on longitudinal trends in subjective well-being (Diener & Chan, 2011; Diener et al., 2018). These studies come mostly (but not exclusively) from industrial nations. The largest ones rely on nationally representative samples, use the same survey questions across time and place, and analyze information at the individual level. Much of that research is sparked by a search for determinants (Carla & Falco, 2018; Du et al., 2019) or by an interest in identifying the effects of subjective well-being (Diener & Chan, 2011; Zaninotto & Steptoe, 2019). The use of the same methods of data collection across sites and time facilitates comparisons and the assessment of external validity and permits lagging predictors to enhance claims about causal effects. The studies have often found positive associations (but also some heterogeneity) between monetary income and subjective well-being (Blázquez-Cuesta & Budría, 2012; Das et al., 2020; Zhang & Hong, 2023). In contrast, our micro-level panel study comes from one place and rests on idiosyncratic indicators of well-being or quality of life relevant to one society (Kaufman et al., 2022). It also differs from international panel studies because it is motivated by a different question and approach. We are interested in a pixelated description of micro-level change in well-being as defined by study participants in an economically self-sufficient society and avoid identifying determinants (Section 1.1). We supplement the current literature through a quantitative ethnographically grounded understanding of micro-level change.

Well-being in small-scale societies. Anthropological studies of well-being among pastoralists, hunter-gatherers, and horticulturists have generally eschewed examining well-being comprehensively, have relied mostly on cross-sectional data, and have focused in identifying predictors (not consequences) of well-being. In a comparative study of three horticultural-foraging societies (Tsimane' in Bolivia, Baka in Cameroon, Punan in Indonesia), researchers asked participants during four consecutive quarters to rate their life satisfaction and the reasons for their rating and found that health was the leading perceived cause of life satisfaction (Reyes-García et al., 2021). In a cross-sectional study of fishing communities in the Solomon Islands and Bangladesh, researchers found that evaluative and hedonic measures of well-being bore a weak association with an index of monetization (Minarro et al., 2021). Like those studies, our study struggled with how to measure well-being in an underrepresented type of society, but our approach differs by documenting micro-level change and by putting aside concerns with determinants.

Deprivation. This study contributes to the literature on deprivation by stressing the difficulties of using the label or its neighbor, poverty (Alkire et al., 2015; UNDP 2022). During the study, Tsimane' were money poor, had low levels of privately owned asset wealth, had low levels of schooling, a life expectancy of 53 years (Gurven et al., 2007), widespread respiratory and gastrointestinal infections (Appendix B), widespread child growth stunting (Undurraga et al., 2018), a diet poor in key micronutrients and diversity (Appendix B), and non-trivial amounts of economic inequalities, as we have seen. These indicators would put Tsimane' into the deprived or poor bin. If so, why have so few Tsimane' emigrated? (Section 3). One can build on Graeber and Wengrow (2021) and speculate about what offsets these objective indicators of deprivations, many of which have an "agreed normative interpretation". The pull to stay might come from the historic freedom Tsimane' have enjoyed to pursue a mix way of life combining farming and foraging (Gehring, 2013), ample wilderness, village and household autonomy and choice, social support from a dense network of kin reflecting a system of preferential cross-cousin marriage, a lifestyle with low stress (Appendix B), and the perceived psychic costs of migration (Chen et al., 2019). Living in a remote area, Tsimane' have been able to seize the rudder when adopting aspects of the Western world and the marketplace.

12.3. Economic inequality in small-scale societies

We included economic inequalities because studies across societies find that they often correlate with poorer quality of life, principally health (Section 1.2). Although there is some evidence that economic inequalities matter for quality of life in small-scale societies, there is less agreement on which economic disparities to assess or the appropriate methods to measure them. So far, most research has focused on asset inequality rather than income inequality and has found that asset inequality varies between villages (Jaeggi et al., 2021), types of subsistence (Tucker et al., 2015), kinship systems (Mattison et al., 2023), and generations (Borgerhoff Mulder et al., 2009; Gurven et al., 2010). Fewer studies have examined income inequality per se and, except for Tucker et al. (2015) and Reyes-García et al (2019), the other studies equate income exclusively with monetary earnings and they equate income inequality with earnings inequality (Godoy et al., 2005; Godoy et al., 2004; Gurven et al., 2015), clearly inadequate since much of a household's income comes from consuming what they produce. The shortfall needs correction because the defining debate of our time centers on income inequality not on wealth inequality (DeLong, 2022; Piketty, 2022), though income and wealth are (far from perfectly) correlated (Keister & Lee, 2017; Piketty, 2014; Saez & Zuckman, 2014).

Without or with little monetary savings, monetary investments, or monetary expenditures, as happens in small-scale societies, current household consumption becomes conceptually equivalent to current household income, even if one cannot see or measure current income. Ernst Engel's Law predicts that household food consumption will dominate current total household consumption in such settings. If so, then consumption inequality will track unobserved income inequality. But how should one aggregate food consumption and use it to measure consumption inequality without relying on prices? We propose to use inequality in energy and macronutrient consumption as a first approximation to consumption inequality (and by implication to income inequality) (Bell et al., 2021). The measure is incomplete because it leaves out the consumption of leisure, shelter, amenities, water, services, and public goods, but is a sensible start.

The intuition needs validation yet note from figures 1A-1B how near to each other lie the Gini coefficients of the amounts of protein, energy (calories), and carbohydrates eaten, and how near all of them are to the area of forest cleared, a coarse measure of yearly income capturing the production of all annual crops to eat, swap, store, and sell. Although area deforested can proxy for current income in horticultural societies, it is not as useful as energy or macronutrient intake to gauge income inequality among pastoralists, fishers, or hunter-gatherers because these societies rely on other livelihood activities. Energy and macronutrient inequality serve as a more general currency. In sum, the suggested approach would allow assessing inequality in current household consumption or unseen household current income in a broader range of small-scale societies.

13. Conclusions

The article points to two future conversations.

The first is a practical conversation between members of small-scale societies, researchers, decision-makers, civil society, and international organizations about how to define well-being so the definition captures what is meaningful to people in these societies, the need to collect data on quality of life in small-scale societies, how to pay for the effort, what type of data (if any) to collect, who owns the data (Reyes-García et al., 2022), and how to use it once collected. If the consensus is to move forward, the information should be collected over time following the same protocol of data collection used in the rest of the country to make it possible to track changes, compare quality of life and social exclusion between members of small-scale societies and groups in the rest of country, and decide what to do about gaps or trends in gaps.

The second conversation is between nutritionists, economists, and

biocultural anthropologists about how to best measure food consumption inequality in small-scale societies. The first step would be to validate the idea that in these societies, consumption approximates unseen income, and that food consumption dominates aggregate household consumption. This would make it possible to test the external validity of prior findings from industrial societies about the effects of income inequality on individual well-being using a valid measure of income for small-scale societies.

Disclaimer

The scientific results and conclusions, as well any views or opinions expressed herein, are those of the authors and do not necessarily reflect the views of NOAA or the Department of Commerce.

CRediT authorship contribution statement

Ricardo Godoy: Conceptualization, Formal analysis, Funding acquisition. **Jonathan Bauchet:** Conceptualization. **Jere R. Behrman:** Writing – review & editing, Formal analysis. **Tomás Huanca:** Methodology, Supervision. **William R. Leonard:** Conceptualization, Data curation, Funding acquisition, Writing – review & editing. **Victoria Reyes-García:** Conceptualization, Data curation, Funding acquisition, Writing – review & editing. **Asher Rosinger:** Formal analysis, Writing – review & editing. **Susan Tanner:** Conceptualization, Data curation, Formal analysis, Writing – review & editing. **Eduardo A. Undurraga:** Conceptualization, Formal analysis, Visualization, Writing – review & editing. **Ariela Zycherman:** Conceptualization, Formal analysis, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Appendix A describes where the public can obtain the coarse and clean datasets of the study + the computer codes used in this article. Data + computer codes are freely available to anyone

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Appendix A

The clean de-identified panel dataset (2002–2010) used for this article is in Stata V17 and is open to the public without restrictions. The dataset can be downloaded from the following two web pages (A and B):

A: Electronic library of Brandeis University:

https://scholarworks.brandeis.edu/esploro/outputs/dataset/Overview-of-the-Tsimane-Amazonian-Panel/9923926193901921?institution = 01BRAND_INST

B. Inter-University Consortium for Political and Social Research (ICPSR), University of Michigan:
https://www.icpsr.umich.edu/web/ICPSR/studies/37671 or.

http://dx.https://doi.org/10.3886/ICPSR37671.v2

The yearly unprocessed de-identified datasets of the panel are also open to the public without restrictions and can be downloaded from the following web page:

C: Electronic library of Brandeis University.

https://scholarworks.brandeis.edu/esploro/search/outputs?query=any,contains,godoy%20coarse&page=1&institution=01BRAND_INST&scope=Research&sort=rank&mfacet=facet_rtype,include,datasets,1

An extensive report summarizing aspects of the panel study is open to the public and can be downloaded from the following web page:

https://scholarworks.brandeis.edu/permalink/01BRAND_INST/1bo2f6t/alma9923926194001921

The Stata 17 computer codes are available as a supplement to this article and the guidelines on how to replicate the results are described in a supplementary Word document titled, "Guidelines to replicate results".

Last, the unprocessed and processed datasets for the ancillary studies of the panel are available in [A] and [B].

Appendix B. . Ethnographic sketch of outcomes

Horticulture: Forest area and number of plots cleared, and hectares under plantains and manioc cultivation. Tsimane' have been accomplished horticulturists since at least the early twentieth century (Nordenskiöld, 1979 [orig. 1924], pp. 34–35). Every year most households clear one plot of old-growth forest or fallow forest to farm. Forest area cleared is a meaningful outcome because it proxies for food availability — a frequently mentioned

reason for happiness and sadness — and total yearly income (cash and imputed). In the forest area cleared, households put in their three main annual crops (rice, manioc, and maize) and the main perennial crop (plantain) they will consume, barter, store, and sell for the rest of the year (Vadez et al., 2008). The annual deforested area captures both household consumption from own horticultural production and earnings from selling the four leading crops and is thus a valid proxy for household yearly non-monetary income, plus some monetary income. Though reasonable as a proxy for total household income, area deforested underestimates total monetary income because it excludes monetary earnings from wage labor and from the sale of wildlife, discussed in the next heading. It also underestimates household consumption because it excludes consumption of wildlife.

Farm crops provided 86 % of the carbohydrates, 64 % of the calories, and 35 % of the fats in the diet of Tsimane'. Among farm crops, rice and plantain occupy most of a cleared forest parcel because Tsimane' use the crops as their principal food staple and cash crops (Zycherman, 2013). We focus on plantain because it provides 60 % of cultigen calories (Kraft et al., 2018), is a chief cash crop, and is a safety net as it tolerates neglect (but not flooding) and attacks from pests, diseases, and predators. Manioc is important not as a food (Tsimane' rarely eat it) but as the principal ingredient to make *chicha*, the fermented beverage households offer guests to display sociality (Zycherman, 2015).

Economic flows: Income, barter, and autarky. We considered two economic outcomes: *(a)* flows of monetary income (earnings) and the monetary value of goods received in barter and *(b)* stocks of privately owned physical assets, discussed in the next section. Tsimane' engage with the marketplace intermittently. To earn cash, men work for cattle ranchers, logger, and for non-Indigenous People dwelling inside or next to the homeland of Tsimane'. Almost no Tsimane' women work for wages. Women and men earn cash by selling thatch palms from the forest and farm produce (crops, eggs, livestock) to traveling traders who come to the village or directly to consumers and merchants in towns. Tsimane' also relied on barter to obtain meat and market foods (e.g., refined white sugar, pasta) and, in exchange, supply rice, plantains, and thatch palms.

Economic-wealth: Total, traditional, commercial, and livestock. Tsimane' have clear private property rights to tools, livestock, and household utensils. Parents give chicks as gifts to their children so children learn how to care for animals, and women and men each own assets separately, though adults in a household have usufruct rights to the goods of others. We grouped privately owned physical assets into three categories (Table 1). These forms of storing private wealth go back at least a century. In the early twentieth century, Nordenskiöld noted Tsimane' built conical coops to guard poultry from night predators, listed the many locally made and commercial goods Tsimane' owned (Nordenskiöld, 1979 [orig. 1924], 2001 [orig 1924]), and remarked on how Tsimane' did not hoard assets; they made or acquired an asset as they needed it, not before (Nordenskiöld, 2001 [orig 1924], p. 157).

Sociality: Gifts and chicha. The main forms of sociality we measured center on *(a)* gifts and *(b)* convivial drinking of *chicha*. Tsimane' typically bestow meat and fish as gifts. When they help each other with labor, they help mainly with farm chores. Adverse regional shocks such as floods do not trigger much intra-village or inter-village transfers of goods or aid from other households, in part because outside institutions step in to help. However, bedridden adults under ordinary circumstances were more likely to receive gifts. Of all forms of displaying pro-social behavior, public drinking of *chicha* in a village is the most ubiquitous (Rosinger & Bethancourt, 2019; Zycherman, 2015). From the time they first set food in the homeland of Tsimane', Protestant missionaries prohibited the drinking of alcohol (including fermented *chicha*); it is possible that villagers underreported the amount of *chicha* drank to avoid potential opprobrium (Godoy et al., 2021). Only women make *chicha*, which each sex drinks separately. *Chicha* is served by women in the village and is offered to anyone who stops by. Men sit in a circle as they sip from a gourd, passing it to the person next to them; when the gourd is empty, a woman in the household refills it until the vat is empty. Women drink likewise in a separate circle. Households gain silent praise for sharing *chicha*.

Foods: Value and macronutrients (calories, proteins, fat, carbohydrates). Pauly (1928, pp. 117-118) and Nordenskiöld (2001 [orig 1924], pp. 158–161) noted that Tsimane' enjoyed a well-balanced diet of wildlife and home-grown crops. Fish eclipsed game animals in their diet and, among foods from livestock, only poultry stood out. Tsimane' had a profusion of food but did not share it with Nordenskiöld. Instead, Tsimane' regaled Nordenskiöld with *chicha*. In summarizing his impressions of the Tsimane' diet, he wrote that the land of Tsimane' was "without doubt a good place to live. I don't think these people are ever hungry" (p. 161). During our study, the diet of Tsimane' consisted of a mix of crops they grew, fish and game animals they caught, and market foods they bought or bartered for (Rosinger et al., 2013). Their diet, though adequate in energy and macronutrients, lacks diversity (Kraft et al., 2018) and may be limiting key micronutrients (Bethancourt et al., 2019; Foster et al., 2005; Kraft et al., 2018, pp. 1186–1187).

Health: Bedridden days and BMI. The health afflictions of Tsimane' include gastrointestinal (McDade et al., 2007; Tanner et al., 2013) and respiratory infections (Gurven et al., 2017), accidents, and illnesses from natural disasters like floods. In 2009, the Bolivian government started a conditional cash-transfer program for pregnant women and mothers with children under two years of age who met program requirements, such as mothers having pre-natal checkups. Compared with international height references, Tsimane' adults are short in stature (Godoy et al., 2006). Our data for the last year of the panel (2010) suggests that adults (n = 637) were below international standards in z-scores of weight-for-age (-0.78), age-sex scores of arm muscle area (-0.60), and sum of triceps and subscapular skinfolds (-0.45). Despite the burden of disease, Tsimane' are physically active and have outstanding cardiovascular health from a way of life amalgamating horticulture, fishing, hunting, and plant collection (Gurven et al., 2013; Kaplan et al., 2017). Bethancourt et al. (2019) found significant increases in the prevalence rates of both overweight and obesity among women and men and Nyberg (2009, 2012) found Tsimane' had very low cortisol levels (a biomarker of stress).

Appendix C. . Textual answers by adults about what made them happy or sad the past week

This appendix documents verbatim answers of respondents during 2002–2004. Twenty-five and 24 unique answers accounted for at least 1 % of the reasons for being happy or sad; these are the ones shown in this appendix.

Happy. The dataset on happiness had a total of 2831 observations. A person who said nothing had made them happy counted as one observation, but so would a person who said only one event had made them happy. People who said nothing had made them happy are excluded from the tabulation below. Of the total of 2831 observations, 2390 observations had a reason for happiness. 25 reasons were mentioned at least 1 % of the time; they accounted for 84.42 % of the 2390 observations.

Verbatim answers	N	Percent
Work well	216	7.6
In company of family in household	207	7.3
Good fish harvest	173	6.1
Drink *chicha*	150	5.3

(*continued on next page*)

(*continued*)

Verbatim answers	N	Percent
Hunting by self or someone in household	150	5.3
Good work in the fields	123	4.3
Play soccer or do sports	107	3.8
Visit towns	105	3.7
Good food; there was food	103	3.6
In company of non-household family members	96	3.4
Village festivity	91	3.2
Harvest or goods from the field	87	3.1
Visit relatives	87	3.1
Visit by relatives in the village	83	2.9
Good health	73	2.6
Visit by relatives living outside the village	68	2.4
Fields produce well	68	2.4
Eat meat	67	2.4
Sell well	62	2.2
Purchases	58	2.0
Domestic animals	53	1.9
Family has good health	47	1.7
Listen to Church messages	46	1.6
Eat fish	41	1.4
Take a walk /a/	29	1.0

Sad. There were a total of 2379 observations on the reasons for sadness, including respondents who said nothing had made them sad. Of this total, 2000 observations (84.06 %) of the 24 reasons for sadness accounted for at least 1 % of all reasons for sadness.

Verbatim answers	N	Percent
Own illness or accident	325	13.7
Illness of someone in the household	278	11.7
Lack of food, poor-quality food	270	11.3
Insults, swears	213	9.0
Lack of meat	79	3.3
Death, illness, or loss of animals	69	2.9
Theft	67	2.8
Lack of money	65	2.7
Lies	62	2.6
Mad at non-household family members	56	2.4
Poor weather	52	2.2
Crop loss	51	2.1
Inferior quality of farm plots	50	2.1
Bad dreams	47	2.0
Drunkenness	42	1.8
No hunting	38	1.6
Mad at a household member	37	1.6
No fish	36	1.5
Bitten by wasp, sting ray, etc.	31	1.3
Unable to work in the fields	29	1.2
A household member left	29	1.2
Accident in the family	25	1.1
Visitors don't come	25	1.1
Almost had an accident	24	1.0

Notes:

N: Frequency of activity

Percent: N/2831 for happiness and N/2379 for sadness

/a/ The phrase "take a walk" does not capture the meaning of the Tsimane' word *sóbaqui*, which stands for visiting, strolling, or taking a leisurely walk for pleasure (Ellis, 1996).

Appendix D. . Part 1. Summary statistics of outcomes among households at baseline (2002): Number of households, mean, and standard deviation /a/

Outcomes:	N	Mean	SD
Horticulture:			
Forest	228	0.179	0.216
Plots	228	0.298	0.205
Plantains	227	0.112	0.131
Manioc	226	0.021	0.051
Economic flows:			
Income	245	4.65	15.7
Barter	245	0.337	0.561

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Outcomes:	N	Mean	SD
Autarky	245	0.061	0.24
Economic stocks: Wealth			
Total	243	886	813
Traditional	243	228	263
Commercial	243	503	560
Livestock	243	155	339
Sociality:			
Gifts	245	0.085	0.089
Chicha	245	0.06	0.084
Food:			
Value	241	6.86	8.004
Macronutrients /b/			
Calories	257	3025	2147
Proteins	257	91	98
Fats	257	49	83
Carbohydrates	257	545	360
Health:			
Bedridden	245	0.131	0.215
BMI-women	192	23.143	2.692
BMI-men	214	23.364	2.105

/a/ Table 1 has definition and measurement of variables.

/b/ For macronutrients, values in the column "Mean" refer to medians instead of averages, which we used as an additional step to redress the influence of outliers.

Appendix D. . Part 2. Year-by-year mean of outcomes among households (2002–2010)

	2002	2003	2004	2005	2006	2007	2008	2009	2010
Horticulture: Forest	0.179	0.201	0.173	0.184	0.207	0.179	0.205	0.230	0.199
Plots	0.298	0.387	0.298	0.306	0.301	0.292	0.271	0.282	0.290
Plantains	0.112	0.127	0.067	0.085	0.052	0.041	0.052	0.055	0.061
Manioc	0.021	0.025	0.012	0.022	0.019	0.016	0.021	0.030	0.018
Income flows:									
Income	4.650	3.429	4.231	5.131	4.584	4.774	5.946	5.584	5.454
Barter	0.337	0.412	0.330	0.455	0.408	0.315	0.331	0.377	0.370
Autarky	0.061	0.120	0.076	0.067	0.111	0.164	0.134	0.158	0.123
Wealth: Total	886	867	854	931	813	911	1393	1019	1262
Traditional	228	209	180	208	197	253	237	192	115
Modern	503	524	520	576	504	515	978	651	968
Livestock	155	134	154	146	112	143	178	176	179
Sociality: Gifts	0.085	0.059	0.035	0.075	0.070	0.092	0.058	0.065	0.062
Chicha	0.060	0.054	0.067	0.077	0.061	0.070	0.068	0.046	0.050
Food: Value	6.86	7.30	9.64	8.16	6.49	7.74	12.51	8.28	14.81
Macronutrients:									
Calories	3025	3714	2629	2851	3056	2275	2624	3116	2817
Proteins	91	118	81	88	90	73	78	90	85
Fats	49	61	42	43	48	47	49	50	53
Carbohydrates	545	642	453	532	564	396	440	549	519
Health: Bed	0.131	0.184	0.064	0.081	0.105	0.134	0.075	0.089	0.053
BMIF-women	23.143	23.446	23.344	23.481	23.762	23.645	23.961	23.574	24.302
BMI-men	23.364	23.486	23.213	23.527	23.658	23.437	23.573	23.655	23.753

For definition of variables see notes to Appendix D, Part 1.

Appendix E. . Regression results for column 2A of Table 2: *No* village fixed effects

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
	Forest	Plots	Plantain	Manioc	Income	Barter	Autarky
Year	0.004	−0.006	−0.008***	0.0001	0.023	−0.004	0.010*
	(0.002)	(0.003)	(0.002)	(0.001)	(0.018)	(0.007)	(0.003)
Constant	−7.170*	11.989**	15.971***	−0.394	−44.412	7.395	−19.023***
	(4.169)	(5.285)	(3.223)	(1.308)	(36.708)	(13.229)	(6.716)
Observations	2,193	2,210	2,183	2,182	2,261	2,261	2,261
R-squared	0.004	0.005	0.039	0.001	0.002	0.001	0.006
	[8]	[9]	[10]	[11]	[12]	[13]	[14]
	Total	Traditional	Commercial	Animals	Food	Calories	Proteins
Year	0.042***	−0.052**	0.076***	−0.063**	0.074***	−0.014*	−0.023*
	(0.009)	(0.017)	(0.013)	(0.021)	(0.014)	(0.007)	(0.009)
Constant	−76.457***	109.899***	−144.893***	131.611***	−145.222***	35.775***	51.833***
	(18.743)	(35.040)	(25.233)	(41.450)	(27.439)	(13.556)	(18.242)

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	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Observations	2,243	2,243	2,243	2,243	2,235	2,261	2,261
R-squared	0.021	0.020	0.051	0.008	0.053	0.004	0.008
	[15]	[16]	[17]	[18]	[19]	[20]	[21]
	Fat	Carbs	Gifts	*Chicha*	Bed	BMI-W	BMI-M
Year	0.001	−0.012	−0.0001	−0.001	−0.008***	0.004*	0.002
	(0.013)	(0.007)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)
Constant	3.093	30.081**	0.590	2.438	15.627***	−5.153	0.782
	(25.767)	(15.009)	(1.829)	(2.458)	(3.704)	(3.161)	(2.232)
Observations	2,261	2,261	2,261	2,261	2,261	1,890	2,018
R-squared	0.001	0.002	0.001	0.001	0.020	0.009	0.001

Appendix E. . Regression results for column 2B of Table 2: With village fixed effects

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
	Forest	Plots	Plantain	Manioc	Income	Barter	Autarky
Year	0.004	−0.006	−0.008***	0.001	0.026	−0.003	0.01
	(0.002)	(0.003)	(0.002)	(0.000)	(0.023)	(0.005)	(0.005)
Constant	−7.346	11.723*	15.863***	−0.137	−50.185	6.585	−19.092*
	(4.897)	(6.337)	(3.305)	(0.841)	(46.987)	(9.666)	(9.050)
Observations	2,193	2,210	2,183	2,182	2,261	2,261	2,261
R-squared	0.004	0.005	0.044	0.001	0.003	0.001	0.006
	[8]	[9]	[10]	[11]	[12]	[13]	[14]
	Total	Traditional	Commercial	Animals	Food	Calories	Proteins
Year	0.043**	−0.048*	0.077***	−0.068	0.074***	−0.014**	−0.023**
	(0.011)	(0.015)	(0.012)	(0.025)	(0.013)	(0.004)	(0.007)
Constant	−78.994***	102.851***	−148.370***	140.599**	−146.767***	36.366***	51.978***
	(22.980)	(29.270)	(23.793)	(50.186)	(25.113)	(8.759)	(14.280)
Observations	2,243	2,243	2,243	2,243	2,235	2,261	2,261
R-squared	0.022	0.019	0.055	0.009	0.057	0.004	0.008
	[15]	[16]	[17]	[18]	[19]	[20]	[21]
	Fat	Carbs	Gifts	*Chicha*	Bed	BMI-W	BMI-M
Year	0.001	−0.012*	−0.001	−0.001	−0.008***	0.005	0.002
	(0.008)	(0.004)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Constant	2.696	31.281***	0.189	2.415	16.100***	−5.555	0.533
	(16.217)	(8.805)	(1.566)	(2.857)	(2.593)	(3.361)	(2.712)
Observations	2,261	2,261	2,261	2,261	2,261	1,890	2,018
R-squared	0.001	0.003	0.001	0.001	0.021	0.010	0.002

Notes: Regressions are ordinary least squares with robust standard errors clustered by households in a village each year (column 2A, Table 2) or clustered by households in a village (column 2B, Table 2). For the year coefficient, *, **, and *** indicate significance levels at ≤ 10 %, ≤5%, and ≤ 1 % adjusted by the Westfall and Young method for false discoveries, as developed and adapted to Stata by Jones et al. (2019). Other than Autarky, all other outcomes were transformed using the inverse hyperbolic sine function. The variable Autarky was left as defined in Table 1. Headings in columns 8–11 of this appendix refer to the type of asset wealth, as defined in Table 1. Carbs = carbohydrates.

Appendix F. . Part 1: Gini coefficients of economic inequalities

	Baseline									Yearly	Grand	
Outcomes:	2002	2003	2004	2005	2006	2007	2008	2009	2010	Mean	Gini	%Δ year
Horticulture: Forest	0.459	0.386	0.446	0.361	0.420	0.408	0.346	0.423	0.437	0.409	0.414	−0.5
Plots	0.359	0.376	0.403	0.354	0.376	0.371	0.366	0.384	0.397	0.376	0.380	0.5
Plantain	0.512	0.517	0.611	0.535	0.612	0.627	0.551	0.671	0.553	0.577	0.594	1.7
Manioc	0.735	0.637	0.802	0.725	0.731	0.740	0.733	0.828	0.801	0.749	0.758	1.6
Economic: Income	0.670	0.594	0.646	0.569	0.588	0.692	0.638	0.650	0.637	0.631	0.639	0.4
Barter	0.717	0.732	0.735	0.749	0.692	0.797	0.804	0.792	0.778	0.756	0.759	1.3
Wealth: Total	0.412	0.400	0.403	0.407	0.386	0.393	0.438	0.449	0.432	0.414	0.426	1.1
Traditional	0.419	0.452	0.411	0.410	0.440	0.447	0.443	0.412	0.532	0.441	0.452	0.2
Commercial	0.452	0.407	0.403	0.421	0.392	0.384	0.467	0.468	0.398	0.421	0.446	1.5
Livestock	0.693	0.663	0.726	0.779	0.713	0.746	0.729	0.789	0.842	0.744	0.753	2.1
Food: Value	0.476	0.479	0.430	0.375	0.387	0.406	0.479	0.370	0.449	0.427	0.453	−1.2
Food: Macronutrients												
Calories	0.304	0.358	0.295	0.297	0.301	0.295	0.336	0.281	0.269	0.304	0.313	−1.6
Proteins	0.373	0.428	0.405	0.358	0.344	0.364	0.419	0.334	0.342	0.374	0.383	−1.7
Fats	0.477	0.475	0.487	0.445	0.449	0.396	0.513	0.437	0.429	0.457	0.463	−1.1
Carbohydrates	0.304	0.357	0.285	0.302	0.297	0.303	0.312	0.278	0.258	0.299	0.310	−2.0

Appendix F. . Part 2: Coefficient of variation (CV) of economic inequalities

	Baseline									Yearly	Grand	
Outcomes:	2002	2003	2004	2005	2006	2007	2008	2009	2010	Mean	CV	%Δ year
Horticulture: Forest	0.890	1.367	1.211	1.496	1.291	1.366	1.549	1.292	1.142	1.291	1.243	2.0
Plots	1.592	1.415	1.348	1.477	1.425	1.448	1.413	1.415	1.333	1.429	1.409	−1.1
Plantain	0.889	0.942	0.481	0.934	0.802	0.771	0.875	0.619	0.896	0.803	0.711	−0.4
Manioc	0.416	0.785	0.507	0.561	0.611	0.633	0.656	0.215	0.484	0.541	0.398	−4.4
Economic: Income	0.305	0.787	0.583	0.833	0.912	0.497	0.616	0.616	0.722	0.656	0.569	3.8
Barter	0.616	0.565	0.558	0.530	0.725	0.504	0.476	0.514	0.502	0.555	0.542	−2.5
Wealth: Total	1.230	1.301	1.175	1.187	1.332	1.186	1.107	1.013	1.042	1.175	1.088	−2.6
Traditional	1.191	1.075	1.246	1.235	1.162	1.088	1.046	1.197	0.905	1.126	1.084	−2.1
Commercial	1.087	1.325	1.316	1.332	1.410	1.394	0.975	1.151	1.349	1.262	1.080	−0.2
Livestock	0.462	0.496	0.388	0.333	0.400	0.333	0.386	0.293	0.246	0.369	0.332	−6.9
Food: Value	0.867	0.934	1.124	1.411	1.365	1.199	0.888	1.420	0.974	1.134	0.950	1.8
Food: Macronutrients												
Calories	1.660	1.159	1.722	1.606	1.494	1.838	1.271	1.720	1.837	1.593	1.443	1.9
Proteins	1.181	0.973	1.150	1.426	1.464	1.312	1.045	1.560	1.367	1.280	1.157	2.9
Fats	0.876	0.868	0.893	1.115	0.761	1.227	0.443	1.095	1.007	0.919	0.768	−0.1
Carbohydrates	1.730	1.196	1.734	1.537	1.629	1.766	1.609	1.607	1.955	1.646	1.495	2.3

Note. The grand Gini or the grand coefficient of variation is computed by combining all household observations for an outcome across all years. Yearly growth rates for Gini coefficients of Appendix F, Part 2, are in the next table (Appendix F, Part 3).

Appendix F. . Part 3: Yearly micro-level growth rates of Gini coefficients of economic outcomes (last column of table in Appendix F. Part 1)(N = 9)

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
	Forest	Plots	Plantain	Manioc	Income	Barter	Total
Year	−0.005	0.005	0.017	0.016	0.004	0.013	0.011
	(0.013)	(0.006)	(0.011)	(0.009)	(0.009)	(0.005)	(0.006)
Constant	9.208	−11.485	−35.373	–32.682	−8.630	−27.167**	–23.189*
	(26.386)	(11.382)	(22.754)	(17.557)	(17.569)	(10.395)	(11.641)
R-squared	0.021	0.109	0.251	0.327	0.030	0.489	0.344
	[8]	[9]	[10]	[11]	[12]	[13]	[14]
	Commercial	Traditional	Animals	Food	Calories	Proteins	Fat
Year	0.002	0.015	0.021	−0.012	−0.016	−0.017	−0.011
	(0.011)	(0.010)	(0.006)	(0.014)	(0.010)	(0.011)	(0.010)
Constant	−4.532	−31.226	−42.838***	22.705	30.978	32.661	22.182
	(21.124)	(19.403)	(11.966)	(27.892)	(20.720)	(22.080)	(19.644)
R-squared	0.004	0.260	0.644	0.092	0.256	0.249	0.163
	[15]						
	Carbs						
Year	−0.020						
	(0.010)						
Constant	39.656*						
	(19.148)						
R-squared	0.394						

Note: P values for the Year coefficient were adjusted for false discovery rates. Carbs = carbohydrates.

Appendix G. . Identifying latent variables

Chronbach's alphas were calculated for all or some of the variables in Table 1 to decide if they reflected one or more latent variables and if a principal component factor was warranted. We used principal component factor with varimax rotation to create a score for the variables that seemed to justify it: all socioeconomic variables and all macronutrients.

Variables included:	**Alpha**
[I] . Socioeconomic and health variables	
[1] All. Forest, plots, plantains, manioc, income, barter, traditional wealth, commercial wealth, livestock, gifts, *chicha*, food value, bedridden, and BMI /a/	0.63
[2] Horticulture.	
[a] Without food. Forest, plots, plantains, manioc	0.65
[b] With food. Forest, plots, plantains, manioc, food value	0.64
[3] Wealth. Traditional wealth, commercial wealth, livestock	0.53
[4] Economic flows. Income, barter, food	0.26
[5] Sociality. Gifts, *chicha*	0.18
[6] Health. Bedridden, BMI	0.15
[II] . Macronutrients and calories	
[7] Macronutrients. Calories, proteins, fat, carbohydrates	0.90

Note: /a/ Total wealth and autarky were excluded because they were created by combining variables in Table 2; for example, total wealth is the sum of the three types of wealth.

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