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How well do people in autarky protect food consumption? Panel evidence from foragers and farmers in the Bolivian Amazon

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Panel evidence from foragers and farmers in the Bolivian Amazon

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Abstract

The ability of rural people to protect their food consumption matters because it captures their economic vulnerability. How well do people in highly autarkic economies protect consumption from income shocks and does protection work equally well for girls, boys, women, and men? We answer the queries with a 5-quarter panel (156 adults, 169 children) from a foraging-farming society in the Bolivian Amazon. We estimate whether quarterly changes in the log of consumption correlate with quarterly changes in the log of cash income while controlling for taste shifters and covariant shocks. We use weather variables to instrument for income and anthropometric indices of short-run nutritional status to proxy for food consumption. 60% of households experienced income shocks. Households had a thin safety cushion to cope with shocks and used only one strategy to smooth income. We find that child consumption is fully protected from income growth and works equally well for girls and boys, but adult consumption is not as well protected. Estimates of income elasticities of consumption fell toward the lower range of estimates from previous studies. We end by discussing the anomaly of almost perfect consumption smoothing despite self-reported weak safety nets to protect income and consumption.

Keywords: Consumption smoothing, income smoothing, risk, insurance, anthropometrics, Tsimane', Bolivia, markets, indigenous peoples, Amerindians

Introduction. Recent years have seen growing interests in formal tests of how well poor people in developing countries protect consumption, particularly food consumption, and whether protection works equally well for girls, boys, women, and men (Dercon & Krishnan 2000a, 2000b; Doss 2001; Frankenberg, Smith & Thomas 2003; Gertler & Gruber 2002; Morduch 1995; Skoufias 2001, 2002; Townsend 1995, 2002; World Bank 2001). The topic has drawn attention because it allows one to assess economic vulnerability and intra-household discrimination, particularly among the poor.

Here we build on this line of research by estimating how well people in a highly autarkic society of foragers and farmers protect their food consumption from income shocks unique to the household (hereafter idiosyncratic shocks), and whether protection works equally well for all people in the household. The literature on consumption smoothing from developing countries comes from either smallholders in rural Asia or Africa, or from people in transition economies. Economists rarely study highly autarkic populations of foragers, and anthropologists, who typically study such populations, have generally not collected the type of information needed to carry out formal tests of consumption smoothing. As a result, we do not know whether findings from smallholders in developing nations or from people in transition economies hold up in much different socioeconomic settings.

The study of consumption smoothing in highly autarkic economies allows one to explore topics that have received much attention in recent years, and thus decide whether findings from more developed economies also apply to these unique settings.

First, the literature on consumption smoothing suggests that rural households protect income by using pre-emptive strategies to diversify production before shocks strike (Morduch 1995, 2002). Morduch reviews case studies and finds that smallholders forgo 10-16% of their crops from producing in conservative ways (Morduch 1995). In highly autarkic economies without access to fully developed credit or labor markets, one might also expect dependence on pre-emptive strategies to smooth income, and one might also expect income losses from producing in conservative ways. However, extensive and deep networks of kinship and reciprocity might lower the need to rely on pre-emptive strategies. If so, the costs of using pre-emptive strategies might be negligible or much lower than the costs among smallholders in more developed economies.

Second, liquidity constraints or lack of well-functioning output or labor markets should induce household heads to make unequal allocation of food and other resources to females and males in the household (Behrman 1998; Garg & Morduch 1998; Pitt, Rosenzweig & Hassan 1990; Ray 1998). As we shall see, case studies suggest that income shocks deepen disparities in the allocation of food between females and males in poorer households. In a highly autarkic society where all people in a household and all households in some of the smaller hamlets might literally eat from the same pot, risks may be fully shared, so one might find little evidence that idiosyncratic income shocks affect individual consumption despite severe resource constraints. Further, extensive systems of sharing and reciprocity across households linked by kinship and by marriage,

so common in small-scale, pre-industrial societies, should protect aggregate household consumption from household income shocks.

Last, the study of consumption smoothing in a highly autarkic society can contribute to our understanding of mechanisms to smooth consumption that have so far received scant attention. Since credit, output, and labor markets are poorly developed or non-existent in these remote settings, one might think that people in highly autarkic societies would have to draw on social capital to smooth consumption. We find that although our subjects have almost perfect consumption smoothing, they do not rely on sharing and reciprocity to smooth consumption in the face of idiosyncratic income shocks, nor do they use strategies common in other rural areas of developing nations. This presents a puzzle: How do people in a highly autarkic society achieve almost perfect consumption smoothing for all members in the household? In the conclusion, we advance several hypotheses to explain the anomaly and make suggestions to guide future empirical research.

To explore the topics we draw on a unique data set from an Amerindian society of hunters, gatherers, and farmers -- the Tsimane' -- in the Bolivian Amazon. The data consists of a panel collected during five consecutive quarters (August 1999-October 2000) from 156 adults and 169 children, in 52 households of two villages, one remote and poor, and one richer and close to a market town. We designed the surveys to collect information on all adverse, unique shocks to the household, on all strategies used by households to cope with shocks, and on the financial costs of shocks. Panel studies of

consumption smoothing have relied on surveys at least one year apart; panel studies relying on shorter periods are more rare, but they are valuable because they make it possible to decide whether households protect food consumption over a short time (Dercon & Krishnan 2000a, 2000b; Skoufias 2001, 2002).

A second novel aspect of the data is the use of several new fine-grained anthropometric measures that proxy for individual short-run nutritional status. Some of the anthropometric indices we use, such as body fat measured with the sum of triceps and subscapular skinfolds or measured with fat from the mid-arm muscle area, provide very accurate measures of short-run nutritional status and have been used infrequently in the behavioral sciences (Bindon & Vitzthum 2002; Crooks 1999; Leonard 1991b). The collection of information from all people in the household allows us to gain a better understanding of how households apportion the burden of shocks among its members. Much of the previous literature on consumption smoothing has focused on households rather than on individuals (Alderman, Hoddinott & Kinsey 2003).

Despite the benefits from studying consumption smoothing in highly autarkic societies, the study presents challenges because in such societies the supply and demand framework does not operate, or does not operate well. For instance, to measure consumption we could not rely on food expenditures, as in often done in developing nations, so we had to rely instead on anthropometric indices of short-run nutritional status. Nor could we rely exclusively on cash earning to measure income. To instrument for income we use

different types of weather variables, idiosyncratic household income shocks, and demographic attributes of adults.

Consumption smoothing: Review of anthropological and economic studies. Pursuing different methods of collecting and analyzing information, cultural anthropologists and economists have arrived at two roughly similar conclusions about consumption smoothing: (a) people in rural economies protect relatively well food consumption from idiosyncratic and small income shocks, but not against large or generalized shocks (also known as covariant shocks; e.g., floods), and (b) protection often works better for males than for females if households face resource constraints. Below we expand on these points by briefly reviewing the literature from anthropology and from economics on how households cope with shocks.

Anthropology. Cultural anthropologists have noted that despite widespread reciprocity and gift giving among foragers, they do not protect well food consumption against covariant shocks (Colson 1979). Much of the anthropological work on economic vulnerability among foragers has focused on the effect of one covariant but predictable shock: changes in food consumption produced by changes in the seasonal supply of food. Among the Hiwi foragers of Venezuela, Hurtado and Hill report significant changes in body weight for females and for males in response to the seasonal availability of food (Hurtado & Hill 1990). Among the Aché hunters and gatherers of Paraguay, Hill and his co-workers document changes in consumption across seasons, driven largely by changes in the seasonal supply of honey and small vegetables (Hill, Hawkes, Hurtado & Kaplan

1984). Working among the Hazda foragers in Northern Tanzania, Hawkes and her co-workers report significant seasonal changes in the body weight of children; consumption smoothing worked better for men than for women, and it worked better for adults than for children (Hawkes, O'Connell & Blurton-Jones 1997; Hill & Kaplan 1993). A longitudinal study (1980-1985) among the Efe foragers and Lese horticulturalists of Congo shows significant changes in body fat during the lean season of the year (April-June) (Bailey, Jenike, Ellison, Bentley, Harrigan & Peacock 1993; Jenike 1995); farmers lost 2-8% of body weight depending on the severity of the dry season (Wilkie, Morelli, Rotberg & Shaw 1999). Farmers showed greater seasonal changes in body-mass index than foragers, in part, because foragers could move widely in search for food during lean times, whereas farmers were tied to their farm plots (Bailey, Jenike, Ellison, Bentley, Harrigan & Peacock 1992, 1993). Anthropometric indices suggest that Lese women suffered more during periods of nutritional stress than Lese men (Bentley, Aunger, Harrigan, Jenike, Bailey & Ellison 1999). During the hunger season, Lese horticulturalists coped with food shortage by reducing non-essential activities with uncertain pay-offs (Jenike 1996). Significant weight loss during seasons of hunger have been reported for other rural societies of Africa (Pagezy 1982, 1988, 1990, 1993; Richards 1990) and, through osteological remains, have been inferred for pre-historic populations (Jenike 2001).

Formal tests of consumption smoothing among foragers and farmers are rare. In a panel study of 2.5 years among 32 households of Tawahka Amerindians, a horticultural and foraging society in the rain forest of eastern Honduras, researchers estimated the value of

consumption by weighing and valuing all goods brought into households on days chosen at random in two villages with different degrees of exposure to the market. They found that the temporary income elasticity of all consumption (food plus non-food) was small (-0.016; z=2.01) but different from zero, suggesting inadequate protection of consumption. Although the Tawahka protected well consumption from idiosyncratic income shocks, they could not protect well from covariant shocks. When Hurricane Mitch struck Honduras in 1998 it caused widespread damage; the Tawahka survived thanks to international aid (Wong & Godoy 2003).

Economics. Economists have drawn on formal models of full insurance with complete risk sharing within a village and on the permanent-income hypothesis to test consumption smoothing (Skoufias 2002). Provided one measures income and consumption with accuracy and provided one controls for covariant shocks, then the growth rate of income (or idiosyncratic shocks to income) should not affect the growth rate of consumption if households protect consumption well (Deaton 1997).

Case studies in rural societies of developing nations suggest that households insure well against small or idiosyncratic shocks, but not against large or covariant shocks (Kurosaki & Fafchamps 2002; Morduch 1995, 1999; Paxson 1992; Townsend 1995; World Bank 2001). In Bangladesh only major floods hurt the physical growth of children, particularly children from landless families that could not borrow (Foster 1995). In rural Ethiopia, Dercon and Krishnan found that women in poor households bore the "brunt of adverse shocks" (Dercon & Krishnan 2000a). Droughts in India increased child mortality,

particularly among households without land (Rose 1999), and in Zimbabwe the drought of 1994-1995 lowered the height for age of children four years after the drought by 1.5-2cm compared with children who had not been exposed to the drought (Hoddinott & Kinsey 2001). In Zimbabwe, droughts and civil wars correlated with lower height and educational attainment as adults (Alderman, Hoddinott & Kinsey 2003). In Indonesia, Gertler and Gruber found that only major bouts of illness hurt consumption; households protected consumption against minor ailments, but not against major ailments (Gertler & Gruber 2002). Frankenberg et al. assess the effects of the Asian crisis on household welfare in Indonesia and find much variation in the way households coped with the shock, including the sale of gold, household recombination, and changes in the labor supply (Frankenberg, Smith & Thomas 2003). Like anthropologists, economists have also found that the seasonal supply of food affects the consumption and nutritional status of rural people (Behrman 1988; Behrman, Foster & Rosenzweig 1997; Dercon & Krishnan 2000b; Kochar 1995).

In several publications Morduch notes that rural households protect food consumption by taking precautionary measures to shield income before shocks strike, by relying on safety nets after shocks strike, or by doing both (Morduch 1995, 2002). As noted earlier, rural households protect income by using pre-emptive, conservative strategies to diversify production and thus stabilize income before misfortunes strike. They also protect consumption by relying on self-insurance (e.g., own savings, sale of assets), or on transfers within or across communities after shocks strike. Morduch notes that traditional mechanisms to smooth income come at a cost relative to the income people might have

earned had they had access to efficient credit and labor markets or to modern forms of insurance.

Econometric specification. We want to estimate the effect of quarter-to-quarter changes of a subject's food consumption against quarter-to-quarter changes in the logarithm of monetary income using different variables to instrument for income (Foster 1995; Gertler & Gruber 2002; Morduch 2002; Skoufias 2002; Townsend 2002). For adults, the reduced-form expression we use to test consumption smoothing takes the following form:

$$[1]\quad \Delta \ln (c_{ihct}) = \zeta_c + \sum_t \delta_t (D_t) + \gamma \Delta \ln (Y_{ihct}) + \alpha H_{ihct} + \Delta \varepsilon_{ihct}$$

where $\Delta \ln (c_{ihct})$ is the first difference in the logarithm of food consumption (proxied by anthropometric indices of short-run nutritional status) of subject i of household h, community c, during quarter t (or the growth rate in food consumption for that subject between quarters t and t-1). ζ_c captures fixed effects of community c. D_t are dummy variables for quarters to control for covariant shocks and for inflation (Skoufias 2002). Y_{ihct} is the cash earnings of subject i of household h, community c during quarter t. $\gamma \Delta \ln$ captures the growth rate of income between two adjacent quarters (t and t-1) for subject i of household h, community c. H represents a vector of demographic controls to take into account shifts taste shifters that might correlate with shocks (e.g., illness) or with income (Gertler & Gruber 2002). Variables under H include quarter-to-quarter changes in the logarithm of household size; H also includes the human-capital variables of subject i of household h, community c, during the first quarter. Human-capital variables include the

subject's education and the subject's skills in Spanish, literacy, and in arithmetic, and the education of the subject's parents. ε_{ihct} is a random, person-specific error term, or the growth rate in consumption left unexplained by the model.

The reduced-form equation for children resembles expression [1], except that we include changes in the cash income of the household rather than changes in the cash income of the subject, and we exclude the human-capital variables of the subject and replace them with the human-capital variables of the child's parents. Since children do not earn cash, we estimate the effect of cash earned by adults in the household on child anthropometrics.

The instruments for quarter-to-quarter Δ in personal cash income for the regression of adults include: (a) quarter-to-quarter Δ in the number of income shocks of the household, (b) age and age^2 of the subject, (c) the quarterly coefficient of variation of daily rainfall, average daily temperature, and average daily cloud cover in the village (Rosenzweig & Wolpin 2000), and (d) interaction of variables in (c) with age and with the village dummy. Instrumental variables for quarter-to-quarter Δ in household cash income for the regression of children include: (a) quarter-to-quarter Δ in the number of income shocks of the household, (b) the education, age, reading skills, and (only for the first quarter) the age and sex-standardized z score of height for age for each of the two parents (or caretakers), (c) the quarterly coefficient of variation of daily rainfall, average temperature, and cloud cover in the village, and (d) interaction of variables in (c) with age and with the village dummy. We used an F test to decide whether the instruments

jointly explained income, and rejected the null hypothesis of no effect at the 99% confidence level (F=7.62). To ensure robustness in results, we use two-stage ordinary-least squares, random-effect, and personal fixed-effect regressions.

Assuming no attenuation bias and controlling for covariant shocks, then full insurance implies $\gamma=0$. If insurance mechanisms work well, then idiosyncratic shocks to household income should have no visible effect on the growth rate of anthropometric indicators of the subject. At the other extreme, without any insurance, consumption and income should move in unison, and γ should equal one (Morduch 2002).

As dependent variables we use several anthropometric indices that capture different dimensions of short-run nutritional status. Dependent variables included: (a) age and sex-standardized z score of sum of triceps and subscapular skinfolds, (b) age and sex-standardized z score of mid-arm muscle area, (c) age and sex-standardized z score of weight for height (children only), (d) age and sex-standardized z score of weight for age (children only), and (e) body-mass index (adults only). Except for body-mass index, all other dependent variables are standardized relative to the age and to the sex-specific norms of the United States using international norms. Body-mass index standardizes weight relative to height, and gives a value that applies equally well to adult women and to adult men. We added a constant term to all z scores to ensure we had positive values before taking logarithms. We took logarithms of transformed z scores to interpret coefficients as elasticities, thereby facilitating comparisons with other studies.

Since the effectiveness of consumption smoothing might vary by sub-groups in the population, we carried out several tests of structural heterogeneity. For adults and for children, we tested whether results differed by village or by the sex of the subject. For children we found no evidence of heterogeneity, so we present regression results for the pooled sample. For adults, we found that only the interaction of the sex of the subject and income was statistically significant, so we present both pooled results and results for adult women and for men separately.

Sample and methods of data collection. Subjects included 156 adults and 169 children from two villages along the Maniqui River. One village, Yaranda, was more traditional, had lower cash income, and was relatively inaccessible. Yaranda was 47.7 km up river as the crow flies from the market town of San Borja (pop ~19,000), and was accessible mostly by canoe or by foot. The other village, San Antonio, was more integrated to the market, had higher cash income, was only 10 km down river from the town of San Borja, and was accessible all year by road. Only two households in the remote village (n=24) and three households in the more accessible village (n=28) refused to take part in the study for reasons that remain unclear.

We collected data during six quarters (May 1999-November 2000), but do not use data from the first quarter because we used the first quarter to train researchers, enhance inter-observer reliability, pilot test questions, and train subjects in the tasks of the survey. The composition of the sample remained stable over time. In fact, the number of households and adults in the sample grew because people married and formed new households or

because outsiders married into the villages during the study. The total number of households during the five quarters was: 45, 47, 48, 49, and 56. People who moved into the village to join a household were added to the panel.

To determine the sources and the level of cash earnings and consumption, we conducted quarterly interviews with all adults, defined as people over the age of 13. We use 13 years of age as a cut-off to define an adult because children by that age clear their own farm plots and sell goods on their own in the market. Survey questions centered on the sources and levels of cash earned during the 30 days before the day of the interview. We measured consumption through a method known as *weigh days*. For each household, we selected at random one day each quarter to measure consumption. On that day, we sat in the open courtyard in front of the house and identified and valued all goods people brought into the house from 7am until 6pm. As people entered the house, we asked the subject bringing the good about the place of origin (e.g., town, forest) and mode of procurement of the good (e.g., bought, exchanged) (Godoy et al. 2002). Each quarter, we also took anthropometric measures of all subjects (Byron 2003). We measured wealth by asking people each quarter about the number of assets they owned or co-owned; we asked about the ownership of a standard basket of modern (e.g., metal fishhooks) and traditional (e.g., dugout canoes) physical assets that proxy for wealth and we valued the goods using the village selling price. Surveys included a module on debts outstanding, sources of credit, and on the reasons for incurring new debts during the 30 days before the day of the interview. To obtain accurate measures of skills in reading, arithmetic, and in fluency in spoken Spanish, we tested subjects at baseline. In the reading tests, we asked subjects to

read simple sentences written in large black letters on a note card in Tsimane' and in Spanish; we administered the test in broad daylight. In the test of arithmetic, we asked subjects to add, subtract, multiply, and divide. We had several versions of the reading and arithmetic tests and selected them at random so subjects who overhead an answer could not use it as their own later when we tested them.

We asked household heads about all shocks experienced by the household during the 30 days before the day of the interview. Shocks reported included such things as fires, theft, crop losses, illness, or loss of domesticated animals. For each shock, we asked household heads how the household had coped with the shock and to estimate the costs of the shock. Besides the information just described, we collected daily information in each village on precipitation, on minimum and maximum temperature, and on cloud cover. Recent publications contain further explanations of how we collected data (Godoy, Kirby & Wilkie 2001; Godoy et al. 2002; Kirby et al. 2002; Reyes-Garcia et al. 2003).

The setting. The Tsimane' are a foraging and farming Amerindian society of about 8,000 people living in about 100 villages in the Amazonian rain forests at the eastern foothills of the Bolivian Andes in the department of Beni. Tsimane' subsistence centers on hunting, fishing, plant collection, and slash-and-burn farming. Tsimane' are linked with the regional and with the national economy through the sale of forest goods and rice (Vadez et al. 2004). They sell the goods to traders who come to the Tsimane' territory, but they also sell the goods in towns. To earn cash, Tsimane' sell timber to logging firms, thatch palm to itinerant traders, and work as unskilled laborers for cattle ranchers,

logging firms, and for highland colonist farmers who have moved into or next to the Tsimane' territory.

Tsimane' have low income and are highly autarkic. Mean annual personal income from cash earnings and from the imputed value of farm and forest consumption is US$332, a third of the average income in Bolivia ($US980/person) or of all low and medium-income nations ($US 1,140/person) (Godoy et al. 2002). Table 1 shows the place of origin of goods brought into the household during weigh days. Information from weight days suggests that goods bought in the market accounted for only 2.68% of the total value of household consumption (Table 1).

INSERT TABLE 1 ABOUT HERE

Most of the goods consumed by the Tsimane' came from farm plots (42.50%), open courtyards and gardens in the immediate vicinity of the home and village (29.68%), river, brooks, and ponds (18.07%), and forests (2.99%)(Table 2). Only 2.47% of the goods consumed by households came from outside the community and its surrounding lands, whether from another community or from towns.

INSERT TABLE 2 ABOUT HERE

When measured through quarterly cash earnings rather than through consumption, the Tsimane' economy is less autarkic. When asked about all sources of cash they had earned during the 30 days before the day of the interview, only 28.97% of people over the age of 13 reported earning no cash (Table 3). Although 71.03% of the subjects earned cash, subjects worked on average only three days each month in jobs to earn cash.

INSERT TABLE 3 ABOUT HERE

Women face more severe economic constraints than men. Women had access to less credit, earned less cash, and had fewer assets. Women household heads earned 19.70% of the cash income of the male household head, obtained in credit an amount equivalent to 18.60% of the amount of credit obtained by the male household head, owned 20.42% of the wealth owned by the male household head, and owned on their own only 16.15% of the total value of household assets, compared with 52.00% of the total value of household assets owned by male heads of households.

Descriptive and bivariate analysis of shocks: Types, costs, and coping mechanisms. Here we describe the types of idiosyncratic shocks reported by Tsimane', the financial costs of the shocks, and the ways households reported coping with shocks.

Types of shocks. Table 4 shows that about two thirds of households (63.37%) reported having experienced some shocks during the 30 days before the day of the interview. Shocks included losses of domesticated animals from predation by wild game (22.34%), losses of crops from localized natural events (12.82%), illness (12.09%), theft (11.72%), and other (4.40%) misfortunes. The category "other" includes such things as fires, deaths of household members, or the breakdown of tools and equipment. Of the households reporting shocks during a quarter, 60.12% reported having experienced only one shock, 27.75% reported having experienced two shocks, and 12.14% reported having experienced three shocks. No household reported more than three shocks.

INSERT TABLE 4 ABOUT HERE

Costs of shocks. Table 4 also contains information on the average costs of shocks to the household. On average, each shock cost a household $11.78 US dollars. An adult man would have had to work in logging camps or cattle ranches for three days to cover the costs of an average shock. Among shocks, illness episodes were the most expensive ($US 41.90), followed by crop losses ($US 12.86), animal losses ($US 9.43), and theft ($US 8.97). The large costs under the category "other" had to do with the costs of repairing or replacing damaged or lost tools and equipment. Illness costs were high, particularly in the more remote village of Yaranda, because of the custom of abandoning a house and building a new house when people become very ill or die. Since we assigned a cost to the building of new homes in response to severe illness shocks, and the practice of moving to a new house is more prevalent in the more remote village, the costs of shocks in general and the costs of illness shocks in particularly are greater in the more remote community of Yaranda.

In Table 5 we express the costs of shocks as a share of total household annual income (value of imputed consumption + cash earnings) to assess the economic significance of shocks. For the pooled sample, the annual costs of shocks represents 8.11% of total household income, but the figure glosses over differences between the two villages. During a year, a typical household in the more modern and accessible village of San Antonio lost $US 41 from all shocks, or about 1.67% of total annual household income ($US 2,453). Households in the poorer village of Yaranda incurred higher costs from shocks for reasons discussed earlier. On average, a household in Yaranda incurred annual costs from all shocks equivalent to $US 314. Given the lower level of total annual

household income in the village of Yaranda ($US 1,597), shocks represented a higher share (19.66%) of total annual household income than in the village of San Antonio (1.67%).

INSERT TABLE 5 ABOUT HERE

Seasonality of shocks. The information in Table 6 suggests that the share of households reporting shocks remained stable at about 64% during all five quarters. Different types of shocks took place at different times of the year. For example, crop losses peaked during the second quarter; 21.82% of households reported crop losses during November-January. Illness and animal losses peaked during the third quarter, and theft during the fourth quarter. Table 6 also hints at large variation across years for some types of shocks. If one compares the same quarter (August-October) in 1999 and 2000 one observes that the share of households hurt by crop losses declined by 47.56% (from 15.22% in 1999 to 7.98% in 2000) and that the share of households afflicted with sickness more than doubled (from 6.52% in 1999 to 15.87% in 2000). The change in the incidence of reported illness could reflect panel conditioning; subjects may have felt more comfortable about reporting ailments as the panel unfolded and as they got to know researchers better.

INSERT TABLE 6 ABOUT HERE

Coping with shocks: Precautionary strategies. We already documented the high degree of autarky in consumption among Tsimane'. Information from weigh days suggests that Tsimane' collected from fields, rivers, and forests 87.63% of the goods they brought into their household for consumption; market purchases accounted for only 2.19% of the goods consumed by the household, and gifts and other transfers entering the

household accounted for an additional 10.18% of consumption (Table 1). The shares were similar in the two villages, and they were similar whether expressed in number of goods entering the household or in dollar values.

Although the Tsimane' do not diversify the way they procure goods for consumption, they diversify the place where they obtain goods. Goods for home consumption came from farm plots (42.50%), home gardens and courtyards in or around the village (29.68%), rivers, ponds, and creeks (18.07%), and from forests (2.99%)(Table 2). The information in Table 2 suggests that households in the more remote village of Yaranda relied more on farm plots (49.86%) and that households in the village of San Antonio relied more on goods from orchards, home gardens, and from lands in the vicinity of the village (34.05%).

In Table 7 we present information on how Tsimane' individuals (rather than households) diversify their sources of cash income. The information in Table 7 suggests that Tsimane' rely primarily on wage labor and, to a lesser extent, on the sale of goods to earn cash. Earnings from wage labor accounted for 64.51%, 79.46%, and 70.72% of mean total personal cash income in San Antonio, Yaranda, and in the pooled sample. Earnings from the sale of farm and forest products accounted for 33.43%, 18.61%, and 27.34% of mean total personal cash income in San Antonio, Yaranda, and in the pooled sample. Remittances and other transfers accounted for only about 2.00% of mean total personal cash income.

INSERT TABLE 7 ABOUT HERE

In Table 3 we identify the different sources of cash for individuals and households. Part B of Table 3 confirms the findings discussed in the previous paragraph. During any one quarter, 53.13% of Tsimane' in the pooled sample earned cash income from one and only one activity or occupation; an additional 16.89% of the pooled sample earned cash from two activities or occupations. A higher share of people in the more accessible village of San Antonio (60.96%) relied on only one source of cash than in the more remote village of Yaranda (44.71%), but in each of the two villages many people relied on only one source or occupation to earn cash. Again, the figures suggest reliance by individuals in only a few ways to earn cash.

Part A of Table 3 suggest that although individual Tsimane' specialize in generally only one activity or occupation to earn cash, the household, as a whole, maintains a diversified portfolio of activities to earn cash. Whereas only 16.89% of *individual* Tsimane' in the pooled sample earned cash from two sources, the share of *households* earning cash from two sources was more than twice as high (37.04%). The pattern found in the pooled sample also applies to each village. The figures suggest that Tsimane' households diversify their sources of cash income, but that individuals specialize in earning cash from generally one activity or occupation.

To explore whether economic diversification creates costs and lowers income, as some of the literature reviewed earlier suggest, we ran ordinary least squares, random-effect, and fixed-effect earning functions with the logarithm of quarterly cash earning for the adult as a dependent variable, and with the number of cash-earning activities of the household on

the right side. Control variables included the subject's human-capital and demographic attributes, and a full set of dummies for quarters, villages, weather variables, and shocks. We found that each additional economic activity to earn cash in a household correlated with 20.85 %, 30.19%, and 47.27 % higher personal income, depending on whether one used a personal fixed-effect (20.85%; p=0.11), random-effect (30.19%; p=0.008), or an ordinary least squares (47.27%; p=0.001) regression. We do not find evidence that pre-emptive forms of diversifying income come at a cost; in fact, pre-emptive strategies correlate with higher monetary income.

Coping with shocks after the shocks. In Table 8 we present information on how households reported coping with shocks after shocks took place. Of the households that experienced shocks, 82.08% said they had to weather the spell on their own, without help from kin, friends, or outside institutions. The figure may underestimate the true social support received after shocks owing to the extensive system of sharing and reciprocity found in everyday village life; Tsimane' are always giving and receiving a wide range of goods and services as part of everyday social interactions, and may have found it hard to identify the extra amounts of goods and services received from others after suffering a negative shock.

INSERT TABLE 8 ABOUT HERE

We find that to cope with shocks, only 4.05% of households relied on informal credit from outside traders. We ran probit regressions and found that a shock during the current or during the previous quarter did not change the probability that a subject would borrow in the current quarter. Shocks experienced during the previous quarter bore no relation to

the amount of borrowing during the current quarter. Current shocks and the amount of current borrowing bore a weak negative correlation. We regressed the amount of new loans and debts outstanding during the current quarter against a dummy variable for current shocks and dummy variables for quarters and villages, and found that a shock during the current quarter did not correlate with current borrowing, but that it did correlate with a reduction in the total current debts outstanding of 6.52 bolivianos ($p=0.044$) (1 US dollar = 6.03 bolivianos).

Nor did Tsimane' rely on the sale of assets, forest goods, or crops to cope with shocks. The information in Table 8 suggests that only 3.47% of the sample sold forest goods or crops in response to shocks. We used a probit model with dummies for quarters and for villages, and found that shocks during the previous or during the current quarter did not affect the current probability of selling crops or forest goods, domesticated animals, or other assets.

Table 8 shows that only 7.51% of households experiencing shocks relied on help from kin, friends, or missionaries, and only 1.16% of the sample migrated in response to shocks. We used a probit model with dummies for quarters and village and standard demographic variables as controls, and found that adults in households with shocks during the current quarter were 4.50% ($p=0.037$) less likely to work in wage labor during the same quarter, so we find some evidence suggesting that households coped with shocks by deflecting the labor supply of adults away from the market for wage labor. We do not know whether labor deflected from the labor market went into subsistence

activities, leisure, or both. We did not collect information on the labor supply or on the school attendance of children, so we cannot tell whether households coped with shocks by adjusting the labor supply of children or by curtailing leisure (Jacoby & Skoufias 1997).

Summary. The picture that emerges from the descriptive analyses is that of a population vulnerable to many types of idiosyncratic negative income shocks. In the more remote village of Yaranda, the costs of shocks represent a high share (19.66%) of total household income. Heads of household said they had a thin safety cushion for use in times of need. Unlike rural populations in other developing nations, Tsimane' do not sell crops or assets (Czukas, Fafchamps & Udry 1998; Frankenberg, Smith & Thomas 2003; Rosenzweig & Wolpin 1993), borrow (Udry 1990; Udry 1994), (Jacoby & Skoufias 1997; Skoufias 2002), or rely on kin or neighbors (Besley 1995; Morduch 1999) to cope with shocks. The only mechanisms we found that could allow households to cope with shocks were income diversification and changes in the adult labor supply. About half (47.33%) of the households had 2-3 different sources of cash income at any one time, and adults from households with a misfortune were slightly less likely to work in wage labor.

Results. Table 9 contains definition and descriptive statistics of the variables used in the regressions. Tables 10-11 contain the regression results. To save space, we only report the value of γ, or the coefficient of Δ income in expression [1].

INSERT TABLE 9 ABOUT HERE

Children. The information in Table 10 suggests that the food consumption of children is fully protected against idiosyncratic adverse income shocks. Regardless of the short-run anthropometric index or of the type of regression used, the income elasticity of food consumption or short-run nutrition is indistinguishable from zero. A doubling in the growth rate of income produces a change in any of the anthropometric status of the child of less than one percent. Two-stage ordinary-least squares, random-effect, and fixed-effect regressions all produced nearly identical, statistically insignificant results.

INSERT TABLE 10 ABOUT HERE

Since many households did not earn cash income, we re-estimated the regressions of Table 10 by adding +1 to income to avoid producing missing values when taking logarithms. We also estimated changes in the levels (rather than in the logarithm) of income (Gertler & Gruber 2002). The results of those regressions (not shown) confirmed the findings reported in Table 10; all coefficients remained small and indistinguishable from zero. Results did not differ by village, season, or by the child's sex.

Adults. Unlike children, among adults growth in food consumption is not as well protected from growth in income (Table 11). In the pooled sample, we find full protection of consumption, except when using growth rates in body-mass index as a dependent variable. The income elasticities of body-mass index were –0.008-0.009 and statistically significant at the 99% confidence level or above.

INSERT TABLE 11 ABOUT HERE

The analysis done for women and men separately suggests that the growth rate of income affected the growth rate of food consumption of women and of men in different ways.

Among women, income growth correlated with lower rates of two short-run nutritional indices: body-mass index and mid-arm muscle area. The income elasticity of body-mass index and mid-arm muscle area for women were about -0.01 (body-mass index) and -0.02 (mid-arm muscle area), and in both cases elasticities were statistically significant at about the 99.00% confidence level or above.

Among men, we find evidence of inadequate protection of food consumption against income changes, but in the opposite direction of what we found among women. A one-percent increase in the growth rate of income correlated with a 0.005% higher growth rate in BMI and with a 0.02% higher growth rate of triceps and subscapular skinfolds. Results were statistically significant at the 95% (triceps and subscapular skinfolds) and at the 99% (body-mass index) confidence level.

As before, to correct for missing values of income we did two types of sensitivity analyses (not shown). First, we added +1 to income and re-estimated the regressions of Table 11. All the results of the regression for men became statistically insignificant. Most of the coefficients of the income variable for women became smaller, but they did not change signs, and they were all statistically significant at the 90% confidence level or above. Irrespective of the type of regression used, we found the following income elasticities for women after adding +1: +0.01 (triceps and subscapular), -0.003 (body-mass index), and –0.01 (mid-arm muscle area). Second, we re-estimated the regressions of Table 11 with changes in the levels rather than in the logarithm of income. The signs of coefficients remained the same, but coefficients generally became statistically

insignificant at the 90% confidence level or above, with one exception: the mid-arm muscle area of women. The coefficient of income growth for women using mid-arm muscle area as a dependent variable remained negative and statistically significant at about the 95% confidence level. Results held up across quarters, subject's sex, and villages.

In sum, among adults we find no clear evidence for or against full insurance. The classic test of full insurance from expression [1] suggests that the short-run nutritional status of women and of men is inadequately protected against changes in the growth rate of personal income. The income elasticities of consumption for women were small and negative, but different from zero; coefficients were about -0.01 for body-mass index and about -0.02 for mid-arm muscle area. For men, the income elasticities of consumption were also low, but positive, and different from zero; elasticities were 0.005 for body-mass index and 0.023 for the sum of triceps and subscapular skinfolds. Results varied by how one defines income; measuring income in levels or adding a +1 to income before taking logarithms produced weaker results and more support for the idea of full insurance.

We have no convincing explanation for why income growth correlates with positive growth in the short-run nutritional status among men and with negative growth in the short-run nutritional status among women. One possible explanation might have to do with the geographical mobility produced by the labor market. Men with greater income might spend more time away from their village in cattle ranches or in logging camps, thereby deflecting cash and other resources away from the household. Those resources

might have contributed to improved nutritional status for people in the household who remained behind. Resources consumed by men away from the household would not improve the general well being of the household, and actually might even erode women's nutritional status. The differential impact of income on the nutritional status of adult women and adult men echoes the finding of Peters and Kennedy from Africa that greater income for men has modest or even negative consequences on nutritional status of family members, whereas greater income for women tends to have more positive impacts on the nutritional status of the rest of the family (Peters & Kennedy 1992).

Comparison with other studies. How do the results presented here compare with results from other studies? We cannot answer the question with certainty owing to differences in estimation methods and in the definition of outcome variables. Bearing those caveats in mind, the income elasticities of food consumption reported here appear to lie toward the lower end of estimates from previous studies. For example, if we focus on body-mass index, a standard indicator of adult short-run nutritional status, we see in the pooled sample income elasticities of consumption that range from –0.008 to –0.009 and highly significant. In the study of consumption smoothing among Tawahka Amerindians of Honduras, another foraging and farming society, we found that the temporary income elasticity of total consumption was -0.016 (z=2.01) (Wong & Godoy 2003).

In two recent publications Skoufias (Skoufias 2001; Skoufias 2002) uses an instrumental-variable approach similar to the one used here to estimate the effect of income shocks on food expenditures in Bulgaria and in Russia and finds that for rural areas, income

elasticities of food consumption were 0.083 (t=2.72; Bulgaria) and 0.051 (t=0.22; Russia). In Indonesia, Gertler and Gruber (2002) find that the income elasticity of consumption (excluding medical expenditures) instrumented with illness shocks was 0.35-0.39 and statistically significant. Using panel information (1976-1983) from three Indian villages, Morduch finds that the effect of income growth on the growth of food consumption was 0.21-0.24 (t values ranged from 2.68 to 6.43), but results varied widely, including negative elasticities for some of the higher castes (Morduch 2002).

How do Tsimane' protect their food consumption? If Tsimane' households do not draw down their assets, borrow, or rely on help from others in times of need, then how do they protect their food consumption? Below we explore several possible explanations to guide future research.

First, the small coefficients among adults and the statistically insignificant coefficients among children might reflect measurement errors in income and shocks and lack of statistical power. Measurement errors of explanatory variables in panel studies worsens attenuation bias (Angrist & Krueger 1999).

Second, Amazonian indigenous peoples save in manioc and in perennial tree crops, including plantains, that we did not measure. Many of these crops are hardy and readily available year-round, so they could buffer income and consumption from a wide range of income shocks. More generally, tropical rain forests in the New World may contain enough edible wild animals and wild plants to provide a cushion when shocks strike.

Third, metabolic mechanisms unique to some populations might also help. One way human populations have adapted to periods of food stress is by lowering their rates of resting (or basal) energy metabolism -- the number of calories spent at rest. Human populations from the tropics have lower resting metabolic rates than human populations from temperate or from northern climates, even after adjusting for body size (Cruz, da Silva & dos Anjos 1999; Henry & Rees 1991; Knowler 1983; Roberts 1978; Soares, Francis & Shetty 1993; Szathmary 1990; Valencia, Moya & McNeill 1994). Research among the Pima Indians (a population with a history of marginal food supply) suggest that they have lower than expected resting metabolic rates (Knowler 1991, 1983; Ravussin 1993). Some of the stability in anthropometric measures that we observed could reflect genetic and metabolic factors that allow Amerindians to store energy efficiently .

Fourth, another possible explanation might have to do with the role of home-brewed beer or chicha. Tsimane' households make chicha by fermenting the ubiquitous root crop manioc that, as mentioned, is hardy and resistant to a wide range of agronomic and climatic insults. Chicha contains many calories, though it is not as dense in calories as other local foods and drinks. Tsimane' share chicha widely. At any time, villagers know which households have chicha, and any child, women, or men has the right and can expect to be served. Since it is made from a hardy root crop that can last for many years in the ground, chicha is available throughout the year. Chicha might serve as an equalizer of short-run nutritional status. A related explanation has to do with the practice

of eating out of a common pot; sometimes such eating includes several closely related households in a hamlet.

Fifth, another possible explanation has to do with the size and with the frequency of the shocks we measured. As noted, large or covariant shocks tend to affect food consumption and, by implication, nutritional status more than small or idiosyncratic shocks. Perhaps the shocks we measured were too small to affect nutritional status in a large and obvious way.

A sixth possible explanation has to do with changes in consumption expenditures or with changes in consumption patterns within households. Skoufias found that households in Russia and in Bulgaria hurt by shocks protected the food consumption, but did not protect the consumption of other goods and services. After shocks, households maintained food expenditures constant, but curtailed expenditures on goods and services unrelated to food (Skoufias 2001, 2002). In their study of the effect of the Asian crisis in Indonesia, Frankenberg et al. also found smoothing for food expenditures, but no smoothing for other expenditures (Frankenberg, Smith & Thomas 2003). Since we did not collect information on expenditures, we cannot explore this line of thinking.

A related reason why children appear fully protected has to do with reallocation of foods in favor of children when shocks strike. In the nearby Peruvian Andes, Leonard found that mothers reallocated food to children during lean times, thus reducing variability in nutritional status among children, but not among adults (Berti & Leonard 1998; Leonard

1991a, 1991b; Leonard & Thomas 1989). We too found that consumption smoothing worked better for children than for adults, so inter-generational transfers of food from parents to children might explain why food consumption for some members of the household (children in this case) was better protected than food consumption for other members of the household (adults). We did not collect information on intra-household allocation of foods to test the idea.

To explore the idea of intra-household transfers further, we turn briefly to a larger five-quarter panel study done during 2002-2003 with 1370 Tsimane' subjects over two years of age in 13 villages. We did not use the more recent survey to study consumption smoothing because it lacks information on shocks. Using the new survey, we compared all the age and sex-standardized anthropometric indices used here between girls and boys, adult women and adult men, children and adults, and females and males. We found that children were 0.10-0.14 standard deviations closer to the median US norm than adults, buttressing the point made here about possible differential allocation of food to children. All results were statistically significant at the 95% confidence level or higher.

The last two possible explanation have to do with the role of tolerated theft and with changes in the workload of people during periods of stress. For obvious reasons, we could not ask subjects about the foods they took from others after a shock, but causal observations in the field suggest villagers often take plantains, manioc, and other crops from the fields of others without asking. Perhaps they do not consider such taking theft proper but simply part of an informal, tacit system of exchange. Recall from Table 4 that

11.72% of households reported having experienced theft. As mentioned, we did not collect information on time allocation so we cannot test whether households protected consumption by curtailing leisure and by working more. Researchers working in foraging and farming populations of Africa and Latin America have described changes in activity levels to conserve calories and cope with periods of nutritional stress (Bentley et al. 1999; Werner, Flowers, Ritter & Gross 1979).

Conclusions. When the demand and supply framework does not operate well, estimating consumption smoothing is hard owing to difficulties in measuring and separating consumption from income, finding reliable instruments for income, and identifying supply and demand functions. Here we have used several anthropometric indices of short-run nutritional status to proxy for food consumption, and have used a wide range of instruments for income to estimate the responsiveness of food consumption to changes in income. Using the approach, we have tried to contribute to the study of consumption smoothing in developing countries by focusing in a highly autarkic society of foragers and farmers. We draw three main tentative conclusions from the empirical analysis.

First, the evidence presented suggests that people practicing hunting, fishing, plant collection, and farming in a highly autarkic setting protect well the short-run nutritional status of their children from adverse idiosyncratic income shocks. We found no evidence to suggest that protection worked better for children of one sex during adverse shocks, as is true in parts of South Asia (Behrman 1988; Rose 1999; Behrman & Deolalikar 1990;

World Bank 2001). At least for children, we tentatively conclude that food consumption in the short run is protected.

The evidence that adults protect their food consumption in full is less clear. We found that income changes among adults translated into changes in their short-run nutritional status, suggesting that adults did not protect their food consumption as well as children. Income changes affected the food consumption of women and of men in different ways. Growth in income correlated with lower growth rates of body-mass index and mid-arm muscle area among women, but it correlated with higher growth rates of body-mass index and sum of subscapular and triceps among men. If we measure income in levels or add +1 to income, results become weaker; with those definitions of income, the food consumption of adult Tsimane' is almost fully protected.

Second, on a methodological front, we found that one cannot equate self-reports of the availability of insurance with economic vulnerability. Recall from Table 8 that 82.08% of the sample experiencing shocks reported having done nothing on their own or having received no help to cope with shocks. From those responses one might have concluded that the Tsimane' were economically vulnerable. The conclusion would have been misleading and did not hold up after estimating how objective indices of short-run nutritional status responded to changes in income. Although useful as an entry point or as a descriptive first step, self-reports of how people cope with shocks do not mirror faithfully whether people, in fact, protect well their nutritional status. One cannot necessarily take self reports as a reliable indicator of vulnerability.

Last, the study uncovered a gap in our understanding of how people in highly autarkic economies protect income and food consumption. The small income elasticities of food consumption could reflect poor measurement of income, a small sample size, the prevalence of tolerated theft, own savings in hardy perennial crops, or our failure to measure other pre-emptive strategies to reduce variance in income. Future studies of consumption smoothing in highly autarkic settings would do well to include objectives measures of shocks that come from either third parties or from scan or direct spot observations of behavior, or a combination of both methods. They would also do well to put greater attention on pre-emptive strategies to diversify production and stabilize income, and explore physiological and metabolic mechanisms that might allow people to conserve body fat when shocks strike.

Table 1. Modes of procuring goods for household consumption and total value of goods for villages of Yaranda and San Antonio over five quarters: August 1999 – October 2000

Mode of procurement:	**Pooled (Yaranda + San Antonio), n=52 households**			
	Observations	*Percent*	*US$*	*Percent of value*
Market	49	2.19	37.22	2.68
Gifts/remittance	228	10.18	68.34	6.88
Own effort	1963	87.63	886.79	89.36
Total	2240	100.00	992.35	100.00
	San Antonio, n=28 households			
	Observations	*Percent*	*US$*	*Percent of value*
Market	40	3.50	34.86	5.35
Gifts/remittance	120	10.49	45.90	7.04
Own effort	984	86.04	570.51	87.59
Total	1144	100.00	651.27	100.00
	Yaranda, n=24 households			
	Observations	*Percent*	*US$*	*Percent of value*
Market	9	0.82	2.36	0.69
Gifts/remittance	108	9.85	22.44	6.57
Own effort	979	89.32	316.27	92.72
Total	1096	100.00	341.07	100.00

Notes: Observations come from weigh days and exclude gifts from researchers to villagers, which accounted for 2.14% of the items in household consumption. The unit of observation is the good entering the household on days chosen at random, measured once every quarter for each household.

Table 2. Geographical diversification of consumption: Provenience of goods entering Tsimane' households during five quarters, August 1999 – October 2000

Place where good obtained:	Pooled		Village:			
			Yaranda		San Antonio	
	N	Percent	N	Percent	N	Percent
Farm plots	981	42.50	549	49.86	432	35.79
Own village	685	29.68	274	24.89	411	34.05
River/brook/pond	417	18.07	222	20.16	195	16.16
Forest	69	2.99	34	3.09	35	2.90
Town	44	1.91	1	0.09	43	3.56
Other community	13	0.56	0	0.00	13	1.08
Other	99	4.29	21	1.91	78	6.46
Total	2308	100.00	1101	100.00	1207	100.00

Notes: Units of observation are goods brought into household on days chosen at random, measured once every quarter for each household.

Table 3. Diversification of personal and household quarterly cash income among Tsimane' adults (13+), August 1999 – October 2000: Different sources of cash income

Number of sources:	**A. Per household**					
	Village:				Pooled	
	Yaranda		San Antonio			
	N	Percent	N	Percent	N	Percent
0	14	12.39	8	6.15	22	9.05
1	43	38.05	63	48.46	106	43.62
2	44	38.94	46	35.38	90	37.04
3	12	10.62	13	10.00	25	10.29
Total	113	100.00	130	100.00	243	100.00
	B. Per person (adult)					
Number of sources:	Village:				Pooled	
	Yaranda		San Antonio			
	N	Percent	N	Percent	N	Percent
0	121	36.56	78	21.91	199	28.97
1	148	44.71	217	60.96	365	53.13
2	60	18.13	56	15.73	116	16.89
3	2	0.60	5	1.40	7	1.02
Total	331	100.00	356	100.00	687	100.00

Notes: Unit of observation is the adult over 13 years of age or the household for each quarter. Under observations are included different sources for earning cash income. For example, a 1 would mean the person or household only earned cash in one way (e.g., wage labor). The three different types of earning cash include (a) sale of farm and forest goods, (b) wage labor, and (c) remittances and other transfers.

Table 4. Type and costs of shocks experienced by Tsimane' households over five quarters: August 1999 – October 2000

Type of shock	Observations	Percent	Mean cost, US dollars/shock	
			Mean	Std Dev
None	100	36.63		
Some:	173	63.37		
Animal loss	61	22.34	9.43	10.63
Crop loss	35	12.82	12.86	11.94
Illness	33	12.09	41.90	64.76
Theft	32	11.72	8.97	21.98
Other	12	4.40	46.35	79.40
Sub total	173	63.37		
Total	273	100.00	11.78	32.23

Notes: Row "other" includes fires, deaths, and productive physical assets that broke. Costs in US dollars; bolivianos transformed to US dollars using the local quarterly exchange rate. Information comes from five quarterly surveys.

Table 5. Average annual costs of shocks to household as a share of annual household income, August 1999 – October 2000 in US dollars

	Village:					
	San Antonio (N=28)		Yaranda (N=24)		Both (N=52)	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Household income:						
Consumption	1920	1044	1226	750	1600	976
Cash earnings	533	326	371	494	458	416
Total household income	2453		1597		2058	
Total income per person	408		266		342	
Cost of shocks	41	50	314	272	167	231
Shocks as % of total household income	1.67%		19.66%		8.11%	

Notes: t-test of comparison of means between the two villages yielded the following t values: 2.70 (p=0.009), 1.34 (p=0.184), and 3.58 (0.001) for consumption, cash earnings, and shocks. Total income includes some double counting since some items brought in during weigh days were later sold. We had no way of linking goods brought in now during weigh days with the later sale of the same good. To get rough measures of personal-level income from the figures in this table, we divide household income by the mean size of the household (about 6 people).

Table 6. Types of idiosyncratic shocks experienced by Tsimane' households: By quarters, August 1999 - October 2000 (%)

Type of shock:	Quarters: First Aug-Oct	Second Nov-Jan	Third Feb-Apr	Fourth May-Jul	Fifth Aug-Oct	Total
	N=46	N=55	N=55	N=54	N=63	N=273
None	39.13	36.36	36.36	35.19	36.51	36.36
Some:						
Theft	15.22	7.27	5.45	20.37	11.11	11.72
Crop loss	15.22	21.82	10.91	9.26	7.94	12.82
Illness	6.52	10.91	18.18	7.41	15.87	12.09
Animal loss	19.57	16.36	27.27	25.93	22.22	22.34
Other	4.35	7.27	1.82	1.85	6.35	4.40
Total	60.88	63.63	63.63	64.82	63.49	63.37

Notes: Shocks are those reported by households for the 30 days before the day of the interview. Interviews conducted once each quarter.

Table 7. Sources of personal cash income and mean earnings among Tsimane' over five quarters: August 1999 – October 2000

	Pooled		
Source of cash:	Observations	Mean: US $	Percent
None	107	0	0
Wage	58	77.95	70.72
Sale of goods	139	30.14	27.34
Remittances/gifts	96	2.13	1.93
Total	400	110.22	100.00
	Yaranda		
None	58	0	0
Wage	25	82.59	79.46
Sale of goods	61	19.35	18.61
Remittances/gifts	60	1.99	1.88
Total	204	103.93	100.00
	San Antonio		
None	49	0	0
Wage	33	74.43	64.51
Sale of goods	78	38.57	33.43
Remittances/gifts	36	2.37	2.05
Total	196	115.37	100.00

Notes: Unit of observation is a person's income during the 30 days before the day of the interview from a particular source added over all five quarters. Under the column on mean dollars we report the average cash earnings from different sources for people in the sample.

Table 8. Mechanisms for coping with idiosyncratic income shocks after occurrence of shocks among Tsimane' households over five quarters: August 1999 – October 2000

Response	Observations	Percent
Did nothing	142	82.08
Did something:		
Credit	7	4.05
Help from non-kin	5	2.89
Help from kin	4	2.31
Sold crops and animals	4	2.31
Missionaries	4	2.31
Sold forest goods	2	1.16
Out-migration	2	1.16
Researchers	3	1.73
Total	31	17.92
Total	173	100.00

Notes: Answers are for households reporting a shock during the month before the day of the interview.

Table 9. Definition and summary statistics of variables used in regression analysis

Variable	Description	N	Mean	Std Dev
Dependent variables for children (<13) (Table 10):				
ZSUMSK2	Z score of sum of triceps and subs-scapular skinfolds by age and sex norms of Frisancho (1990)	598	-0.691	0.456
ZMAM	Z score of mid-arm muscle area by sex and age norms of Frisancho (1990)	596	-0.173	0.735
ZWA	Z score of weight for age by sex and age norms of National Center for Health Statistics (NCHS)	671	-0.775	0.896
ZWH	Z score of weight for height by sex and age norms of NCHS	598	0.236	0.855
Dependent variables for adults (≥13) (Table 11):				
BMI	Body mass index (kg/mt^2). In regressions, entered in logarithms	651	22.525	2.590
ZSUMSK2	Z score of sum of triceps and subs-scapular skinfolds by age and sex norms of Frisancho (1990)	634	-0.676	0.559
ZMAM	Z score of mid-arm muscle area by sex and age norms of Frisancho (1990)	634	-0.472	0.781
Explanatory variables for children (<13)(Table 10):				
Mother's attributes:				
Mother's zht	Z score: height for age standardize by US norms of Frisancho (1990); instrumental variable	584	-1.846	0.826
Mother's age*	Age in years	35	29.296	8.730
Mother read*	Reading skills in Spanish: 1= can read; 0=cannot read; instrumental variable	47	0.191	0.397
Mother's education*	Maximum education grade completed	47	1.170	1.479

Table 9. Definition and summary statistics of variables used in regression analysis

Variable	Description	N	Mean	Std Dev
Explanatory variables for children (<13)(Table10):				
Father's attributes:				
Father's zht	Z score height for age standardize by norms of Frisancho (1990); instrumental variable	538	-1.838	0.600
Father's age*	Age in years	33	32.803	11.504
Father read*	Reading skills in Spanish: 1=can read; 0=cannot read; instrumental variable	40	0.450	0.503
Father's education*	Maximum education grade completed	40	1.900	2.362
Child's attributes:				
Age	Age of child in years	169	5.3.75	3.691
Male*	Sex; 1=male; 0=female	169	0.508	0.501
Explanatory variables for adults (≥13)(Table 11):				
Subject's attributes:				
Income	Cash income earned during quarter	687	78.215	169.148
Age	Age in years of subject	156	32.262	15.389
Male*	Sex; 1=male; 0=female	156	0.506	0.501
Education*	Maximum education attained by subject	156	1.846	2.263
Read*	Skills in Spanish: 2=reads well; 1=can read; 0=cannot read	155	0.606	0.871
Arithmetic*	Skills in arithmetic, scored from 0 to 4	156	1.121	1.465
Mother's education*	Maximum education attained by subject's mother	155	0.077	0.387
Father's education*	Maximum education attained by subject's father	155	0.425	1.619
Household's attributes (also applies to regression with children):				
Household size	Household size/quarter when researchers measured consumption; in regression Δ in log of household size between quarters.	214	6.046	2.842
Shock	Dummy variable if household had a shock during quarter (1=yes; 0= no); in regression Δ in total # of shocks between two quarters used as IV	273	0.633	0.482
Village-level controls measured quarterly in each village (Tables 10-11):				
Rain	Coefficient of variation of rain	10	2.834	0.846
Temperature	Coefficient of variation of average (minimum + maximum) daily temperature	10	0.318	0.070
Cloud cover	Coefficient of variation of cloud cover	10	0.756	0.187

Notes: All variables are quarterly; variables with an asterisk were measured only once at the start of the study.

Table 10. The impact of quarterly Δ in idiosyncratic household income shocks on quarterly Δ in the log of anthropometric measures of short-run nutritional status for Tsimane' children (<13 years): Instrumental-variable estimations

	Dependent variables, quarter-to-quarter Δ in logarithm of:			
Regression type:	ZAMA (N = 272)	ZSK2 (N = 274)	ZWA (N = 279)	ZWH (N = 234)
OLS (2SLS)	0.003 (0.007)	0.006 (0.004)	-0.008 (0.007)	-0.008 (0.036)
Random effect	0.003 (0.008)	0.006 (0.004)	-0.008 (0.007)	-0.008 (0.030)
Fixed effect	0.004 (0.009)	0.005 (0.005)	-0.008 (0.007)	-0.011 (0.037)

Notes: Standard errors in parentheses. Dependent variables are quarterly Δ in the log of the anthropometric index; a constant value added to anthropometric index to make them positive number to read coefficient as elasticity. Coefficients shown are the quarterly Δ in the log of household monetary income using the following instruments for Δ in household income: (a) Δ in quarterly household shocks, (b) education, age, reading ability, and first-quarter values of standardized height for age of mother and father, each entered separately, (c) coefficient of variation of village daily rainfall, temperature, and cloud cover, and (d) interaction of age with (c) and interaction of quarter with village. Controls not shown include: sex and age of child, quarterly Δ in logarithm of household size, dummies for quarters and village, and constant. 2SLS under OLS = two-stage ordinary least squares. Table 9 contains definition of variables. Robust standard errors used in 2SLS. *, **, and *** significant at the 90%, 95%, or 99% confidence level.

Table 11. The impact of quarterly Δ in idiosyncratic household income shocks on quarterly Δ in the log of anthropometric measures of short-run nutritional status for Tsimane' adults (13+ years): Instrumental-variable estimations

	Dependent variables, quarter-to-quarter Δ in logarithm of:		
Estimation method	ZSK2	BMI	ZAMA
Pooled	(N = 316)	(N = 318)	(N = 316)
OLS (2SLS)	0.001 (0.025)	-0.009 (0.003)***	-0.022 (0.010)**
Random effect	0.020 (0.019)	-0.008 (0.002)***	-0.025 (0.019)
Fixed effect	0.028 (0.021)	-0.008 (0.003)***	-0.032 (0.021)
Women	(n=143)	(n=143)	(n=143)
OLS (2SLS)	-0.006 (0.025)	-0.010 (0.003)***	-0.020 (0.010)**
Random effect	0.014 (0.022)	-0.009 (0.002)***	-0.028 (0.007***
Fixed effect	0.015 (0.023)	-0.009 (0.003)***	-0.029 (0.008)***
Men	(n=173)	(n=175)	(n=173)
OLS (2SLS)	0.023 (0.009)**	0.005 (0.001)***	0.015 (0.017)
Random effect	0.023 (0.011)**	0.005 (0.002)***	0.014 (0.018)
Fixed effect	0.023 (0.012)**	0.005 (0.002)***	0.011 (0.020)

Table 11. The impact of quarterly Δ in idiosyncratic household income shocks on quarterly Δ in the log of anthropometric measures of short-run nutritional status for Tsimane' adults (13+ years): Instrumental-variable estimations

Notes: Standard errors in parentheses. Dependent variables are quarterly Δ in the log of the anthropometric index; a constant value added to anthropometric index (except body-mass index) to make them positive number. Coefficients shown is the quarterly Δ in the log of subject's monetary income using the following instruments for Δ personal monetary income: (a) Δ in quarterly household shocks, (b) age and age^2 of subject, (c) coefficient of variation of village daily rainfall, temperature, and cloud cover, and (d) interaction of age with (c) and interaction of quarter with village. Controls not shown include: sex and age of subject, Δ in logarithm of quarterly household size, dummies for quarters and village, subject's education and skills in reading and arithmetic, education of subject's mother and father, and constant. Table 9 contains definition of variables. Robust standard errors used in 2SLS. *, **, and *** significant at the 90%, 95%, or 99% confidence level.

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Literature Cited

Alderman H, Hoddinott J, Kinsey B. 2003. Long-term consequences of early childhood malnutrition Washington, D.C.: IFPRI, Food Consumption and Nutrition Division Working Paper; Report nr 168.

Angrist JD, Krueger AB. 1999. Empirical strategies in labor economics. In: Ashenfelter O, Card D, editors. Handbook of labor economics. Volume 3 ed. Amsterdam: Elsevier Science; p 1277-1366.

Bailey RC, Jenike MR, Ellison PT, Bentley GR, Harrigan AM, Peacock NR. 1992. The ecology of birth seasonality among agriculturalists in central Africa. Journal of Biosocial Science 24:393-412.

Bailey RC, Jenike MR, Ellison PT, Bentley GR, Harrigan AM, Peacock NR. 1993. Seasonality of food production, nutritional status, ovarian function and fertility in Central Africa. In: Hladik CM, Hladik A, Linares OF, Pagezy H, Semple A, Hadley M, editors. Tropical forests, people and food: Biocultural interactions and applications to development. Paris: UNESCO; p 387-402.

Behrman JR. 1998. Intra-household allocation of resources: Is there a gender bias? In: Too Young to Die: Genes or Gender. New York: United Nations, Department of Economic and Social Affairs, Population Division; pp 223-242.

Behrman JR. 1988. Intra-household allocation of nutrients in rural India: Are boys favored? Do parents exhibit inequality aversion? Ox Econ Papers 40(1):32-54.

Behrman JR, Deolalikar A. 1990. The intra-household demand for nutrients in rural South India: Individual estimates, fixed effects and permanent income. Journal of Human Resources 24 (4):655-96.

Behrman JR, Foster A, Rosenzweig MR. 1997. The dynamics of agricultural production and the calorie-income relationship. Journal of Econometrics 77 (1):187-208.

Bentley GR, Aunger R, Harrigan AM, Jenike MR, Bailey RC, Ellison PT. 1999. Women's strategies to alleviate nutritional stress in a rural African society. Social Science and Medicine 48:149-62.

Berti PR, Leonard WR. 1998. Demographic and socioeconomic determinants of variation in nutrient intake in an Andean community. Am J Phys Anthro 105:407-17.

Besley T. 1995. Non-market institutions for credit and risk sharing in low-income countries. J Econ Pers 9 (3): 115-27.

Bindon JR, Vitzthum V.V.J. 2002. Household economic strategies and nutritional anthropometry in American Samoa and highland Bolivia. Social Science and Medicine 54:1299-308.

Byron E. 2003. Markets and Health: The Impact of Markets on the Nutritional Status, Morbidity, and Diet of the Tsimane' Amerindians of Lowland Bolivia. PhD dissertation, Department of Anthropology, University of Florida.

Colson E. 1979. In good years and in bad: Food strategies of self-reliant societies. J Anthr Res 35(1):18-29.

Crooks DL. 1999. Child growth and nutritional status in a high-poverty community in Eastern Kentucky. Am J Phys Anthro 109:129-42.

Cruz CM, da Silva AF, dos Anjos LA. 1999. Basal metabolic rate is overestimated by predictive equations in college aged women of Rio de Janeiro, Brazil. Archivos Latinoamericanos de Nutricion 49:232-7.

Czukas K, Fafchamps M, Udry C. 1998. Drought and savings in West Africa: Are livestock a buffer stock? J Dev Econ 55:273-305.

Deaton A. 1997. The analysis of household surveys: a microeconometric approach to development policy. Baltimore, MD: Johns Hopkins University Press.

Dercon S, Krishnan P. 2000a. In sickness and in health: Risk sharing within households in rural Ethiopia. J Political Econ 108 (4):688-727.

Dercon S, Krishnan P. 2000b. Vulnerability, seasonality, and poverty in Ethiopia. Journal of Development Studies 36 (6):25-53.

Doss CR. 2001. Is risk fully pooled within the household? Evidence from Ghana. Econ Dev Cult Change 50 (1):101-30.

Foster AD. 1995. Prices, credit markets and child growth in low income rural areas. The Economic Journal 105:551-70.

Frankenberg E, Smith JP, Thomas D. 2003. Economic shocks, wealth, and welfare. The Journal of Human Resources 38 (2): 280-321.

Garg A, Morduch J. 1998. Sibling rivalry and the gender gap: Evidence form child health outcomes in Ghana. Journal of Population Economics 11 (4):471-293.

Gertler P, Gruber J. 2002. Insuring consumption against illness. Am Econ Rev 92(1):51-70.

Godoy RA, Kirby KN, Wilkie D. 2001. Tenure security, private time preference, and use of natural resources among lowland Bolivian Amerindians. Ecol Econ 38(1):105-18.

Godoy RA, Overman H, Demmer J, Apaza L, Byron E, Huanca T, Leonard W, Perez E, Reyes-Garcia V, Vadez V, Wilkie D, McSweeney K, Cubas A, Brokaw N. 2002. Local financial benefits of rain forests: Comparative evidence from Amerindian society in Bolivia and Honduras. Ecol Econ 40:397-409.

Hawkes K, O'Connell JF, Blurton-Jones NG. 1997. Hazda women's time allocation, offspring provisioning, and the evolution of long postmenopausal life spans. Curr Anthr 38(4):551-77.

Henry CJK, Rees DG. 1991. New predictive equation for the estimation of basal metabolic rate in tropical populations. European Journal of Clinical Nutrition 45:177-85.

Hill K, Hawkes K, Hurtado M, Kaplan H. 1984. Seasonal variance in the diet of Ache hunter-gatherers in eastern Paraguay. Hum Ecol 12:23-54.

Hill K, Kaplan H. 1993. On why male foragers hunt and share food. Current Anthropology 34(5):701-10.

Hoddinott J, Kinsey B. 2001. Child growth in the time of drought. Oxford Bulletin of Economics and Statistics 63(4):409-36.

Hurtado MA, Hill KR. 1990. Seasonality in a foraging society: Variation in diet, work effort, fertility, and sexual division of labor among the Hiwi of Venezuela. J Anthr Res 46(3):293-335.

Jacoby H, Skoufias E. 1997. Risk, financial markets, and human capital in a developing country. Review of Economic Studies 64(3):311-35.

Jenike MR. 1995. Variation in body fat and muscle mass: responses to seasonal hunger among tropical horticulturalists, Zaire. Ecology of Food and Nutrition 34:227-49.

Jenike MR. 1996. Activity reduction as an adaptive response to seasonal hunger. Am J Human Biol 8:517-34.

Jenike MR. 2001. Nutritional ecology: diet, physical activity and body size. In: Panter-Brick C, Layton RH, Rowley-Conwy P, editors. Hunter-gatherers: an interdisciplinary perspective. Cambridge, United Kingdom: Cambridge University Press; pp. 205-238.

Kirby K, Godoy RA, Byron E, Leonard W, Wilkie D, Apaza L, Reyes-Garcia V, Vadez V, Perez E. 2002. Correlates of delay-discount rates: Evidence from Tsimane' Amerindians of the Bolivian rain forest. Journal of Economic Psychology 23:291-316.

Knowler WC. 1991. Obesity in the Pima Indians: Its magnitude and relationship with diabetes. American Journal of Clinical Nutrition 53:1543Sp-1551S.

Knowler WC. 1983. Diabetes mellitus in the Pima Indians: Genetics and evolutionary considerations. Am J Phys Anthro 62:107-14.

Kochar A. 1995. Explaining household vulnerability to idiosyncratic income shocks. Am Econ Rev 85(2): 159-64.

Kurosaki T, Fafchamps M. 2002. Insurance market efficiency and crop choices in Pakistan. J Dev Econ 67: 419-53.

Leonard WR. 1991a. Age and sex differences in the impact of seasonal energy stress among Andean agriculturalists. Hum Ecol 19 (3): 351-68.

Leonard WR. 1991b. Household-level strategies for protecting children from seasonal food scarcity. Social Science and Medicine 33(10): 1127-33.

Leonard WR, Thomas BR. 1989. Biosocial responses to seasonal food stress in highland Peru. Hum Biol 61(1):65-85.

Morduch J. 1995. Income smoothing and consumption smoothing. J Econ Pers 9(3):103-14.

Morduch J. 1999. Between the market and state: Can informal insurance patch the safety net? World Bank Research Observer 14:187-207.

Morduch J. 2002. Consumption smoothing across space: Testing theories of risk-sharing in the ICRISAT study region of South India. In: Dercon S, editor. Insurance Against Poverty. London: Oxford University Press.

Pagezy H. 1982. Seasonal hunger, as experienced by the Oto and the Twa of a Ntomba village in the equatorial forest (Lake Tumba, Zaire). Ecology of Food and Nutrition 12:139-53.

Pagezy H. 1988. Coping with uncertainty in food supply among the Oto and Twa living in theequatorial flooded forest near lake Tumba, Zaïre. In: I De Garine and G A Harrison,Coping with Uncertainty in Food Supply Clarendon Press, Oxford.

Pagezy H. 1990. Seasonal variation of food supply in the Lake Tumba region of Zaire. In: Hladik CM, Bahuchet S, de Garine I, editors. Food and nutrition in the African rain forest. Paris, France: UNESCO-MAB; p 37-42.

Pagezy H. 1993. The importance of natural resources in the diet of the young child in a flooded tropical forest in Zaire. In: Hladik CM, Hladik A, Linares OF, Pagezy H, Semple A, Hadley M, editors. Tropical forests, people and food: Bio-cultural interactions and applications to development. Paris: UNESCO; pp. 365-380.

Paxson CH. 1992. Using weather variability to estimate the response of savings to transitory income in Thailand. Am Econ Rev 82(1):15-33.

Peters P, Kennedy E. 1992. Household food security and child nutrition: The interaction of income and gender of household head. World Development 20(8):1077-85.

Pitt M, Rosenzweig M, Hassan MN. 1990. Productivity, health, and inequality in the intra-household distribution of food in low-income countries. Am Econ Rev 80(5):1139-56.

Ravussin E. 1993. Energy-metabolism in obesity - studies in the Pima Indians. Diabetes Care 16(1):232-8.

Ray D. 1998. Development Economics. Princeton, New Jersey: Princeton University Press.

Reyes-Garcia V, Byron E, Godoy RA, Vadez V, Perez E, Leonard WR, Wilkie D. 2003. Measuring culture as shared knowledge: Do data collection formats matter? Data from Tsimane' Amerindians, Bolivia. Field Methods 15(2): 1-22.

Reyes-Garcia V, Godoy RA, Vadez V, Apaza L, Byron E, Huanca T, Leonard W, Perez E. 2003. Indigenous people share botanical knowledge. Estimates from an Amerindian society in Bolivia. Science 299:1707.

Richards P. 1990. Local strategies for coping with hunger: Central Sierra Leone and Northern Nigeria compared. African Affairs 89:265-75.

Roberts DF. 1978. Climate and Human Variability. 2nd ed. Menlo Park, California: Cummings.

Rose E. 1999. Consumption smoothing and excess female mortality in rural India. The Review of Economics and Statistics 81(1):41-9.

Rosenzweig MR, Wolpin KI. 1993. Credit market constraints, consumption smoothing, and the accumulation of durable production assets in low-income countries: Investments in bullocks in India. J Political Econ 98:223-44.

Rosenzweig MR, Wolpin KI. 2000. Natural 'natural experiments' in economics. Journal of Economic Literature 38:827-74.

Skoufias E. 2001. Consumption smoothing in Russia: Evidence from the RLMS.

Skoufias E. 2002. Risk sharing in a transition economy: Evidence from monthly data in Bulgaria.

Soares MJ, Francis DG, Shetty PS. 1993. Predictive equations for basal metabolic rates of Indian males. European Journal of Clinical Nutrition 47(6):389-94.

Szathmary EJE. 1990. Diabetes in Amerindian populations: The Dogrib studies. Genetic and Evolutionary Perspectives 34:75-103.

Townsend RM. 1995. Consumption insurance: an evaluation of risk-bearing systems in low-income economies. J Econ Pers 9(3):83-102.

Townsend R. 2002. Risk and insurance in village India. Econometrica 62(3):539-91.

Udry C. 1990. Credit markets in northern Nigeria: Credit as insurance in a rural economy. World Bank Research Observer 4:251-75.

Udry C. 1994. Risk and insurance in a rural credit market: An empirical investigation in northern Nigeria. Review of Economic Studies 61:495-505.

Vadez V, Reyes-Garcia V, Godoy RA, Apaza L, Byron E, Huanca T, Leonard WR, Wilkie D, Perez E, C. 2004. Does integration to the market threaten agricultural diversity? Panel and cross-sectional evidence from a horticultural-foraging society in the Bolivian Amazon. Hum Ecol. In press.

Valencia ME, Moya SY, McNeill G. 1994. Basal metabolic rate and body fatness of adult men in northern mexico. European Journal of Clinical Nutrition 48(3):205-11.

Werner D, Flowers NM, Ritter ML, Gross DR. 1979. Subsistence productivity and hunting effort in native south America. Hum Ecol 7(4):303-16.

Wilkie DS, Morelli GA, Rotberg F, Shaw E. 1999. Wetter isn't better: Global warming and food security in the Congo Basin. Global Environmental Change 9:323-8.

Wong G, Godoy RA. 2003. Consumption and vulnerability among foragers and horticulturalists in the rainforest of Honduras. World Development 31(8): 1405-19.

World Bank. 2001. World Development Report 2000/2001. Attacking Poverty. New York: Oxford University Press.