Networks, Finance, and Development: Evidence from Hunter-Gatherers*

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Abstract

Using household survey data from an Amazonian hunter-gatherer society, I analyze the relationship between village networks and capital market imperfections arising from the social structure. The village-network structure features a boundary that is based on mating norms and splits each village into two groups: a large group comprising three-quarters of the population that practice cross-cousin marriage, and a small group that is more open towards outsiders. In this village economy, individuals enter into informal contracts to finance their foraging-farming activities as well as human capital investments in pursuit of employment with loggers, cattle ranchers, and colonist farmers. The informal capital market is endogenously incomplete: while the default financing contract can be characterized as debt, insurance in the form of equity-like financing is available only from fellow villagers. By examining the villagers' financing streams and sources, I find that, as a consequence of its limited availability, equity/insurance is a benefit that accrues primarily to the large group of villagers that adhere to the traditional system of cross-cousin marriage. However, this benefit comes at the cost of taxation of individual efforts aimed at connecting with the labor market, such as human capital investments. I show that the observed capital allocation potentially leads to substantially lower investment in human capital by the large group, and calibrate the counterfactual gains from completing the market. (*JEL* O12, O16)

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1 Introduction

Informal networks substitute for institutions in developing countries, and there exists ample documentation of the benefits of such networks (e.g., Rosenzweig 1988, Grimard 1997, Bayer et al. 2008). However, there is little empirical knowledge about the cost and other downsides of networks (Banerjee and Newman 1998) – knowledge that is needed to assess the actual performance of networks in replacing a market structure.

In this paper, I attempt to shed light on the relationship between kinship networks and the informal capital market in an Amazonian hunter-gatherer society. In particular, my findings suggest that the adherence to traditional mating norms, namely cross-cousin marriage, is requited with financing from fellow villagers. Hence, the social structure has explanatory power for the workings (and shortcomings) of the informal capital market. This paper contrasts the benefits of intra-village financing and insurance with their cost in the form of taxing individual efforts directed at connecting with the outside labor market through human capital investment. The resulting human capital and income gaps between the majority group practicing cross-cousin marriage and the remaining minority reflect a generalizable downside of networks, and attest to the idea that some network structures can be impediments to development and growth. Conversely, the economic success of the minority group that relies less on the village network but, instead, interacts more with outsiders is reminiscent of the prosperity of ethnic minorities, characterizing the aftermath of various immigration waves.

My analysis is based on five-year panel data from an in-depth account of recorded activities in villages in Amazonian Bolivia, where the Tsimane' reside. The villagers allocate their time to foraging-farming and human capital investment. The Tsimane' typically do not speak Spanish, but studying it opens doors to lucrative wage labor. Returns to human capital investment are understood to be high: villagers can seek schooling at virtually all ages and, subsequently, work on farms, at schools, and eventually in administration.

The trade-off between foraging-farming and human capital accumulation is typical of underdeveloped economies, and reflects the fundamental setup for the transformation from agriculture to market sophistication and industrialization. To understand that transformation and evaluate the role of informal networks, one would want to scrutinize different allocation

mechanisms and their impact on household wealth composition. In the absence of markets, social organization forms – such as networks – determine the rules of exchange and distribution, and particularly so in developing countries. However, what distinguishes network-based from market-based exchange is that participants in the former are often joined together by kinship or other social bonds, whereas markets offer alternative, impersonal exchange mechanisms. Against this background, I study the relationship between growth-enhancing human capital investments and the social structure in Tsimane' villages.

Given their small size, every village can be considered a tight network of individuals that exhibit different degrees of connectedness with the outside world. More traditional villagers are likely to rely more heavily on their village networks, and this trait is strongly correlated with mating preferences that preserve the strength of the village networks. Roughly three-quarters of the population practice cross-cousin marriage and deem any deviation from that practice unacceptable, whereas the remainder do not. Thus, the preferential system of cross-cousin marriage can be considered a boundary that splits each village into two groups. Due to intergenerational transmission of mating preferences, this village-network structure proves to be exogenous, which enables the measurement of the impact of group affiliation on economic outcomes. I find that the group practicing cross-cousin marriage is more invested in traditional assets, has lower income, and performs worse on human capital measures despite similar learning productivity. While these aggregate differences are consistent with the different attitudes of the two groups, they may also be outcomes of the interaction between the social structure and the informal capital market. In the Tsimane' economy, borrowed funds are used for investments in foraging-farming and human capital. Hence, varying investment levels can be traced, in part, to capital market imperfections.

In order to explore this possibility, I analyze data on the villagers' financing streams and sources. Village-network affiliation turns out to have explanatory power for both the supply and demand of informal finance. The informal capital market is endogenously incomplete: while the default financing contract can be characterized as debt, insurance in the form of equity-like financing is available only within villages. Here, equity arrangements are loans for which the repayment is proportional to the debtor's income. As a consequence of its limited availability, equity/insurance is a benefit that accrues primarily to villagers that have

stronger ties with their fellow villagers, i.e., members of the group practicing cross-cousin marriage, and there is selection on ability, forcing less capable villagers of that group to contract with outsiders instead. On the other hand, the ability distribution across the two contracts is more dispersed in the remaining group of less traditional villagers. This capital allocation could explain the human capital and income gaps between the two groups: the insurance cushion provided to the most capable members of the group practicing cross-cousin marriage disincentivizes them to work harder, and the least capable ones are discouraged by the lack of downside insurance in debt arrangements.

To identify such adverse effects associated with the financial friction, I test the impact of contract choice on income structure, individual work effort and – most importantly – the human capital investment process. The empirical evidence lends strong support to the hypothesis that the observed capital allocation leads to lower effort exertion and investment in human capital by members of the group practicing cross-cousin marriage. The last part of the paper then calibrates the loss in human capital investment, which ultimately results from the limited supply of equity/insurance, by quantifying how much more the villagers in that group would invest in human capital if equity/insurance were allocated to the least capable borrowers first while extending its availability. I show that the implied loss potentially explains 20 to 45% of the earnings gap between the two groups.

This paper presents, and is based on, some of the merits of studying hunter-gatherers. A simplistic economy such as the one in Amazonian Bolivia (two assets, two contracts) aids in identifying the effect of financial frictions on investment outcomes. Given that the allocation of time between foraging-farming and human capital investment spans the space of variation in economically meaningful decisions of the villagers, financing-contract choice is the only explanatory variable for human capital outcomes that potentially reflects contract preferences. This way, the simplicity of the Tsimane' economy reduces the risk of omitting important measures of revealed preference, and thus, this economy can serve as a quasi-laboratory setting for testing economic models.

1.1 Related Literature

This paper sheds light on capital market imperfections arising from the social structure that eventually lead to income inequality in a simple village economy. Although their theoretical setting is not quite akin to the one in this paper, Banerjee and Newman (1998) predict migration, which also characterizes the most successful human capital investments of the Tsimane', at inefficient levels as a consequence of underinsurance outside the village network. Insofar, the present analysis of the relationship between financial frictions and human capital formation can be understood as (the underpinnings for) an empirical estimate of the downside of village networks in developing countries.

The strands of literature on networks are multifaceted, and cover characteristics that may explain economic outcomes within and between networks. While there are many different types of networks, kinship and other social networks play a particularly important role in developing countries (for an overview of social networks, based on co-residence patterns, in other hunter-gatherer societies, see Hill et al. 2011). Social networks are shown to foster trust and altruism (Karlan et al. 2009, Leider et al. 2009, Alger and Weibull 2010). As these traits help enforce informal contracts, they also translate to allocations in networks, e.g., informal insurance or consumption smoothing via risk sharing (Bloch, Genicot, and Ray 2008; Ambrus, Moebius, and Szeidl 2010; Angelucci et al. 2010). Through these channels, social networks can affect a wide variety of economic outcomes and sources of inequality, most notably financial access (Banerjee and Munshi 2004, Kinnan and Townsend 2011), welfare participation (Bertrand, Luttmer, and Mullainathan 2000), and labor (im)mobility (Alesina et al. 2010).

Furthermore, this paper touches on various issues at the intersection of finance and development. The vast literature on the topic is surveyed by Levine (1997, 2005). For instance, Rajan and Zingales (1999) define financial development as a reduction in the agency cost of external finance, and find larger effects of financial development in industries that are in greater need of external finance. Based on data from Thailand, Townsend and Ueda (2006) shed light on the link between financial development and inequality by calibrating the average movements in financial deepening, inequality, and growth.

Lastly, the spirit in which this paper analyzes financial contracts and their link to invest-

ment decisions is akin to that in Tirole (2006). Using a similar framework in a developing-country context (India), Fischer (2010) presents experimental evidence of the relationship between risk taking in investment decisions and financial-contract design. This paper puts particular emphasis on individual differences in human capital investment and in related economic outcomes. The empirical characterization of the returns to human capital investment has been the subject of scrutiny in many studies: while some contributions (e.g., Williams 1978 and Palacios-Huerta 2003) focus on the returns to human capital and the investment process, others (e.g., Jacoby and Skoufias 1997; Krebs 2003; Berk and Walden 2010; Erosa, Koreshkova, and Restuccia 2010; Huggett and Kaplan 2011) explore the interaction of human capital accumulation and markets (e.g., the financial sector).

2 Description of the Economy and the Data

In this paper, I discuss the Tsimane' of Amazonian Bolivia, a hunter-gatherer society in the Department of Beni. I use a panel data set from a team of anthropologists who recorded the socioeconomic activities of the villagers from 2002 to 2006. Whereas Godoy et al. (2005) give a more detailed account of the traits and developments among the Tsimane', I shall focus on the elements that, to a large extent, characterize the economy and, thus, define the framework for my analysis. Based on the characterization of the economy, this section describes the survey data, the construction of key variables, and the motivating evidence.

2.1 Salient Features of the Village Economies in Amazonian Bolivia

As is typical of native Amazonian societies, the Tsimane' hunt both game and fish, and practice slash-and-burn agriculture by clearing plots from the forest. Also, most Tsimane' have sufficient land to farm (5.7 ha per person according to Godoy et al. 2006). These foraging-farming activities, paired with a lack of exposure to outside institutions, established autarky among the Tsimane'. However, beginning in the early 1950s, they opened up to contact with Westerners. That development culminated in the establishment of permanent Protestant missions by the Department of Beni. Upon their arrival, the missionaries played a crucial role in the education of the Tsimane', as the Bolivian government gave them schooling

responsibilities – an agreement that lasted until 1985. The 30-year training period – first in Tumichuco and later in San Borja,[1] which is closer to the Tsimane' territory – left its mark on the present-day situation of the Tsimane'. For instance, most Tsimane' teachers in the villages who speak Spanish were educated by Protestant missionaries, as was today's elite among Tsimane' bureaucrats working in Bolivia.

The impact of Protestant missionaries on the socioeconomic development of the Tsimane' is symptomatic of the latter's gradual exposure to a market economy: the prospects of employment in towns such as San Borja have gained notice among the Tsimane', and schooling is now recognized as an entry ticket to prosperity. Other opportunities arise from interactions with loggers, cattle ranchers, and colonist farmers, who buy and trade crops as well as forest goods, and also offer employment. These interactions characterize the three sources of income, which are earnings from the sale of goods, wage labor, and barter. There is great variation in the composition of the villagers' income portfolios, and this paper scrutinizes relevant market frictions arising from the social structure that eventually lead to the observed income inequality.

In the following, I focus on two salient features of the Tsimane' economy that are at the core of this paper's analysis. First, I present an exogenous network structure in the economy. Second, I turn to the investment side, and consider the process of human capital formation as an alternative to foraging-farming.

2.1.1 Practice of Cross-Cousin Marriage as a Measure of Connectedness

The Tsimane' live in villages that constitute tight networks. There is a general sense of autarky manifested in the fact that if a member of the community leaves the village, he is more likely to move to a town (e.g., San Borja) in order to pursue employment opportunities, rather than to another village.[2] However, there is some variation in the degree of connectedness among the Tsimane': while the vast majority in the villages tend to have more conservative views of the outside world and, particularly, the market economy evolving around them,

[1] San Borja has roughly 19,000 inhabitants and is, on average, three walking hours away from the villages from which the data for this paper are drawn.

[2] From 2003 to 2006, only six villagers left their communities for other villages, whereas 128 villagers changed households within their villages.

a small group is more open to outsiders (e.g., loggers, cattle ranchers, colonist farmers, merchants in towns, and the government) while also interacting with other Tsimane' in the village. A characteristic that is highly correlated with a more traditional, self-preserving attitude – and, thus, a low degree of connectedness with outsiders – are the villagers' mating norms.

The traditional kind of marriage among the majority of the Tsimane' is cross-cousin marriage – i.e., a man should marry his mother's brother's daughter (matrilateral cross cousin) or his father's sister's daughter (patrilateral cross cousin). About three-quarters of the Tsimane' population practice cross-cousin marriage. The preferential system of cross-cousin marriage splits each village into two groups: one that practices cross-cousin marriage and deems any deviation from that norm unacceptable, and one that does not impose this mating rule. In fact, Tsimane' who practice cross-cousin marriage believe that, upon death, those who did not comply with this norm become jaguars and eat living people (Godoy et al. 2008).

[Insert Table 1 about here]

In that respect, the mating norms define a network boundary in the villages under scrutiny. The resulting subnetworks differ in size, with the larger group being more traditional and inward-looking based on cross-cousin marriage (cf. Table 1). These groups are exogenous insofar as the belief in cross-cousin marriage is conferred by the villagers' parents, and there is no switching to other beliefs upon adolescence. This can be backed up by the data: the majority opinion of the children in a household overlaps with the household heads' reported mating preference in 94.5% of all households, regardless of the children's age. Throughout the paper, I define an individual as a member of the large (inward-looking) group if he belongs to a household in which the majority report their intolerance for deviations from the mating norm. The remainder of the villagers are assumed to belong to the small (outward-looking) group. Survey questions on attitudes towards others support the role of mating preferences as a proxy for traditional attitudes – mainly intolerance towards non-Tsimane' – and connectedness in the form of exposure to outsiders and other parties in towns. For instance, members of the small group, on average, travel to towns more frequently

than members of the large group (13.47 vs. 9.9 times per year; the difference is significant at the 1% level). The small group also reports significantly greater tolerance for farmers, ranchers, traders, and institutions (the Bolivian Agrarian Reform Agency).

In order to use the practice of cross-cousin marriage as a measure of connectedness (i.e., openness to outsiders and, thus, weaker dependence on fellow villagers), one should make sure that the latter is not a sheer consequence of different degrees of exposure to the outside market economy through Protestant missionaries in the past. A simple way of testing this is to compare the distributions of self-professed religions.[3] In both groups, typically, more than 60% indicate that they are Catholics, and roughly 30% report that they are Protestants (with the remainder being split between atheists and adherents of other religions). A two-sample Kolmogorov-Smirnov test reveals that, in every year of the survey, the distributions of self-professed religions do not differ between the two groups.

2.1.2 Human Capital Formation

Having discussed the village-network structure, I now complete the characterization of the action space of the villagers. Despite the prevalence of foraging-farming, the Tsimane' are increasingly aware of the potential returns to schooling. The available forms of schooling are manifold and open to all ages, so schooling is not uncommon even among adults: 40% of Tsimane' villages have a primary school, but no village has a middle or high school (Reyes-García et al. 2007). Protestant missionaries and other local teachers offer training courses in reading and writing for Tsimane' adults, and there also exist other adult educational programs in some villages, where Tsimane' adults with a primary school background can complement their education by earning a high school degree. By attending school, Tsimane' can study Spanish, Bolivia's national language, which enables them to connect with the labor market. A rudimentary command of Spanish is sufficient to take orders, and, thus, helps villagers gain employment in logging camps, on cattle ranches, and on farms of colonist farmers. Further investment in human capital can pay off in the form of employment by the government in towns such as San Borja.

[3]Given the prominent role of the Protestant missionaries in the education of the Tsimane', one would suspect that the dominance of Protestantism in one group would be correlated with the degree of connectedness (with outsiders) and other traits relevant for economic interactions.

Since there is no mandatory school attendance for children, human capital investment is a choice for the Tsimane'. The unique alternative to human capital investment is foraging-farming. Tsimane' with no fluency in Spanish are limited in their ability to assume employment with outsiders, but they do interact with them by selling forest goods or rice and other crops from their farms.

Villagers allocate their time to foraging-farming and human capital investment. To quantify the differences in returns, one can turn to the survey data. On the one hand, a villager who spends his time foraging-farming instead of attending school, generating income from the sale of goods, has a bi-weekly income of 101.38 on average (with a standard deviation of 336.27). On the other hand, a villager with some knowledge of Spanish whose major income source is wage labor earns a bi-weekly income of 200.20 on average (with a standard deviation of 201.46).[4] To see that education is indeed a necessary condition for wage labor, one can also compare differences in Spanish ability (rated from 0 to 2) between villagers who derive their income solely from wage labor and those who have income only from foraging-farming. The former group demonstrates greater Spanish fluency in both speaking (1.50) and reading (1.20); the differences from the group of forager-farmers are 0.57 and 0.79, respectively, and are significant at the 1% level.

The payoff to education is thus substantial. However, human capital is a risky asset: the empirical likelihood of zero income turns out to be approximately 16% lower for foraging-farming than for wages upon schooling.

In order to finance investments in foraging-farming and human capital, villagers may opt, or be required, to borrow money. As I will show in Section 3, the nature of these informal financing contracts varies with the relationship between borrower and lender, depending on whether the lender is a fellow villager or an outsider.

[Insert Table 2a about here]

[Insert Table 2b about here]

[4] These averages are conditional on non-zero earnings from the respective activity.

2.2 Data

My main data source is an unbalanced five-year survey (2002 to 2006) comprising 1,814 individuals from 618 households located in 14 villages in Amazonian Bolivia. As indicated in Section 2.1.1, the villages can be separated into two groups: a large group that practices cross-cousin marriage and a small one that does not. A household is defined as practicing cross-cousin marriage if more than half of the household members report that marrying anyone but a cross cousin is unacceptable. In Tables 2a and 2b, I present the descriptive statistics for the variables in the empirical portion of this paper, namely in the total sample and the calibration sample (comprising the subset of villagers who borrowed a non-zero amount in at least one year) used in Section 6, respectively.

As for the data-gathering process, the villagers were interviewed at the same time of year for five years. Some variables (most notably earnings and consumption) are measured on a weekly basis for two weeks prior to the interview, while others (e.g., loans) are also measured on a two-month or annual basis before the day of the interview. All tables indicate the time dimension of the variables.

Tables 2a and 2b display the descriptive statistics for two broad classes of variables:[5] income-related variables and assets, and human capital. Regarding the former, total income is the sum of earnings from the sale of goods, wage labor, and barter. Wages always describe earnings from employment with outsiders. In the survey data, consumption is measured at the household level, and comprises the consumption of game, fish, eggs, maize, manioc, rice, oil, and bread. Furthermore, there are two types of assets – traditional and modern. As opposed to modern assets which are acquired in the market, traditional assets can be considered assets for production (i.e., foraging-farming): they include domesticated animals and artifacts that form part of traditional culture, such as bows or dug-out canoes.

Credit, which includes the amount of money borrowed from any other person, is a key variable. Extensive data on the sources of financing have been made available to me; that is, for every recorded transaction, I have information on whether credit was provided by a

[5]Note that while the qualitative differences between the two groups are preserved in the calibration sample, some magnitudes are naturally augmented, as the latter sample is conditioned on the villagers' borrowing capacity, whereas the total sample comprises all household members (including interviewed children) of each group.

fellow villager or by an outsider (e.g., loggers, cattle ranchers, colonist farmers, or merchants in towns). The time dimension of loans is diverse: I have data on weekly loans from two weeks prior to the interview, loans from two months prior to the interview, and the amount of any outstanding loans older than two months.

Lastly, I discuss the available measures of human capital. The villagers were asked in every year whether they were currently attending any type of school and how much schooling (in years) they had received so far. A math test (scored on a scale from 0 to 4) was conducted on a yearly basis as well. The ratio of the math score to the number of years of schooling is used as a measure of learning productivity. The most important measure of human capital in this paper is Spanish fluency in both speaking and reading (on a scale from 0 to 2, differentiating between no competence, some knowledge of, and a good command of the Spanish language). The speaking and reading abilities were judged by the surveyors.

2.3 Heterogeneity in Income and Human Capital Accumulation

As can be seen in Tables 2a and 2b, the large (inward-looking) group is very similar to the small (outward-looking) group in many respects, but strikingly different along few dimensions. It turns out that the large group is more invested in traditional assets and performs worse on human capital measures. As a consequence of this allocation, members of the large group earn less, on average, than members of the small group, and the income differential is primarily driven by different pay outcomes under wage labor (at least in the more relevant calibration sample).

This constitutes a puzzle: what drives these differences between the two groups that are otherwise very similar? Two seemingly obvious explanations lack evidence. First, both groups exhibit indistinguishable educational attributes, learning productivity, and productivity under wage labor, so ability (of relevant kinds) does not seem to drive the human capital and income gaps. Second, the small group is unlikely to generate greater returns to studying Spanish on the basis of higher endowment. To see this, note that the average value of total assets in the small group does not differ from that in the large group. This also rules out the possibility that the small group had higher endowments in the past, i.e., before investing in human capital. That is because – given that the small group is more heavily invested in

human capital, which pays more – its members should be wealthier than those of the large group after investing in human capital. Furthermore, although the small group earns more, its members do not consume more. This intuitively points to the idea that the small group saves more, but it is difficult to speculate on the actual savings amount in the absence of any data on the respective savings technology. The explanation that this paper offers is an attempt to reconcile the sum of these facts.

The core idea of this paper is to explain differences in investments by their financing counterparts on the villagers' balance sheets. In particular, I investigate whether the same financing sources are available for investments in foraging-farming and human capital. There are many reasons to suspect that there is underfunding of human capital investments with village resources. Naturally, one is that there is less capital available inside than outside the villages. Another reason may be that, given that human capital investments are individually beneficial but detrimental to maintaining a critical village network size, fellow villagers are less willing to provide capital for such purposes. Therein also lies a potential explanation for the higher savings rate of the small group: if they lack network support and are more likely to leave their villages after successfully investing in human capital (i.e., after attaining a job), members of the small group have stronger motives for saving.

The limited availability of intra-village financing would constitute a financial friction. As a consequence of that friction, some people might be forced to seek financing outside their villages. For the financial friction to actually matter in terms of investment decisions, one would require financing arrangements to differ inside as opposed to outside the villages. The following section sheds light on this very issue.

3 Organization of Capital

3.1 Implicit Financing Contracts Inside and Outside the Villages

Does the form of financial arrangements vary depending on whether the lender is a fellow villager or an outsider? To infer the implicit-contract form from the villagers' annual balance sheets, I construct a measure for yearly repayment of borrowed funds, and test whether repayment is fixed (as in standard debt contracts) or covaries with income (as in equity or

insurance arrangements).

[Insert Table 3a about here]

[Insert Table 3b about here]

In Table 3a, I regress repayment in the form of $\max\{0, -\Delta Total\ loans_{it}\}$, i.e., negative yearly changes in total loans (defined as the sum of old credit and any amount borrowed two months prior to the interview), on variables indicating whether a villager borrowed from inside or outside his village in the previous year. I interact the indicator variables with the borrower's (bi-weekly) gross income[6] in the last period[7] in order to test whether certain lender groups participate in the borrowers' investment success. Given that the data do not comprise all changes in credit throughout the year between two interviews, the negative change in total loans reflects a lower bound on the total repayment of credit. Furthermore, as the maturity of financing claims is unknown, Table 3b presents additional regressions for implicit contracts under which a villager borrowed money from inside or outside the village anytime in the past *one or two years* before period t.[8]

The results in Tables 3a and 3b are similar: borrowing from external lenders implies fixed repayment (significant intercept effect), whereas fellow villagers provide arrangements in which repayment amounts are proportional to the borrowers' gross income (significant slope effect). In other, more modern terms, financing from outside the villages can be characterized as debt, whereas equity-like financing, or insurance, is available only within villages.[9] Besides enforcement issues, given that a lender's payoff is more information-sensitive under an equity/insurance contract than under debt, it seems plausible that the issuance of equity contracts becomes more likely among those who can bear the informational cost. This should apply to fellow villagers rather than to outsiders, e.g., fellow villagers are more likely

[6]To yield a measure of gross income, I add the average consumption expenditure (for lard, oil, flour, bread, noodles, and sugar) per household member to the earnings from the sale of goods, wage labor, and barter. Note that all results are robust to subtracting consumption expenditure from gross income.

[7]Two weeks is the longest period for which earnings data are available for all types of income. Thus, I assume that yearly repayment is a function of some multiple of bi-weekly income.

[8]Regressions unreported in this paper show that the results are robust to extending maturity up to the maximum in the data, i.e., four years.

[9]Similar credit-cum-insurance arrangements have been found to be used elsewhere, e.g., by rural households in northern Nigeria (Udry 1994).

than outsiders to have unconditional monitoring rights. More than that, the results can be interpreted as indicating that financing in villages consists of both an equity and a debt component, or that both contracts are available separately (as reflected by the positive but insignificant intercept effect of equity). Regressions unreported in this paper also show that a similar repayment structure holds for other transfers, as intra-village lenders seem to enforce them (e.g., work on the lenders' fields) in proportion to the borrowers' gross income. Henceforth, I use the terms "debt" and "equity" for funds from outside and within the villages, respectively.

The above-discussed results do not account for potential endogeneity. In that respect, a crucial assumption for safeguarding the validity of the comparison between intra- and extra-village financing is the equal presence or absence of hidden information, irrespective of the nature of the lender. If intra-village lenders are better able to assess the types of borrowers and, thus, lend relatively more money to the higher types, then the correlation between repayment and income under intra-village equity could be due to superior information on borrower types among villagers. To further investigate this issue, I next include the demand side, and analyze the ability distributions across the two contracts in the two groups.

3.2 Allocation of Financing Contracts

In order to explore the sources of the villagers' borrowed funds in any given year, conditional on receiving a non-zero amount of credit, I examine the determinants of the proportion of funds that are raised within the villages as measured by *Proportion funds borrowed from* $villager_{it} \in [0, 1]$.

[Insert Table 4 about here]

The results in Table 4 are twofold. First, the most capable members of the large group raise a significantly greater proportion of their funds from fellow villagers, whereas within the small group the most capable members tend to raise their funds outside their villages. The latter effect is, however, not as robust, so the evidence can be interpreted as indicating that the ability distribution across the two contracts is more dispersed in the small group,

while there is selection on ability in the large group due to the limited availability of equity/insurance. Thus, less capable members of the large group are more likely to end up with debt contracts. Note that while limited supply of equity can explain why not all villagers can be served, it does not necessarily imply selection on borrower ability. This outcome is chiefly based on the assumption of (lacking) interest-rate flexibility of loans granted by fellow villagers, i.e., if lenders could adjust rates to reflect individual borrowers' ability, one should not observe less variation in the ability of villagers who receive equity contracts. But this is not the case, and it seems reasonable to believe that such "price discrimination" is less feasible inside the villages (reflecting the informal nature of these loans) than outside, which contributes to the characterization of the equity market as imperfect. The data lend support to this presumption: if interest rates are less flexible in the villages, then – under the assumption that the average maturity of both equity and debt arrangements is roughly similar – the variation in repayment amounts under equity contracts should be dampened, despite the fact that repayment varies with income. To test this in the data, I compare the coefficients of variation of my previous repayment proxy, $\Delta Total\ loans_{it}$ (from Tables 3a and 3b) conditional on being positive. There is, indeed, even less variation in repayment amounts among individuals who borrowed 100% from fellow villagers as opposed to those who borrowed 100% from outsiders in the 54 weeks leading up to the period at which repayment is measured: the coefficients of variation are, respectively, 1.30 and 2.31 (or 1.99 after winsorizing $\Delta Total\ loans_{it}$, conditional on being positive, at the 1^{st} and 99^{th} percentiles).

Second, conditional on ability, participation in the cross-cousin marriage norm, characterizing the large group, facilitates access to financing from fellow villagers. That is, the availability of equity/insurance is a potential benefit accruing primarily to individuals that have stronger ties with their fellow villagers, as reflected by their traditional mating preferences. Indeed, the members of the large group turn out to be in general better insured through risk sharing, which I demonstrate next.

Risk sharing in the villages A way of testing the (non-)insurability of idiosyncratic shocks is to run risk-sharing regressions in the spirit of Cochrane (1991) and Mace (1991) separately for the two groups. As observed in Tables 2a and 2b, the small group is more

heavily invested in human capital than the large group, but – except for the income differences resulting from these investments – very similar otherwise. In the following, I hypothesize that the small group is not as well insured against idiosyncratic shocks as the large group,[10] and test the following specifications:

$$\Delta \ln \overline{c}_{it} = \mu_i + \beta_1 \Delta \ln \overline{c}_{vt} + \beta_2 Income_{it} + \beta_3 X_{it} + \epsilon_{it} \tag{1}$$

and

$$\Delta \ln \overline{c}_{it} - \Delta \ln \overline{c}_{vt} = \mu_i + \beta_2 Income_{it} + \beta_3 X_{it} + \epsilon_{it} \tag{2}$$

if one is willing to assume that $\beta_1 = 1$,[11] where $\overline{c}_{jt}$ denotes unit j's average weekly consumption per household member of game, fish, eggs, maize, manioc, rice, oil, and bread (in bolivianos) in year t; i stands for a villager; v denotes the respective village (average, excluding i); and X_{it} is a vector of idiosyncratic shock dummies that affect earnings from foraging-farming and from wage labor (i.e., the returns to human capital investment).

[Insert Table 5a about here]

[Insert Table 5b about here]

The results, alongside more detailed information on the variables, are given in Table 5a. There is perfect risk sharing if the joint hypothesis of a unit coefficient of aggregate consumption and a zero coefficient of income cannot be rejected. On the one hand, I find that consumption among villagers in the small group varies significantly with income and multiple idiosyncratic shocks, as a result of which the coefficient of aggregate consumption is less than one. On the other hand, for both specifications, perfect risk sharing cannot be rejected for the large group, which is less invested in human capital. The degree of risk sharing even surpasses that in Indian villages analyzed by Townsend (1994). However, the extent to which the large group is better insured than the small group is probably not precisely

[10] The empirical validity of the non-insurability of idiosyncratic shocks for the small group, which is more heavily invested in human capital, would also affirm the assumption made in this paper that human capital is riskier than foraging-farming.

[11] The second specification assumes a unit coefficient of aggregate consumption to avoid a bias of the coefficient on aggregate consumption due to a possible correlation with the error term (Mace 1991).

estimated given the relatively noisy consumption data (which are measured at the household rather than at the individual level for one week on an annual basis).

In Table 5b, I replace specification (1) by:

$$\Delta \ln \overline{c}_{it} = \mu_i + \beta_1 \Delta \ln \overline{c}_{gt} + \beta_2 \left(\Delta \ln \overline{c}_{vt} - \Delta \ln \overline{c}_{gt} \right) + \beta_3 Income_{it} + \beta_4 X_{it} + \epsilon_{it} \qquad (3)$$

where $\overline{c}_{jt}$ denotes unit j's average weekly consumption per household member of game, fish, eggs, maize, manioc, rice, oil, and bread (in bolivianos) in year t; i stands for a villager; v denotes the respective village (average, excluding i); g represents i's group (average, excluding i); and X_{it} is a vector of idiosyncratic shock dummies.

For both groups in Table 5b, β_1 is not significantly different from β_2. This implies that the large group shares risk only with fellow Tsimane' in the same village, but not exclusively with other households practicing cross-cousin marriage. Thus, perfect risk sharing in the large group is not driven by the mere fact that members of that group are more likely to be part of a large family (brought together through cross-cousin marriages).

Furthermore, given its connectedness with outsiders, the small group is part of a network with nodes outside the village, so the measures of aggregate consumption adopted in Tables 5a and 5b might be misspecified for that group. However, as long as there are no bilateral exchanges taking place between Tsimane' and outsiders other than through financing (and the sale of goods or labor), the finding of imperfect insurance in the small group should be robust because, as seen in the previous section, outsiders – unlike fellow villagers – do not provide insurance in the form of equity financing. This indicates that the degree of risk sharing in the small group is probably not underestimated.

To conclude, given that the two groups differ in principle only in their levels of human capital investment, one can infer that villagers planning to invest in human capital (the small group) generally face limited support from fellow villagers, primarily in the form of a lower degree of risk sharing, which comprises equity financing. As already encountered in, for instance, Munshi and Rosenzweig (2006), network members often cannot pursue higher aspirations without sacrificing some of their network support, which takes the form of equity/insurance in the Tsimane' economy.

Insurance and individual work effort As I have just shown, the characterization of the groups by their contract allocation has implications for village-level risk sharing. The next step is to understand how the limited availability of equity/insurance and the contract allocation affect differences in income and human capital between the two groups. Tables 2a and 2b indicate that the small group is less invested in traditional assets, has higher income, and performs better on human capital measures. Furthermore, Table 4 provides evidence that the most capable members of each group receive different financing contracts, namely equity for those in the large group and debt for those in the small group. These findings could be reconciled by differential effects of equity and debt on ex-post outcomes of the borrowers with respective ability characteristics in the two groups.

[Insert Table 6a about here]

[Insert Table 6b about here]

To test the impact of contract choice on income structure and individual work effort, I use as dependent variables, first, an indicator for whether a villager has earned more from wage labor than from the sale of goods in the last two weeks of any given year and, second, provided that a villager has earned a non-zero income from wage labor, the number of days worked in the last two months of any given year. I control for various (lagged) measures or signals of ability, in particular Spanish fluency because it is a necessary condition for the interaction with outsiders (i.e., wage labor). The results are in Tables 6a and 6b, respectively, and across all specifications hint at the idea that villagers who receive intra-village financing work less hard and, thus, earn less despite their lenders' screening them based on ability.[12] Put differently, equity financing discourages effort exertion due to insurance cushion, whereas debt from outsiders incentivizes effort through its full upside exposure and lack of downside insurance.

Next, I present a model for the financing and investment problem of the villagers in this economy, with particular emphasis on a major determinant of income inequality, namely human capital in the form of Spanish fluency. The purpose of the model is twofold. First,

[12] This also attests that the correlation between repayment and income under intra-village equity (cf. Tables 3a and 3b) is unlikely due to superior information on borrower types among villagers.

it enriches the above-described observations with further testable hypotheses. Second, by relating contract demand to human capital investment, the model provides a parametric structure for eventual human capital investment losses arising from the observed capital allocation, which is due to the unavailability of equity contracts outside the villages.

4 Optimal Financing in a Two-Asset Problem

In this section, I attempt to formalize the decision problem of the villagers, and set up a model for the constituents of their investments in foraging-farming and human capital under optimal financing. I incorporate the choice of a financing contract in the borrowers' investment decision, and yield a preference order for contracts based on the associated investment portfolios.

4.1 Model Setup

Tsimane' villagers face a portfolio problem: they can allocate time (denoted by $e \in [0,1]$) to foraging-farming and schooling. To finance this portfolio, they borrow the amount $I - W$, where I equals the fixed cost of investment and W denotes the borrower's internal funds (wealth). To simplify matters, I sketch a one-period decision problem. There are two assets in which the borrower can invest: I assume that foraging-farming yields a risk-free cash flow X^L at maturity, and human capital yields a cash flow of $X^H > 0$ with probability $p \in (0,1)$ and 0 otherwise. As discussed in Section 2.1.2, investment in human capital is riskier but yields higher cash flows. I therefore assume that $pX^H > X^L$. The borrower optimizes portfolio weights e and $1-e$ to maximize his expected utility. The marginal cost of investing in risky human capital is c and known to all parties. This reflects the assumption that the observed capital allocation in Table 4 is not due to superior information on borrower types among villagers (see also the discussion leading up to Footnote 12), but due to lacking loan-rate flexibility in the villages.

I assume ex-ante moral hazard over investment choice, so the portfolio weights are not contractible. The lender's payoff depends on state-contingent claims where a state is defined by a non-zero investment in one of the two asset classes. I assume that all lenders have the

same opportunity cost (normalized to zero). There are two types of lenders: one that provides extra-village debt and one that provides intra-village equity. Both lenders cannot observe e (moral hazard), but – depending on the contract that is written – they can observe the realized cash flows. That is, intra-village providers of equity have unconditional monitoring rights with respect to the borrowers' cash-flow realizations, whereas the monitoring rights of extra-village providers of debt are contingent (typically on default). The contract offered by external lenders can be characterized as follows: $R^L = \min\{X^L, K^L\}$ and $R^H = \min\{X^H, K^H\}$, where K^L and K^H are determined by the lender (at a zero interest rate, K is simply the face value of debt). For the sake of simplicity, I assume $K^L = K^H$. Also, repayments must not decrease with cash flows, hence $R^L \leq R^H$. However, equity contracts can be provided only by intra-village lenders, and they demand $1 - \delta$, $\delta \in [0, 1]$, of the cash flow earned in each state.

In the remainder of this section, I solve for the borrower's equilibrium debt and equity contracts (assuming they are available to him separately) – and their associated weights on human capital – given all possible combinations of borrowers and lenders with regard to their risk preferences, and determine which contract the borrower prefers.

4.2 Risk Neutral Borrower

In the baseline case, I assume the borrower to be risk neutral with a quadratic cost function in e.

4.2.1 First Best (No External Funds Required)

Given the model setup, one can solve for the first best: the equilibrium portfolio weight on human capital e if the risk neutral borrower has sufficient internal funds to finance the investment $I - W$. The borrower solves:

$$\max_e \left\{ W + epX^H + (1-e)X^L - \tfrac{ce^2}{2} - I \right\}$$

$$\Rightarrow e^*_{fb} = \tfrac{\Delta X}{c} \tag{4}$$

where $\Delta X \equiv pX^H - X^L$.

The equilibrium portfolio weight on human capital increases in the probability of success p, and decreases in the payoff to foraging-farming X^L and the marginal cost of investing in human capital c.

4.2.2 Borrower and Lender are Risk Neutral

If the borrower is not wealthy enough to self-finance the investment, he seeks outside finance. There are two financing contracts available (cf. Section 3.1). I first assume that the risk neutral borrower can freely choose between *extra-village debt* and *intra-village equity* from a risk neutral lender, and consider these two contracts separately.

Extra-village debt

$$\max_e \left\{ W + pe^l R^H + (1-e^l)R^L + ep\left(X^H - R^H\right) + (1-e)\left(X^L - R^L\right) - \tfrac{ce^2}{2} - I \right\}$$

$$\Rightarrow e_d^* = \tfrac{\Delta X - \Delta R}{c} \tag{5}$$

where $\Delta X \equiv pX^H - X^L$, $\Delta R \equiv pR^H - R^L$, and e^l is the lender's expectation of e chosen by the borrower.

Comparing (5) to (4), one can see that the equilibrium portfolio weight on human capital is lower as long as $\Delta R > 0$, which is due to the moral hazard involved in raising funds.

The lender has rational expectations – i.e., $e^l = e_d^*$ – and, for zero profit, requires:

$$pe^l R^H + (1-e^l)R^L = \Delta R \tfrac{\Delta X - \Delta R}{c} + R^L = I - W. \tag{6}$$

This expression is maximized for $R^L = X^L$ and $\Delta R = \frac{\Delta X}{2}$, yielding the maximum amount $F_{extra}^{max} \equiv \frac{(\Delta X)^2}{4c} + X^L$.

Intra-village equity

$$\max_e \left\{ W + (1-\delta)pe^l X^H + (1-\delta)(1-e^l)X^L + \delta epX^H + \delta(1-e)X^L - \tfrac{ce^2}{2} - I \right\}$$

$$\Rightarrow e_e^* = \delta \tfrac{\Delta X}{c} \tag{7}$$

where $\Delta X \equiv pX^H - X^L$, e^l is the lender's expectation of e chosen by the borrower, and e_e^* is, again, lower than e_{fb}^*.

The lender has rational expectations – i.e., $e^l = e_e^*$ – and breaks even:

$$(1-\delta)pe^l X^H + (1-\delta)(1-e^l)X^L = \delta(1-\delta)\frac{(\Delta X)^2}{c} + (1-\delta)X^L = I - W. \tag{8}$$

Expression (8) implies a maximum borrowing amount $F_{intra}^{max} < F_{extra}^{max}$ (because $\delta(1-\delta)$ is at most $\frac{1}{4}$, but then $(1-\delta)X^L < X^L$). Interestingly, the borrower can raise more from outsiders than from fellow villagers, as debt, rather than equity, is less information-sensitive (the payoff to the lender is proportional to the borrower's cash flow only in the case of default).

So far, I have assumed only that $W < I$. In the following, denote by F^{max} either F_{extra}^{max} or F_{intra}^{max}, depending on whether one considers debt or equity. One has to differentiate among three cases for values of W:

1. $F^{max} < I - W \Leftrightarrow W < I - F^{max}$
2. $I - X^L > W \geq I - F^{max}$
3. $I - W \leq X^L \Leftrightarrow W \geq I - X^L$.

Case 1 implies no investment, and any contract is feasible in Case 3. Hence, one is left with Case 2. From this, one knows that $R^L = X^L$, because raised funds will not be sufficient otherwise. I also impose the following technical assumption to yield a real solution:

A1 $\frac{(\Delta X)^2}{c} \geq \max\left\{4(I - W - X^L), X^L\right\} \Rightarrow \left(\Delta X - \frac{X^L c}{\Delta X}\right)^2 \geq 4c\left(I - W - X^L\right)$

I now present the borrower's optimal contract in Proposition 1, with the corresponding proof in the Appendix.

Proposition 1 *Under A1, if the borrower and the lender are risk neutral, the borrower prefers debt to equity. The corresponding debt contract is given by*
$K = \frac{1}{2}\left(pX^H + X^L\right) - \frac{1}{2}\sqrt{(\Delta X)^2 - 4c\left(I - W - X^L\right)}$.

Given the borrower's risk neutrality and the assumption that human capital has a higher expected return than foraging-farming, the borrower's utility is increasing in the portfolio weight on human capital. Thus, the optimality of debt implies $e_e^* < e_d^*$.

4.2.3 Risk Neutral Borrower and Risk Averse Lender

For the case of risk aversion on the part of the lender, I impose an additional assumption on the nature of the cash flows:

A2 $2X^L > \Delta X$

This assumption should not be of concern, as it imposes a generous upper bound on the spread in expected payoffs between human capital and foraging-farming. As I have discussed in Section 2.1.2, the data suggest that $X^H - X^L \approx X^L$, which is, even without discounting X^H by p, clearly less than $2X^L$. With A2, the following proposition can be understood as a corollary of Proposition 1 (again, the proof is in the Appendix).

Proposition 2 *Under A1 and A2, if the borrower is risk neutral, he prefers debt to equity (irrespective of the lender's risk preferences).*

As in the previous case, the optimality of debt implies $e_e^* < e_d^*$. Finding conditions under which a borrower's preference for debt is independent of the lender's type (as defined by his risk preferences) is useful insofar as one can more easily test the proposition in the data without controlling for the lender's risk preferences. To this end, I next present an analogous result for the case of the risk averse borrower.

4.3 Risk Averse Borrower

Debt and equity contracts have different features that are appreciated by different borrower types: while debt provides full upside potential for the borrower, equity allows him to give up some of the upside in order to gain partial downside protection. Given that the way cash flows are shared among borrowers and lenders distinguishes debt from equity, risk preferences are a likely (but not necessarily the unique) determinant of the demand for such contracts. To make the equity/insurance contract desirable for all villagers, I shall henceforth assume that they are equally risk averse, irrespective of their group affiliation, and seek insurance against idiosyncratic shocks associated with their human capital and foraging-farming investments.

In the following, I analyze the case of the risk averse borrower in a similar fashion as the previous one. For purely algebraic reasons, I assume that the borrower has a simple CARA utility function $U(x) = -\exp(-x)$, alongside a linear cost function.

4.3.1 First Best (No External Funds Required)

The borrower solves the following problem:

$$\max_{e} \left\{ \begin{array}{c} -p\exp\left(-\left(W + eX^H + (1-e)X^L - ce - I\right)\right) \\ -(1-p)\exp\left(-\left(W + (1-e)X^L - ce - I\right)\right) \end{array} \right\}$$

$$\Rightarrow e^*_{fb} = \frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-c}{X^L+c}\right)}{X^H} \tag{9}$$

where $\Delta\widetilde{X} \equiv X^H - X^L$.

As in the case of the risk neutral borrower, the equilibrium portfolio weight on human capital increases in the probability of success p, and decreases in the payoff to foraging-farming X^L and the marginal cost of investing in human capital c.

4.3.2 Risk Averse Borrower and Risk Neutral Lender

I present the borrower's problem separately for debt and equity. Note that I have already inserted $pe^lR^H + (1-e^l)R^L = (1-\delta)pe^lX^H + (1-\delta)(1-e^l)X^L = I - W$, and that $X^L = R^L$, as seen in the previous analysis.

Extra-village debt

$$\max_{e} \left\{ \begin{array}{c} -p\exp\left(-\left(e\left(X^H - R^H\right) + (1-e)\left(X^L - R^L\right) - ce\right)\right) \\ -(1-p)\exp\left(-\left((1-e)\left(X^L - R^L\right) - ce\right)\right) \end{array} \right\}$$

$$\Rightarrow e^*_d = \frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}} \tag{10}$$

where $\Delta\widetilde{X} \equiv X^H - X^L$, $\Delta\widetilde{R} \equiv R^H - R^L$, and $\Delta\widetilde{X} - \Delta\widetilde{R} = X^H - R^H$ because $X^L = R^L$.

Intra-village equity

$$\max_{e} \left\{ \begin{array}{c} -p\exp\left(-\left(\delta e X^H + \delta(1-e)X^L - ce\right)\right) \\ -(1-p)\exp\left(-\left(\delta(1-e)X^L - ce\right)\right) \end{array} \right\}$$

$$\Rightarrow e_e^* = \frac{\ln\left(\frac{p}{1-p}\frac{\delta\Delta\widetilde{X}-c}{\delta X^L+c}\right)}{\delta X^H} \tag{11}$$

where $\Delta\widetilde{X} \equiv X^H - X^L$.

The risk neutral lender has rational expectations and breaks even, i.e., $pe_d^* R^H + (1-e_d^*)R^L = (1-\delta)pe_e^* X^H + (1-\delta)(1-e_e^*)X^L = I - W$.

As in Proposition 2, I impose assumptions on the cash flow structure:

A3 $c > p\left(pX^H - X^L\right)\frac{I-W-X^L+1}{I-W-X^L}$

A4 $c > -\frac{\left(pX^H-X^L\right)X^L}{2pX^H} + \sqrt{\left(\frac{(pX^H-X^L)X^L}{2pX^H}\right)^2 + X^L\Delta\widetilde{X}}$

I now state Proposition 3, the proof of which can be found in the Appendix.

Proposition 3 *Under A3 and A4, if the borrower is risk averse and the lender is risk neutral, the borrower prefers equity to debt.*

The proof shows that, due to the borrower's assumed lower ability (A3 and A4), the optimality of equity implies $e_d^* < e_e^*$. A3 and A4 reflect the idea that the least capable borrowers derive greater disutility from receiving debt instead of equity/insurance than more capable ones, who behave more like risk neutral borrowers, would. The proof also implies that there exists some $\overline{c} \leq \min\left\{p\left(pX^H - X^L\right)\frac{I-W-X^L+1}{I-W-X^L}, -\frac{\left(pX^H-X^L\right)X^L}{2pX^H} + \sqrt{\left(\frac{(pX^H-X^L)X^L}{2pX^H}\right)^2 + X^L\Delta\widetilde{X}}\right\}$ such that for all $c < \overline{c}$, one has $e_e^* < e_d^*$, while the borrower still prefers equity to debt. That is, while equity is optimal for a wide range of risk averse borrowers, the most capable ones will be disincentivized to invest in human capital (the riskier asset in the economy) by the insurance cushion, whereas the opposite holds for the least capable ones.

4.3.3 Borrower and Lender are Risk Averse

Now the lender is also risk averse. Similarly to the relationship between Propositions 1 and 2, Proposition 4 can be understood as a corollary of Proposition 3 (with the proof in the Appendix).

Proposition 4 *Under A3 and A4, if the borrower is risk averse, he prefers equity to debt (irrespective of the lender's risk preferences).*

Again, the optimality of equity means that $e_d^* < e_e^*$ for borrowers with assumed lower ability, and the proof of Proposition 4 implies that there exists an upper bound on c such that the opposite holds for borrowers of higher ability, with $c < \overline{c}$ as above, while both types prefer equity to debt.

Overall, I have shown that while the borrower's risk aversion induces a preference for equity, more capable types invest less in human capital under the latter contract due to the insurance cushion, and less capable types are also disincentivized to invest in human capital under the debt contract because of the lack of downside insurance, which would be required to compensate less capable borrowers for their high cost of entering the risky human capital investment. Empirically, given the contract allocation in Table 4, one would expect the average impact of equity on human capital investment to be more negative (because the most capable members of the large group receive the contract) than that of debt. While this relationship has already been reflected in Tables 6a and 6b, I now show that it also holds when testing the model's implications for human capital investment.

5 Empirical Evidence of the Relationship between Financing Contracts and Human Capital Investment

Section 2.3 presents two key facts about the differences between the large and the small group: the large group is more invested in foraging-farming and less invested in human capital, and yields a lower average income than the small group. Furthermore, the large group showcases a lower degree of connectedness with outsiders.

The differences between the groups' investment profiles could readily be reconciled with their different attitudes towards outsiders. However, there exists an alternative explanation for investment differences between the two groups. In order to invest in foraging-farming and schooling, many villagers borrow money from external resources. As seen in Section 3.1, the type of financing contract offered depends on the relationship between borrowers and lenders, such that insurance in the form of equity-like financing, as an alternative to more standard debt contracts, is available inside but not outside the villages. Due to the limited availability of equity/insurance, the most capable members of the large group participating in the cross-cousin marriage norm are given priority, and less capable members of the large group thus have to attain debt from outside their villages. This capital allocation leads to lower human capital investment by the large group, because the most capable members invest less time in human capital formation than they could (because of the insurance cushion) and the least capable ones are discouraged by the lack of insurance. In this section, I scrutinize whether these consequences of the observed contract allocation can explain the earnings gap.

5.1 Testing the General Model for Human Capital Investment

I first test the general model for the equilibrium portfolio weight on human capital investment (see e^* in equations 5 and 7 for the risk neutral case, and equations 10 and 11 for the risk averse case), not yet accounting for the financing-contract form as approximated by the source of financing. In particular, I make two assumptions about the information structure in the borrower-lender relationship. First, monitoring rights with respect to the borrower's cash-flow realizations matter insofar as the payoff structure for the lender is more information-sensitive under an equity contract than under debt. The immediate consequence is that $F_{intra}^{max} < F_{extra}^{max}$, and, indeed, the mean yearly loan amount in the data, conditional on being non-zero, is 104.67 bolivianos (with a standard deviation of 336.32) under extra-village debt, compared to 46.61 (with a standard deviation of 62.95) under intra-village equity (the difference is significant at the 1% level).

Second, and most importantly, the only reason why the equilibrium portfolio weight e^* varies with the type of financing is the moral hazard involved in raising funds.

I now test the model prediction for the equilibrium portfolio weight on human capital.

As demonstrated in Section 4, the equilibrium portfolio weight on human capital increases in the probability of success p, and decreases in the payoff to foraging-farming X^L as well as the marginal cost of human capital investment c. Under the assumption that more time investment in human capital leads to improved human capital outcomes, I define the dependent variable *Marginal human capital investment*$_{it} \in \{0, 1\}$ as an indicator of whether villager i's Spanish speaking and/or reading skills improved since $t-1$. As a proxy for p, I use a dummy variable that indicates whether any people left i's village between $t-1$ and t to move to San Borja, which is a sufficient indicator for their having found a job, potentially inducing fellow villagers to update their beliefs about such opportunities. Furthermore, I approximate the inverse of the payoff to foraging-farming $1/X^L$ by the inverse of the village selling price of a one-year-old pig, a frequently traded commodity. Last, I use the ratio of villager i's math-test score to years of education in $t-1$, *Ability*$_{i,t-1}$, as a proxy for i's learning productivity and, thus, for the inverse of c. Note that I choose the lagged value to avoid simultaneity with *Marginal human capital investment*$_{it}$.[13] In all regressions, I also control for the log change of i's traditional assets and for whether i is currently in school.

[Insert Table 7a about here]

[Insert Table 7b about here]

In the first two columns of Tables 7a and 7b, one can see that all three variables generally have the predicted positive sign. Next, I include changes in borrowed funds by defining Δ*Leverage ratio*$_{it}$ as the log change of i's net total loans over bi-weekly earnings from the sale of goods, wage labor, and barter. I weight changes in borrowed funds by changes in income in order to account for expected repayment ability, which explains the drop in the number of observations in the last two columns of Tables 7a and 7b. If funds need to be raised, the marginal benefit of investing in human capital drops, and so do the positive sensitivities to p, $1/X^L$, and $1/c$. Thus, second-best investment in human capital implies that, in the presence of leverage, the positive impact of the regressors in the first two columns is, on average,

[13] On a more general note, one might worry that serial correlation emerges in a setup that involves lagged variables on the right-hand side that might partially be a function of the dependent variable. However, the Baltagi-Wu locally best invariant (LBI) test statistic is greater than two in all specifications of this paper involving lagged variables, implying that, if anything, standard errors are likely to be overestimated.

reduced, i.e., the respective interaction effects with Δ*Leverage ratio*$_{it}$ should be negative. Indeed, in the last two columns, the signs are negative (and almost always significant).

5.2 Allocation of Contracts and its Impact on Human Capital Investment

Having empirically verified the basic features of the model in Section 4, I finally test the impact of financing-contract choice on human capital investment. As stated in Section 4, given that the most capable members of the large group are more likely to attain the equity contract than their counterparts in the small group, the average impact of equity on human capital investment should be more negative than that of debt.

To test this conjecture, I refine the specification used in Table 7a, with *Marginal human capital investment*$_{it}$ as the dependent variable, by including the amounts of funds borrowed in equity and debt:[14] *Funds borrowed from villager*$_{it}$ and *Funds borrowed from outside*$_{it}$ (as defined in Tables 6a and 6b). These two variables span the (three-dimensional) state space for potential borrowers: if both variables are zero, i is in the first-best case where no funds are required, and he is in either the equity or the debt case if the respective variable is non-zero.

[Insert Table 8 about here]

In Table 8, I augment the specification of Table 7a additionally by *Member of large group*$_i$, and include different sets of fixed effects per column. The estimates are in line with the findings in Tables 6a and 6b: villagers receiving equity invest significantly less in human capital than those using debt. This lends support to the model's implications, as one knows from Table 4 that the most capable members of the large group are more likely to receive equity, so the average impact of the latter on human capital investment primarily captures the disincentive effect due to insurance cushion. It is furthermore noteworthy that the intercept effect *Member of large group*$_i$ is insignificant throughout all estimations in Table 8, which demonstrates that the negative impact of equity is unlikely to be driven by other

[14] As seen in Tables 7a and 7b, the linear probability and probit models do not yield qualitatively different results. Thus, I use linear specifications in the remaining analysis.

characteristics of the large-group members that keep them from investing in human capital (e.g., their more conservative attitude towards the economy evolving around them).

The findings so far provide evidence that the limited availability of equity affects human capital investment as follows. Equity is attained predominantly by individuals that have stronger ties with their fellow villagers, i.e., members of the large group practicing cross-cousin marriage, and that exhibit higher ex-ante ability. This capital allocation, however, leads to lower investment in human capital (studying Spanish) by the large group: the insurance cushion discourages the most capable villagers practicing cross-cousin marriage from exerting effort, and so does the lack of downside insurance in debt arrangements taken up by the least capable members of the group.

5.3 Alternative Explanations

I next discuss two major alternative explanations for the observed human capital and income patterns. First, it might be that human capital investments are discouraged particularly in villages with a higher concentration of foraging-farming income, differentially affecting the two groups. Second, if risk aversion is a function of wealth, so will be contract choice. This would, in turn, explain differences in contract choice and human capital investment between the two groups as a consequence of wealth differences (but *not* vice versa).

Intra-village income inequality and discouragement of human capital accumulation A plausible alternative explanation for the underlying differences in human capital accumulation between the two groups would be that the large group, as the more inward-looking and village-oriented group, is more easily discouraged when it comes to human capital investments that open doors to migration. Individuals that would be particularly interested in discouraging fellow villagers from studying Spanish (and eventually leaving the village) are likely to be heavily invested in foraging-farming, because they are more dependent on the participants and resources of the village's informal labor market. Galor, Moav, and Vollrath (2009) argue in a similar fashion, and present evidence that the concentration of land ownership slowed down the emergence of human-capital-promoting institutions in the U.S. during the high school movement in the early 20^{th} century.

[Insert Figure 1 about here]

Given that the Tsimane' practice slash-and-burn agriculture, I use the village-level concentration of income from the sale of goods (à la Herfindahl-Hirschman Index) as a measure of foraging-farming income inequality. Figure 1 shows the simple scatter plots of the differences in average wage labor income and in average spoken Spanish fluency between the small and the large group (in the total and the calibration sample) as a function of the average sales-income concentration in 11 villages.[15] Indeed, villages with higher sales-income concentrations are associated with larger wage and human capital gaps (more clearly so in the calibration sample, which is restricted to villagers who borrowed a non-zero amount in at least one year).

[Insert Table 9 about here]

While the descriptive evidence suggests that foraging-farming income inequality may affect group differences in returns to and investments in human capital, this does not rule out that the differences are actually driven by the contract allocation, as argued in this paper. To test this, I include the sales-income-concentration measure on the right-hand side of the specification in Table 4, which examines the determinants of the proportion of funds that are raised from fellow villagers. The results are in Table 9. The first column reveals that individuals in villages with higher sales-income concentrations end up borrowing relatively more funds from outsiders than from fellow villagers, which reflects the role of the limited supply of equity. The second and fourth columns decompose this effect, and demonstrate that it is due to the capable members of the small group, whereas the sum of the respective coefficients for the capable members of the large group (in the last two rows of the second and fourth columns) is not significantly different from zero. In line with this paper's argumentation, this implies that the human capital and income gaps can be derived as consequences of the contract allocation, because the most capable members of the large group receive equity relatively more often than their counterparts in the small group, especially in villages with high sales-income concentrations.

[15] Note that the small groups in Villages 8, 9, and 14 consist of fewer than two members, which is why the respective villages are dropped from the plots.

Decreasing absolute risk aversion This paper's main explanation for the income gap between the two groups is based on the relationship between contract choice and human capital investment, which is, however, subject to simultaneity. Most importantly, both groups could have the same risk preferences, as assumed before, but exhibit decreasing absolute risk aversion. Then, the large group would be more risk averse and choose equity alongside lower human capital investment[16] as a consequence of its lower income, rather than the other way around.

If, as suspected, risk averse villagers were to prefer intra-village equity rather than extra-village debt, then – under decreasing absolute risk aversion – one would expect an abnormally negative income shock to be associated with increased demand for funds from fellow villagers. As a quantitatively meaningful exogenous variation in income, I use a villager's flood-shock cost in excess of the average flood-shock cost in the village as an explanatory variable for the proportion of funds that are raised within the village. This specification is actually somewhat biased towards a positive coefficient, as a negative village-wide income shock hinders the issuance of equity, i.e., it constitutes a negative shock to the supply of funds in a village. However, the results in the third and fourth columns of Table 9 reveal a non-positive impact of the negative income shock, which runs counter to the idea of decreasing absolute risk aversion. Lastly, note that group-specific learning productivity generally remains an important determinant of financing-contract choice (cf. first and third columns).[17]

6 A Counterfactual Analysis of Human Capital Investment and Imperfect Capital Markets

In this section, I explore the aggregate-growth implications of the observed capital allocation, calibrate the loss in terms of human capital investment for the large group, and evaluate its explanatory power for the human capital and income gaps between the two groups.

[16] As can be seen by comparing (5) to (10) and (7) to (11) in Section 4, a risk averse borrower invests less in human capital than in the case of risk neutrality, and even more likely so the higher his degree of risk aversion.

[17] The decrease in significance in the third column of Table 9 is partly due to the drop in the number of observations resulting from the unavailability of flood-shock-cost data for all years.

In the actual state of the economy, all villagers are assumed to be equally risk averse, generating general demand for equity contracts, which are used to finance human capital investments. Given the observed contract allocation, which results from the capital market imperfection that equity can be written only within villages, the large (inward-looking) group invests less in human capital. This is because its most capable members receive equity, which disincentivizes them to invest in human capital (the riskier asset in the economy), whereas the least capable members have to enter into debt contracts with lenders outside their villages, leading them to also invest less in human capital than they would want to.

To quantify the loss in terms of human capital investment, I compare the status quo to a counterfactual scenario which speaks to the two sources of the loss, namely underfunding with equity/insurance and the allocation of the latter contract to the most capable rather than the least capable members of the large group. In order to compute a counterfactual (average) human capital portfolio weight, I calibrate the equilibrium portfolio weights on human capital investment e^* from the model in Section 4 for the debtors in the large group.

6.1 Procedure and Parameters

As seen in Section 4, the equilibrium portfolio weight on human capital investment is a function of the borrower's and the lender's risk preferences and the contract type. I shall assume that all borrowers are equally risk averse and the lenders are risk neutral (as the latter can theoretically diversify risk away by lending to multiple borrowers), although the results also go through qualitatively if the lenders are assumed to be risk averse (cf. Section 4.3.3).

The data comprise the subset of all villagers in the large group ($N = 364$) who borrowed money in any given year (see Table 2b for the descriptive statistics). In the actual state of the economy, borrowers can either receive equity from fellow villagers or debt from outside lenders. Denote the respective human capital portfolio weights by e^{actual}_{equity} and e^{actual}_{debt}, where a risk averse villager is assigned to the type of lender (i.e., contract) from whom he receives the majority of his funds in the data. The empirical fact that, according to this assignment, only one quarter of the large group receives equity from fellow villagers attests to the idea that the limited availability of equity/insurance is binding. The two human capital portfolio

weights are averages for the respective matches, and calibrated as follows. First, I calibrate the portfolio weights for two types of utility specifications, CARA and CRRA utility. Then, based on bi-weekly data, one has $X^H \approx 2X^L$, and – as stated in Section 2.1.2 – the likelihood of zero income turns out to be 16% lower for foraging-farming than for wages upon schooling, so one can interpret p to be at most 0.84. To be somewhat conservative, I use $p = 0.8$.

Furthermore, I assume the marginal cost of investing in human capital to be heterogenous:[18]

$$c_i = \alpha - \beta Ability_i \tag{12}$$

where $Ability_i$ is the time average of $Ability_{it}$, the ratio of i's math score to years of schooling.

[Insert Table 10 about here]

Also, as seen in Section 4, I assume that $I - W > X^L$. Based on these assumptions, I calibrate the parameters such that the equilibrium portfolio weights on human capital are between zero and one. Table 10 lists all baseline parameters.

Finally, the average investment in human capital in the actual state equals the weighted average of the two human capital portfolio weights, which are averages across equity and debt recipients, respectively:

$$e = \theta_{equity} e^{actual}_{equity} + \theta_{debt} e^{actual}_{debt} \tag{13}$$

where n_{equity} and n_{debt} denote the number of individuals receiving the majority of their funds from fellow villagers and outsiders, respectively, $\theta_{equity} = \frac{n_{equity}}{n_{equity}+n_{debt}}$, and $\theta_{debt} = 1 - \theta_{equity}$.

In the counterfactual scenario, I invert the contract availability, i.e., I replace all debt contracts by equity contracts and vice versa, and allocate the debt contracts, which are now less numerous, to the most capable villagers first. Hence, the counterfactual average investment in human capital is equal to:

$$\widetilde{e} = \frac{1}{n_{equity}+n_{debt}} \left(\sum_{j=1}^{n_{equity}} e^{(j)}_{debt} + \sum_{j=n_{equity}+1}^{n_{equity}+n_{debt}} e^{(j)}_{equity} \right) \tag{14}$$

[18] For sheer computational reasons, I use a linear cost function ce (as in the model in Section 4.3), rather than a quadratic cost function, for the CARA utility specification.

where j denotes the j^{th}-highest ranked individual in the large group by $Ability_i$.

Based on (13) and (14), one can compute a counterfactual human capital investment rate $\widetilde{e}$ and the corresponding difference $\widetilde{e}-e$, which is the increase in the villagers' efforts towards schooling rather than towards foraging-farming. In summary, given a utility specification (either CARA or CRRA), I will present the results for the calibrated human capital increase $\widetilde{e}-e$ with varying β, the sensitivity of the marginal cost of human capital investment to $Ability_i$ in (12). I now turn to the results and a discussion of the role of the observed capital allocation in explaining the earnings gap between the two groups.

[Insert Figure 2 about here]

6.2 Discussion of Results

Figure 2 displays the counterfactual increase in human capital investment $\widetilde{e}-e$ for different values of β. The results for CARA and CRRA utility are presented in the top and bottom panel, respectively. In the case of CARA utility, the results are robust to variations in β: the counterfactual increase in human capital investment is roughly 0.22 to 0.23. The results with CRRA utility are somewhat more volatile, and range from 0.10 to 0.16.

From this, one can infer the explanatory power of an imperfect capital market for the earnings gap between the two groups, as given in Table 2b. The gap in bi-weekly income is approximately 30 bolivianos. The spread in expected payoffs between human capital and foraging-farming, pX^H-X^L, measured on a bi-weekly basis, is 60 bolivianos ($0.8\times200-100$). Therefore, in order to explain the entire earnings gap through lower investment in human capital, $\widetilde{e}-e$ would have to be equal to $\frac{30}{60}=0.5$. The calibration results imply that the loss in terms of investment in human capital is sizable and can explain a substantial portion of the actual earnings gap in the data. In the case of CRRA utility, that portion amounts to 20 to 32% of the earnings gap between the two groups, and exceeds 45% for CARA utility.

7 Concluding Remarks

This paper analyzes a very simple economy in Amazonian Bolivia, and attempts to characterize the relationship between village networks and investment decisions. This economy

features an exogenous network boundary that is based on mating norms and splits each village into two groups: one that practices cross-cousin marriage and deems any deviation from that norm unacceptable, and one that is more open towards outsiders. Villagers who are not fully invested in foraging-farming can attend school to study Spanish and find employment. In order to finance these investments, funds are raised from fellow villagers and from lenders outside the villages. While the standard contract can be characterized as debt, insurance in the form of equity – i.e., loans for which the repayment is proportional to the debtor's income – is available only within villages. I have shown that this financial friction affects the majority of villagers, who consequently invest less in human capital, and thus has the potential to explain a substantial portion of the income heterogeneity between the two groups.

The link between consanguinity and access to finance bears intriguing implications for future developments in the Tsimane' society. If insurance is indeed a major benefit from participating in the traditional system of cross-cousin marriage, then one would anticipate its relative value to deteriorate in the course of the gradual market integration of the Tsimane'. This would, in turn, contribute to a decline in consanguinity in a way that is potentially generalizable to (the history of) other small-scale societies.

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Appendix

Tables

Table 1: Proportion of Households Practicing Cross-Cousin Marriage

Village	Average proportion from 2002-2006	# of households
Village 1	0.351	111
Village 2	0.538	132
Village 3	0.667	78
Village 4	0.433	60
Village 5	0.682	107
Village 6	0.913	46
Village 7	0.865	37
Village 8	0.980	51
Village 9	0.973	73
Village 10	0.918	122
Village 11	0.737	38
Village 12	0.837	123
Village 13	0.724	98
Village 14 (only 2005-2006)	0.917	12
All villages	0.718	1,088

Notes: A household is defined as practicing cross-cousin marriage if more than half of the household members report that marrying anyone but a cross cousin is unacceptable. Most households unanimously agree on mating norms.
Given the size of the group of villagers practicing cross-cousin marriage, I label it as the "large group" (and the remaining group as the "small group").

Table 2a: Descriptive Statistics (Total Sample)

Variable	Small group		Large group		
	Mean [Std. dev.]	N	Mean [Std. dev.]	N	p-value
Income (in bolivianos in two weeks)	152.94 [595.02]	212	91.79 [117.75]	600	0.017
Income (no barter, in bolivianos in two weeks)	144.33 [594.43]	212	84.23 [114.72]	600	0.019
Wage labor income (in bolivianos in two weeks)	58.55 [104.08]	212	44.62 [89.02]	600	0.061
Bi-weekly wage per hour (productivity under wage labor)	28.82 [22.19]	93	26.14 [7.77]	245	0.100
Consumption (in bolivianos in a week)	161.86 [79.39]	75	165.38 [95.70]	192	0.778
Total assets (in bolivianos)	3165.83 [2012.26]	75	3058.42 [1944.45]	192	0.688
Traditional assets (in bolivianos)	623.17 [377.55]	75	745.30 [426.00]	192	0.031
Credit (in bolivianos in a week)	5.07 [18.33]	212	3.64 [15.51]	600	0.272
Currently in school	0.31 [0.40]	458	0.29 [0.38]	1,268	0.214
Years of schooling (latest available)	1.81 [2.18]	381	1.64 [2.02]	963	0.180
Math score $(0-4)$	0.84 [1.27]	385	0.77 [1.21]	1,045	0.311
Math score / Years of schooling	0.29 [0.53]	386	0.26 [0.41]	1,046	0.226
Spanish reading $(0-2)$	0.42 [0.72]	385	0.41 [0.71]	1,045	0.652
Spanish speaking $(0-2)$	0.75 [0.78]	388	0.59 [0.70]	1,047	0.000
Household size	6.03 [2.73]	76	6.14 [2.73]	193	0.764

Notes (Tables 2a and 2b): All means and standard deviations are calculated based on averages of individuals (and averages of households for consumption, assets, and household size). The third column indicates the p-value of a two-sided difference-in-means test where */**/*** denote significance at the 10%/5%/1% level, respectively.

Table 2b: Descriptive Statistics (Calibration Sample)

Variable	Small group		Large group		
	Mean [Std. dev.]	N	Mean [Std. dev.]	N	p-value
Income (in bolivianos in two weeks)	145.46 [171.41]	115	115.70 [130.65]	363	0.050
Income (no barter, in bolivianos in two weeks)	136.32 [167.27]	115	105.57 [127.65]	363	0.038
Wage labor income (in bolivianos in two weeks)	79.65 [120.84]	115	57.78 [101.37]	363	0.055
Bi-weekly wage per hour (productivity under wage labor)	30.24 [24.38]	65	26.91 [7.54]	181	0.103
Consumption (in bolivianos in a week)	168.25 [73.71]	66	164.14 [95.96]	177	0.753
Total assets (in bolivianos)	3088.94 [1981.11]	66	3074.35 [1937.24]	178	0.956
Traditional assets (in bolivianos)	631.35 [386.75]	66	740.36 [424.74]	178	0.070
Credit (in bolivianos in a week)	9.15 [24.15]	115	6.00 [19.59]	363	0.157
Currently in school	0.20 [0.30]	114	0.20 [0.32]	361	0.949
Years of schooling (latest available)	2.42 [2.82]	121	2.24 [2.54]	331	0.506
Math score $(0-4)$	1.29 [1.50]	115	1.15 [1.47]	362	0.364
Math score / Years of schooling	0.36 [0.50]	115	0.34 [0.43]	363	0.678
Spanish reading $(0-2)$	0.74 [0.86]	115	0.65 [0.85]	362	0.335
Spanish speaking $(0-2)$	1.17 [0.75]	115	1.00 [0.74]	362	0.031
Household size	6.17 [2.63]	68	6.29 [2.75]	178	0.756

Table 3a: Repayment Increases with Borrower's Income Only in Villages
(Equity in Villages, Debt Outside)

	Dependent variable: $\max\{0, -\Delta Total\ loans_{it}\}$		
Borrowed from villager$_{i,t-1}$	2.741		10.279
	[25.95]		[25.64]
Borrowed from outside$_{i,t-1}$		38.710**	46.509***
		[15.50]	[12.10]
Gross income$_{i,t-1}$	0.032	0.008	-0.014
	[0.04]	[0.02]	[0.02]
Borrowed from villager$_{i,t-1}$	0.383**		0.348**
$\times$ *Gross income*$_{i,t-1}$	[0.17]		[0.17]
Borrowed from outside$_{i,t-1}$		0.159	0.084
$\times$ *Gross income*$_{i,t-1}$		[0.11]	[0.07]
Fixed effects	Individual	Individual	Individual
# of observations	1,552	1,552	1,552
# of individuals	662	662	662

Notes (Tables 3a and 3b): */**/*** denote significance at the 10%/5%/1% level, respectively. In the (individual) fixed-effects regressions, standard errors are clustered at the household level. Controls for the following idiosyncratic shocks at time t are included: animal loss, crop loss, family death, fire, flood, health, theft, divorce, and "other." *Borrowed from villager*$_{it}$ and *Borrowed from outside*$_{it}$ are indicator variables for whether i borrowed any money from inside or outside the Tsimane' community during the 54 weeks before year t. *Gross income*$_{it}$ is equal to earnings from the sale of goods, wage labor, and barter over the last two weeks in year t, plus the average consumption expenditure per household member for lard, oil, flour, bread, noodles, and sugar (in bolivianos) in the last two weeks of year t.

Table 3b: Repayment Increases with Borrower's Income Only in Villages
(Equity in Villages, Debt Outside)

	Dependent variable: $\max\{0, -\Delta Total\ loans_{it}\}$		
Borrowed from villager before$_{i,t-1}$	13.136		12.929
	[28.74]		[28.20]
Borrowed from outside before$_{i,t-1}$		27.377**	29.714***
		[12.71]	[10.14]
Gross income$_{i,t-1}$	0.030	0.014	-0.029
	[0.05]	[0.03]	[0.03]
Borrowed from villager before$_{i,t-1}$	0.328**		0.319*
$\times$ *Gross income*$_{i,t-1}$	[0.17]		[0.17]
Borrowed from outside before$_{i,t-1}$		0.113	0.073
$\times$ *Gross income*$_{i,t-1}$		[0.09]	[0.05]
Fixed effects	Individual	Individual	Individual
# of observations	1,552	1,552	1,552
# of individuals	662	662	662

Notes: *Borrowed from villager before*$_{i,t-1}$ and *Borrowed from outside before*$_{i,t-1}$ are indicator variables for whether i borrowed any money from inside or outside the Tsimane' community during the 108 weeks before year t. Or, put differently: $x_{it} \equiv$ *Borrowed from* y *before*$_{it}$, $y \in \{villager, outside\}$, is given by $x_{it} = \max\{x_{ij}\}_{j \geq t-1}$.

Table 4: Determinants of Financing Portfolio

	Dependent variable: *Proportion funds borrowed from villager*$_{it}$			
Member of large group$_i$	0.148**	0.159***	0.200***	0.220***
$\times$ *Ability*$_{i,t-1}$	[0.06]	[0.06]	[0.07]	[0.07]
Member of large group$_i$	0.001	-0.002		
	[0.06]	[0.06]		
Ability$_{i,t-1}$	-0.095**	-0.081**	-0.045	-0.055
	[0.04]	[0.04]	[0.05]	[0.05]
Other controls	No	Yes	No	Yes
Fixed effects	Village	Village	Individual, village-year	Individual, village-year
# of observations	808	795	808	795
# of individuals	419	415	419	415

Notes: */**/*** denote significance at the 10%/5%/1% level, respectively. *Proportion funds borrowed from villager*$_{it} \in [0, 1]$ denotes, conditional on receiving a non-zero amount of credit, the proportion of funds held in intra-village equity by i during the 54 weeks before year t. Standard errors are clustered at the household level, and, whenever applicable, other controls include an indicator for being household head, gender, household size, wealth in traditional assets, and total loans (in bolivianos) in year t.

Table 5a: Perfect Risk Sharing in the Large Group

	Dependent variable: $\Delta \ln \overline{c}_{it}$		Dependent variable: $\Delta \ln \overline{c}_{it} - \Delta \ln \overline{c}_{vt}$	
$\Delta \ln \overline{c}_{vt}$	0.702***	0.850***		
	[0.19]	[0.12]		
$\Delta \ln Income_{it}$	0.104**	-0.016	0.130**	-0.019
	[0.05]	[0.05]	[0.05]	[0.05]
# of negative idiosyncratic shocks	2	1	2	1
Sample	Small group	Large group	Small group	Large group
Fixed effects	Individual	Individual	Individual	Individual
# of observations	239	689	239	689
# of individuals	143	382	143	382

Notes (Tables 5a and 5b): */**/*** denote significance at the 10%/5%/1% level, respectively. In the (individual) fixed-effects regressions, standard errors are clustered at the household level. Controls for the following idiosyncratic shocks are included: animal loss, crop loss, family death, fire, flood, health, theft, divorce, and "other." An idiosyncratic shock is indicated as negative if it is at least significant at the 10% level. $\overline{c}_{it}$ and $\overline{c}_{vt}$ denote the weekly consumption of game, fish, eggs, maize, manioc, rice, oil, and bread (in bolivianos) per household member and at the average village level (excluding i), respectively. $Income_{it}$ is equal to earnings from the sale of goods, wage labor, and barter for one week.

Table 5b: Perfect Risk Sharing in the Large Group

	Dependent variable: $\Delta \ln \overline{c}_{it}$		Dependent variable: $\Delta \ln \overline{c}_{it} - \Delta \ln \overline{c}_{gt}$	
$\Delta \ln \overline{c}_{gt}$	0.584***	0.855***		
	[0.19]	[0.12]		
$\Delta \ln \overline{c}_{vt} - \Delta \ln \overline{c}_{gt}$	0.618**	0.716**	1.042***	0.817***
	[0.31]	[0.28]	[0.23]	[0.28]
$\Delta \ln Income_{it}$	0.116**	-0.016	0.152***	-0.018
	[0.06]	[0.05]	[0.05]	[0.05]
# of negative idiosyncratic shocks	3	1	2	1
Sample	Small group	Large group	Small group	Large group
Fixed effects	Individual	Individual	Individual	Individual
# of observations	228	683	228	683
# of individuals	137	379	137	379

Notes: $\overline{c}_{it}$, $\overline{c}_{vt}$, and $\overline{c}_{gt}$ denote the weekly consumption of game, fish, eggs, maize, manioc, rice, oil, and bread (in bolivianos) per household member, at the average village level (excluding i), and at the average group level (excluding i), respectively.

Table 6a: Financing and Entering Wage Labor

	Dependent variable: *Entered wage labor*$_{it}$			
Funds borrowed from villager$_{it}$	0.006	-0.043	-0.034	-0.039
	[0.05]	[0.04]	[0.04]	[0.04]
Funds borrowed from outside$_{it}$	0.007**	0.011***	0.013***	0.013***
	[0.00]	[0.00]	[0.00]	[0.00]
Spanish fluency$_{i,t-1}$		0.013	0.082*	0.090**
		[0.04]	[0.04]	[0.04]
Currently in school$_{it}$		0.105*	0.122	0.108
		[0.06]	[0.08]	[0.08]
Sample	Non-zero amount of credit in given year			
Other controls	No	No	No	Yes
Fixed effects	Individual	Individual	Individual, village-year	Individual, village-year
# of observations	1,169	830	830	819
# of individuals	529	439	439	435

Notes: */**/*** denote significance at the 10%/5%/1% level, respectively. *Entered wage labor*$_{it}$ is defined as an indicator for having earned more from wage labor than from the sale of goods in the last two weeks of year t. *Funds borrowed from villager*$_{it}$ and *Funds borrowed from outside*$_{it}$ denote the amount of funds (in 100 bolivianos) borrowed from inside and outside the Tsimane' community, respectively, during the 54 weeks before year t. Spanish fluency is measured as the total score $(0-4)$ for speaking and reading Spanish, and *Currently in school*$_{it}$ is an indicator variable. Standard errors are clustered at the household level, and, whenever applicable, other controls include i's math score $(0-4)$ in year $t-1$ and wealth in traditional assets (in bolivianos) in year t.

Table 6b: Financing and Days Working under Wage Labor

	Dependent variable: *Number of days of work*$_{it}$			
Funds borrowed from villager$_{it}$	-0.940	-3.163*	-4.997**	-5.074**
	[1.45]	[1.91]	[2.27]	[2.38]
Funds borrowed from outside$_{it}$	0.358***	0.182	0.126	0.133
	[0.11]	[0.15]	[0.17]	[0.18]
Spanish fluency$_{i,t-1}$		4.918*	4.952	4.746
		[2.79]	[3.37]	[3.41]
Currently in school$_{it}$		-1.168	-0.656	-0.070
		[2.18]	[2.79]	[2.68]
Sample	Non-zero amount of credit in given year, non-zero number of days of work			
Other controls	No	No	No	Yes
Fixed effects	Individual	Individual	Individual, village-year	Individual, village-year
# of observations	543	390	390	389
# of individuals	271	224	224	224

Notes: */**/*** denote significance at the 10%/5%/1% level, respectively. *Number of days of work*$_{it}$ is equal to the number of days worked under wage labor in the last two months of year t. *Funds borrowed from villager*$_{it}$ and *Funds borrowed from outside*$_{it}$ denote the amount of funds (in 100 bolivianos) borrowed from inside and outside the Tsimane' community, respectively, during the 54 weeks before year t. Spanish fluency is measured as the total score $(0-4)$ for speaking and reading Spanish, and *Currently in school*$_{it}$ is an indicator variable. Standard errors are clustered at the household level, and, whenever applicable, other controls include i's math score $(0-4)$ in year $t-1$ and wealth in traditional assets (in bolivianos) in year t.

Table 7a: Human Capital Outcomes and Changes in Leverage (LPM)

	Dependent variable: *Marginal human capital investment*$_{it}$			
Δ*Leverage ratio*$_{it}$			0.050**	0.060**
			[0.02]	[0.03]
Ability$_{i,t-1}$	0.035**	0.039*	0.019	0.006
	[0.01]	[0.02]	[0.02]	[0.04]
Proxy for p_{it}	0.167***	0.167***	0.241***	0.249***
	[0.02]	[0.02]	[0.03]	[0.04]
1/*Pig selling price*$_{it}$	3.607*	2.483	11.332***	11.776***
	[1.98]	[2.10]	[2.27]	[2.65]
Ability$_{i,t-1}$			-0.038**	-0.056**
$\times$ Δ*Leverage ratio*$_{it}$			[0.02]	[0.02]
Proxy for p_{it}			-0.047**	-0.060**
$\times\Delta$*Leverage ratio*$_{it}$			[0.02]	[0.03]
1/*Pig selling price*$_{it}$			-4.079*	-1.765
$\times$ Δ*Leverage ratio*$_{it}$			[2.31]	[2.72]
Δ*Traditional assets*$_{it}$	0.020*	0.018	0.026*	0.034*
	[0.01]	[0.01]	[0.01]	[0.02]
Currently in school$_{it}$	0.083***	0.036*	-0.008	-0.017
	[0.02]	[0.02]	[0.02]	[0.03]
Fixed effects	Village	Individual, village	Village	Individual, village
# of observations	3,417	3,417	1,159	1,159
# of individuals	1,153	1,153	556	556

Notes: */**/*** denote significance at the 10%/5%/1% level, respectively. *Marginal human capital investment*$_{it} \in \{0, 1\}$ indicates whether i's Spanish speaking and/or reading skills improved since $t-1$. In the linear-probability-model regressions, standard errors are clustered at the household level. Whenever applicable, regressions include controls for being household head, gender, household size, the number of teachers in i's village, alternative human capital measures (other training besides school), and both parents' Spanish speaking and reading skills. Δ*Leverage ratio*$_{it}$ denotes the log change of i's net total loans over bi-weekly earnings from the sale of goods, wage labor, and barter. *Ability*$_{i,t-1}$ denotes the ratio of i's score $(0-4)$ on last period's math test to years of education. The proxy for p is a dummy for whether any people left i's village to move to the next biggest town – a sufficient indicator for their having found a job – and *Pig selling price*$_{it}$ equals the village selling price of a one-year-old pig (in bolivianos) in the last three months of year t. Δ*Traditional assets*$_{it}$ denotes the log change of i's traditional assets, and *Currently in school*$_{it}$ is an indicator variable.

Table 7b: Human Capital Outcomes and Changes in Leverage (Probit)

	Dependent variable: *Marginal human capital investment*$_{it}$			
Δ*Leverage ratio*$_{it}$			0.022***	0.022***
			[0.01]	[0.01]
Ability$_{i,t-1}$	0.022**	0.022*	0.007	0.007
	[0.01]	[0.01]	[0.01]	[0.00]
Proxy for p_{it}	0.192***	0.192***	0.249***	0.249***
	[0.02]	[0.06]	[0.06]	[0.11]
1/*Pig selling price*$_{it}$	3.103*	3.103	5.429***	5.429**
	[1.72]	[3.95]	[1.95]	[2.38]
Ability$_{i,t-1}$			-0.017**	-0.017**
$\times$ Δ*Leverage ratio*$_{it}$			[0.01]	[0.01]
Proxy for p_{it}			-0.015***	-0.015**
$\times\Delta$*Leverage ratio*$_{it}$			[0.01]	[0.01]
1/*Pig selling price*$_{it}$			-1.172*	-1.172**
$\times$ Δ*Leverage ratio*$_{it}$			[0.75]	[0.60]
Δ*Traditional assets*$_{it}$	0.012	0.012	0.012*	0.012
	[0.01]	[0.02]	[0.01]	[0.01]
Currently in school$_{it}$	0.073***	0.073***	0.003	0.003
	[0.01]	[0.02]	[0.01]	[0.01]
Standard error clustering	Household level	Village level	Household level	Village level
Fixed effects	Village	Village	Village	Village
# of observations	3,416	3,416	1,159	1,159
# of individuals	1,153	1,153	556	556

Notes: */**/*** denote significance at the 10%/5%/1% level, respectively. The table reports marginal effects of pooled probit regressions that use the same variables as in Table 7a.

Table 8: Human Capital Outcomes and Contract Choice

	Dependent variable: *Marginal human capital investment*$_{it}$			
Funds borrowed from villager$_{it}$	-0.030***	-0.028**	-0.070**	-0.065**
	[0.01]	[0.01]	[0.03]	[0.03]
Funds borrowed from outside$_{it}$	-0.001	-0.002*	0.001	0.001
	[0.00]	[0.00]	[0.00]	[0.00]
Member of large group$_i$	-0.005	0.003		
	[0.02]	[0.02]		
Different impact of funds borrowed from villager/outside (p-value, two-sided test)	0.004	0.045	0.024	0.036
Fixed effects	No	Village	Individual	Individual, village
# of observations	1,108	1,108	1,108	1,108
# of individuals	527	527	527	527

Notes: */**/*** denote significance at the 10%/5%/1% level, respectively. *Marginal human capital investment*$_{it} \in \{0, 1\}$ indicates whether i's Spanish speaking and/or reading skills improved since $t-1$. *Funds borrowed from villager*$_{it}$ and *Funds borrowed from outside*$_{it}$ denote the amount of funds (in 100 bolivianos) borrowed from inside and outside the Tsimane' community, respectively, during the 54 weeks before year t. In the linear-probability-model regressions, standard errors are clustered at the household level, and regressions include all of the regressors from Tables 7a and 7b, besides *Member of large group*$_i$.

Table 9: Determinants of Financing Portfolio – Alternative Explanations

	Dependent variable: *Proportion funds borrowed from villager*$_{it}$			
Sales HHI$_{vt}$	-0.005**	-0.002		-0.004
	[0.00]	[0.00]		[0.00]
Flood-shock cost$_{ivt}$			-0.067	-0.063
			[0.04]	[0.04]
Member of large group$_i$	0.241***	0.118	0.189*	-0.048
× *Ability*$_{i,t-1}$	[0.07]	[0.09]	[0.10]	[0.14]
Ability$_{i,t-1}$	-0.069	0.123*	-0.055	0.178**
	[0.05]	[0.06]	[0.06]	[0.07]
Member of large group$_i$		0.008		0.017**
× *Ability*$_{i,t-1}$× *Sales HHI*$_{vt}$		[0.01]		[0.01]
Ability$_{i,t-1}$× *Sales HHI*$_{vt}$		-0.014**		-0.017***
		[0.01]		[0.01]
Other controls	Yes	Yes	Yes	Yes
Fixed effects	Individual, village-year	Individual, village-year	Individual, village-year	Individual, village-year
# of observations	795	795	564	564
# of individuals	415	415	343	343

Notes: */**/*** denote significance at the 10%/5%/1% level, respectively. *Proportion funds borrowed from villager*$_{it} \in [0, 1]$ denotes, conditional on receiving a non-zero amount of credit, the proportion of funds held in intra-village equity by i during the 54 weeks before year t. *Sales HHI*$_{vt} \in [0, 100]$ is defined as $\sum_i \left(10 \frac{Sales_{ivt}}{\sum_i Sales_{ivt}}\right)^2$ where $Sales_{ivt}$ denotes i's income from the sale of goods in village v in year t, and *Flood-shock cost*$_{ivt}$ is equal to the difference between villager i's flood-shock cost and the average flood-shock cost in village v (excluding i) in year t. Standard errors are clustered at the household level, and other controls include an indicator for being household head, gender, household size, wealth in traditional assets, and total loans (in bolivianos) in year t.

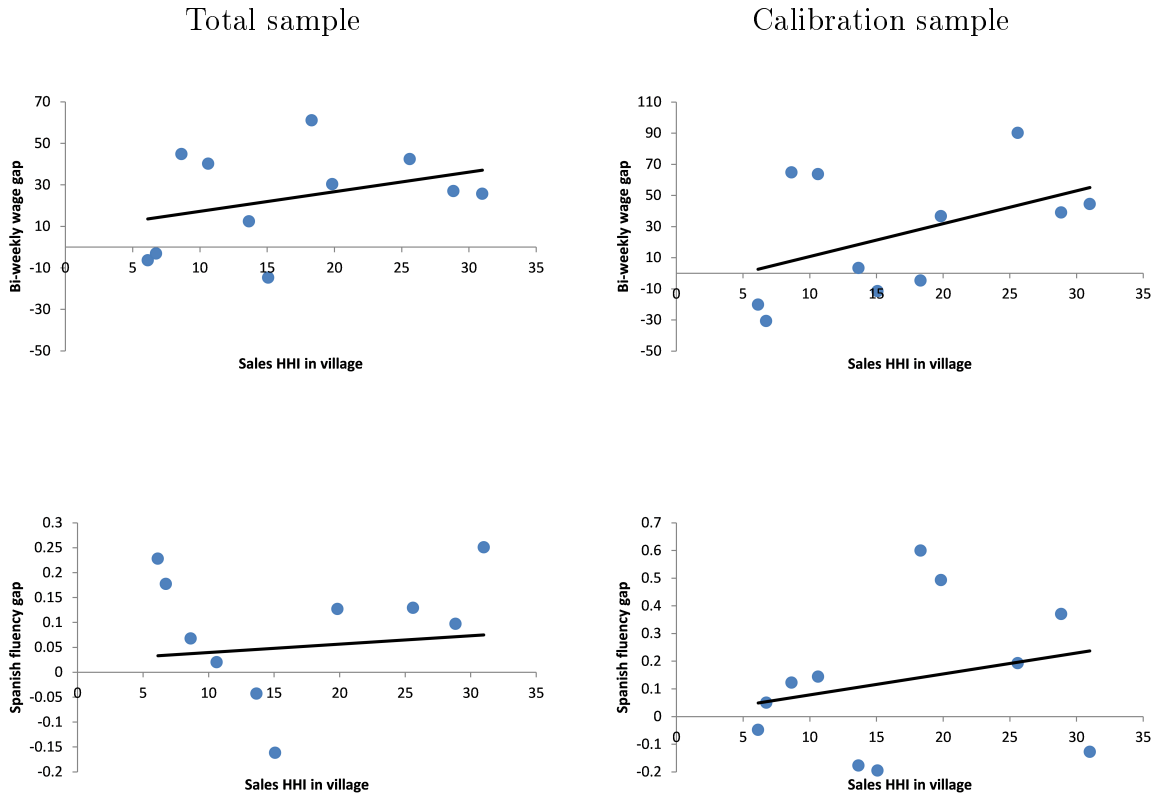
Table 10: Baseline Parameter Values

	CARA	CRRA
X^H	600	900
X^L	300	450
p	0.8	0.8
c_i	$\alpha - \beta Ability_i$	$\alpha - \beta Ability_i$
Cost function	linear	quadratic
α	200	298
β	6.2 to 17.7 in steps of 0.5	6.2 to 17.7 in steps of 0.5
$I - W$	318	477
n_{equity}	89	275
n_{debt}	89	275
Coefficient of ARA/RRA	0.007	2

Notes: The first column presents the baseline parameters for a borrower with constant absolute risk aversion. The second column presents the baseline parameters for a borrower with constant relative risk aversion. $Ability_i$ is equal to i's average $Ability_{it}$ over time.

Figures

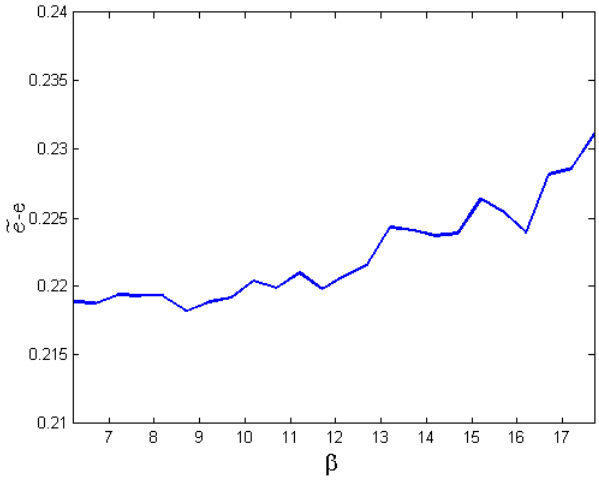
Figure 1: Intra-village Differences as Functions of the Sales-income Distribution



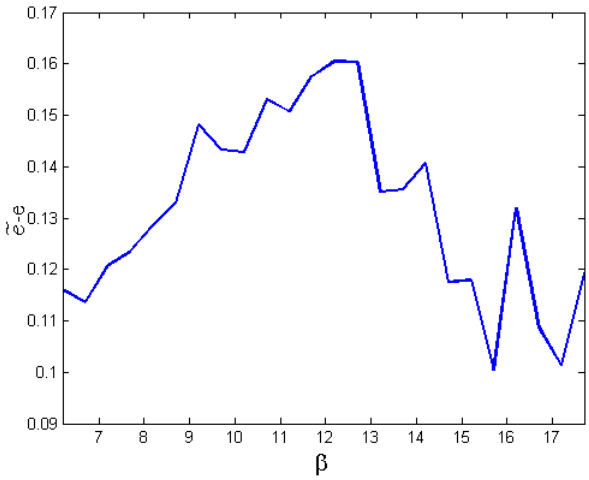
Notes: The top panel is the scatter plot of the difference in average wage labor income (in bolivianos in two weeks) between the small and the large group vs. the average village-level sales-income "Herfindahl-Hirschman Index" (HHI) between 0 and 100: $\frac{1}{5}\sum_{t=2002}^{2006}\sum_{i}\left(10\frac{Sales_{ivt}}{\sum_{i}Sales_{ivt}}\right)^2$ where $Sales_{ivt}$ is i's income from the sale of goods in village v in year t. The bottom panel is the scatter plot of the difference in average spoken Spanish fluency (rated from $0-2$) between the small and the large group vs. the average village-level sales-income HHI. The outcome variables in the left panel are based on the total sample, whereas those in the right panel are limited to the subset of villagers who borrowed a non-zero amount in at least one year.

Figure 2: Counterfactual Increase in Human Capital Investment

CARA utility



CRRA utility



Notes: $\widetilde{e} - e$ (as defined in (13) and (14)) is the calibrated mean difference in portfolio weights on human capital investment for risk averse borrowers (with CARA utility in the top and CRRA utility in the bottom panel) of equity and debt provided by risk neutral lenders. β is the sensitivity of the marginal cost of human capital investment to learning productivity: $\alpha - \beta Ability_i$ where $Ability_i$ is equal to i's average $Ability_{it}$ over time.

Proofs

Proof of Proposition 1 Given the borrower's risk neutrality and the assumption that human capital has a higher expected return than foraging-farming, the borrower's utility is increasing in e^* (cf. (5) and (7)). Hence, one can show Proposition 1 by comparing equilibrium levels of $1-\delta^*$ and $\frac{\Delta R^*}{\Delta X}$, i.e., the shares of ΔX retained by the lender. The borrower will prefer debt to equity if $1-\delta^* > \frac{\Delta R^*}{\Delta X}$. To show this, I first determine δ^* and ΔR^* from the lender's participation constraint. For the latter, one has from (6):

$$R^L + \Delta R\tfrac{\Delta X-\Delta R}{c} = I - W \Leftrightarrow X^L + \Delta R\tfrac{\Delta X-\Delta R}{c} = I - W$$

$$\Leftrightarrow \Delta R\left(\Delta X - \Delta R\right) = c\left(I - W - X^L\right)$$

$$\Leftrightarrow (\Delta R)^2 - \Delta R\Delta X + c\left(I - W - X^L\right) = 0.$$

The lender will then set ΔR according to:

$$\Delta R^* = \tfrac{\Delta X}{2} \pm \tfrac{1}{2}\sqrt{(\Delta X)^2 - 4c\left(I - W - X^L\right)}.$$

Now, for the optimal equity contract, one has from (8):

$$I - W = \delta(1-\delta)\tfrac{(\Delta X)^2}{c} + (1-\delta)X^L \Leftrightarrow I - W = \delta\tfrac{(\Delta X)^2}{c} - \delta^2\tfrac{(\Delta X)^2}{c} - \delta X^L + X^L$$

$$\Leftrightarrow \delta^2\tfrac{(\Delta X)^2}{c} + \delta\left(X^L - \tfrac{(\Delta X)^2}{c}\right) - X_L + I - W = 0$$

$$\Leftrightarrow \delta^2 + \delta\left(\tfrac{X^L c}{(\Delta X)^2} - 1\right) - c\tfrac{X^L - I + W}{(\Delta X)^2} = 0.$$

The lender will choose δ s.t.:

$$\delta^* = \tfrac{1}{2}\left(1 - \tfrac{X^L c}{(\Delta X)^2}\right) \pm \tfrac{1}{2}\sqrt{\left(1 - \tfrac{X^L c}{(\Delta X)^2}\right)^2 - 4c\tfrac{I-W-X^L}{(\Delta X)^2}}.$$

By assumption (all lenders have zero opportunity cost), intra- and extra-village lenders offer contracts s.t. $1-\delta^*$ and ΔR^* are the smallest possible values that fulfill the lender's participation constraint. Then, it is sufficient to show that:

$$1 - \delta^* > \tfrac{\Delta R^*}{\Delta X} \Leftrightarrow \tfrac{1}{2} + \tfrac{1}{2}\tfrac{X^L c}{(\Delta X)^2} - \tfrac{1}{2}\sqrt{\left(1 - \tfrac{X^L c}{(\Delta X)^2}\right)^2 - 4c\tfrac{I-W-X^L}{(\Delta X)^2}} > \tfrac{1}{2} - \tfrac{1}{2}\sqrt{1 - \tfrac{4c(I-W-X^L)}{(\Delta X)^2}}$$

which is true because $\sqrt{\left(1 - \tfrac{X^L c}{(\Delta X)^2}\right)^2 - 4c\tfrac{I-W-X^L}{(\Delta X)^2}} < \sqrt{1 - \tfrac{4c(I-W-X^L)}{(\Delta X)^2}}$, so the borrower prefers debt to equity. ■

Proof of Proposition 2 Compared to the case of risk neutrality, the relationship between required funding and the utility from granting debt or equity is determined by the variability of the claims; that is:

$$U(I-W) \geq pU\left(e_d^* \tfrac{\Delta R^* + X^L}{p} + (1-e_d^*)\, X^L\right) + (1-p)U\left((1-e_d^*)\, X^L\right)$$

and

$$U(I-W) \geq pU\left((1-\delta^*)\left(e_e^* X^H + (1-e_e^*)\, X^L\right)\right) + (1-p)U\left((1-\delta^*)\,(1-e_e^*)\, X^L\right)$$

where $e_d^* > e_e^*$ denote the borrower's optimal portfolio weights with debt and equity, respectively, granted by the risk neutral lender.

Denote $G\left(\frac{\Delta R}{\Delta X}\right) \equiv pU\left(e\frac{\Delta R + X^L}{p} + (1-e)\, X^L\right) + (1-p)U\left((1-e)\, X^L\right)$ and $H\,(1-\delta) \equiv pU\left((1-\delta)\left(eX^H + (1-e)\, X^L\right)\right) + (1-p)U\left((1-\delta)\,(1-e)\, X^L\right)$. As $U'(\cdot) > 0$ and $G\left(\frac{\Delta R}{\Delta X}\right)\big|_{e=e_d^*} \leq U(I-W) \leq U(F^{max})$ where marginal utility (wrt $\frac{\Delta R}{\Delta X}$ and $(1-\delta)$) is zero, and by A2, one has that:

$$\frac{\partial G}{\partial \frac{\Delta R}{\Delta X}}\bigg|_{e=e_d^*} > 2\min\left\{ \begin{array}{c} pU'\left(e\frac{\Delta R + X^L}{p} + (1-e)\, X^L\right), \\ (1-p)U'\left((1-e)\, X^L\right) \end{array} \right\} \frac{\partial\left[e\frac{\Delta R + X^L}{p} + 2(1-e)X^L\right]}{\partial \frac{\Delta R}{\Delta X}}\bigg|_{e=e_d^*} > 0.$$

That is, given the lender's risk aversion, he will not decrease $\frac{\Delta R}{\Delta X}$, so $\frac{\Delta R^*}{\Delta X} \leq \frac{\Delta R^{**}}{\Delta X}$. However, whenever the risk neutral borrower is indifferent between debt and equity – i.e., $\frac{\Delta R}{\Delta X} = 1-\delta$ and, thus, e does not vary with the form of financing – the lender prefers debt to equity:

$$\frac{\Delta R}{\Delta X} = 1-\delta \Leftrightarrow \Delta R = (1-\delta)\Delta X \Leftrightarrow pR^H = pX^H - \delta\Delta X = R^H = (1-\delta)\, X^H + \frac{\delta X^L}{p} > (1-\delta)X^H \Rightarrow G\left(\tfrac{\Delta R}{\Delta X}\right) > H\left(\tfrac{\Delta R}{\Delta X}\right).$$

In combination with $\frac{\partial G}{\partial \frac{\Delta R}{\Delta X}}\Big|_{e=e_d^*} > 0$, one can conclude that $\frac{\Delta R^{**}}{\Delta X}$ is the smallest possible solution to the lender's participation constraint. In order to attain $U(I-W)$, the risk averse lender will offer debt and equity contracts s.t. $\frac{\Delta R^{**}}{\Delta X} < 1-\delta^{**} \Rightarrow e_d^{**} > e_e^{**}$, and the borrower prefers debt to equity. ■

Proof of Proposition 3 The equilibrium contract determinants $\frac{\Delta\widetilde{R}^*}{\Delta\widetilde{X}}$ and $1-\delta^*$ are derived from the lender's participation constraint. In equilibrium, the lender is effectively indifferent between providing debt and equity, i.e., $\frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}}\left(pR^H-X^L\right)+X^L = (1-\delta)\frac{\ln\left(\frac{p}{1-p}\frac{\delta\Delta\widetilde{X}-c}{\delta X^L+c}\right)}{\delta X^H}\left(pX^H-X^L\right)+(1-\delta)X^L = I-W$. Assume that $\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}=1-\delta$. But then:

$$\frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}}\left(pR^H-X^L\right)+\delta X^L > (1-\delta)\frac{\ln\left(\frac{p}{1-p}\frac{\delta\Delta\widetilde{X}-c}{\delta X^L+c}\right)}{\delta X^H}\left(pX^H-X^L\right).$$

To see this, insert $\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}=1-\delta$ in the participation constraint for debt, and use $e_d^*\leq 1$:

$$\frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}}\left(pR^H-X^L\right)+\delta X^L = \ln\left(\frac{p}{1-p}\frac{\delta\Delta\widetilde{X}-c}{c}\right)\frac{(1-\delta)\left(pX^H-X^L\right)-(1-p)\delta X^L}{\delta\Delta\widetilde{X}}+\delta X^L$$

$$> (1-\delta)\ln\left(\frac{p}{1-p}\frac{\delta\Delta\widetilde{X}-c}{c}\right)\frac{pX^H-X^L}{\delta\Delta\widetilde{X}} > (1-\delta)\frac{\ln\left(\frac{p}{1-p}\frac{\delta\Delta\widetilde{X}-c}{\delta X^L+c}\right)}{\delta\Delta\widetilde{X}}\left(pX^H-X^L\right)$$

$$> (1-\delta)\frac{\ln\left(\frac{p}{1-p}\frac{\delta\Delta\widetilde{X}-c}{\delta X^L+c}\right)}{\delta X^H}\left(pX^H-X^L\right).$$

From this, one can conclude that $\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}=1-\delta$ is not an equilibrium solution. In equilibrium, it holds that $\frac{\Delta\widetilde{R}^*}{\Delta\widetilde{X}} > 1-\delta^*$ if the term $J\left(\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}\right) \equiv \frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}}\left(pR^H-X^L\right)+X^L$ is decreasing in $\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}$. To see that the latter condition is true, note that by using the implicit function theorem on the lender's participation constraint, one yields:

$$\frac{\partial e_d^*}{\partial\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}} \leq \frac{\frac{pX^H-X^L}{\Delta\widetilde{X}-\Delta\widetilde{R}}\frac{\Delta\widetilde{X}}{\Delta\widetilde{X}-\Delta\widetilde{R}-c}-e_d^*\frac{\Delta\widetilde{X}\left(p(\Delta\widetilde{X}-\Delta\widetilde{R})+pR^H-X^L\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}}}{pR^H-X^L} = \frac{\Delta\widetilde{X}\frac{pX^H-X^L}{\Delta\widetilde{X}-\Delta\widetilde{R}}\left(\frac{1}{\Delta\widetilde{X}-\Delta\widetilde{R}-c}-\frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}}\right)}{pR^H-X^L}$$

because $R^H\leq X^H$.

The denominator must be positive because the lender of debt cannot break even otherwise. Given A3, $\frac{\partial e_d^*}{\partial\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}}<0$ follows if $\frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}} > \frac{1}{(1-p)X^H+X^L-R^H}$. Suppose that this were not true, i.e., $\frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}} \leq \frac{1}{(1-p)X^H+X^L-R^H}$. Also, note that for e_d^* to be positive, one requires $X^H-R^H>\frac{c}{p}$. Then, the lender's participation constraint would not be fulfilled as:

$$e_d^*\left(pR^H-X^L\right)+X^L \leq \frac{pR^H-X^L}{(1-p)X^H+X^L-R^H}+X^L < p\frac{pX^H-X^L}{c+pX^L-p^2X^H}+X^L < I-W$$

because $c>p\left(pX^H-X^L\right)\frac{I-W-X^L+1}{I-W-X^L} > p^2X^H-pX^L$ (by A3). Hence it follows that $\frac{\partial e_d^*}{\partial\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}}<0$, which one can use to derive:

$$\frac{\partial J}{\partial \frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}} = \frac{\Delta\widetilde{X}}{\Delta\widetilde{X}-\Delta\widetilde{R}}\left(\frac{pR^H-X^L}{\Delta\widetilde{X}-\Delta\widetilde{R}-c} - \left(pX^H-X^L\right)\frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}}\right) + \frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}}p\Delta\widetilde{X} < 0$$

$$\Leftrightarrow \frac{pR^H-X^L}{\Delta\widetilde{X}-\Delta\widetilde{R}-c} - \left(pX^H-X^L\right)\frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}} < \frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}}p\left(\Delta\widetilde{R}-\Delta\widetilde{X}\right)$$

$$\Leftrightarrow \frac{pR^H-X^L}{\Delta\widetilde{X}-\Delta\widetilde{R}-c} < \left(pR^H-X^L\right)\frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}},$$

which holds as shown above. Hence, $\frac{\Delta\widetilde{R}^*}{\Delta\widetilde{X}} > 1-\delta^*$ in equilibrium.

As seen and used above, $e_d > e_e$ if $\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}} = 1-\delta$. As $\frac{\partial e_d^*}{\partial\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}} < 0$, one can conclude that $e_d^* < e_e^*$ if even increasing $\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}$ to the point that $e_d = e_e$ does not lead to the lender's indifference between debt and equity. That is, assume that $e_d = e_e$, and one already knows that $\frac{\Delta\widetilde{R}^*}{\Delta\widetilde{X}} > 1-\delta^* \Rightarrow R^{H*} > (1-\delta^*)X^H + \delta^* X^L > (1-\delta^*)X^H$, then one obtains:

$$e_d\left(pR^{H*}-X^L\right) = e_e\left(pR^{H*}-X^L\right) > e_e\left((1-\delta^*)pX^H - X^L\right) \geq$$
$$(1-\delta^*)e_e\left(pX^H-X^L\right) - \delta^* X^L$$

because $e_e \leq 1$. Hence, it must hold that $e_d^* < e_e^*$ in equilibrium.

Finally, for the borrower's utility to *increase* in e^*, it must hold that e_d^* and e_e^* are *lower* than in the first-best case. For this, it is sufficient to show that $e_{fb}^* = \frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-c}{X^L+c}\right)}{X^H} > e_e^* = \frac{\ln\left(\frac{p}{1-p}\frac{\delta\Delta\widetilde{X}-c}{\delta X^L+c}\right)}{\delta X^H}$, which is true by A4 and the fact that for e_e^* to be positive, one requires $pX^H - X^L > \frac{c}{\delta}$. To demonstrate this: $c > -\frac{\left(pX^H-X^L\right)X^L}{2pX^H} + \sqrt{\left(\frac{(pX^H-X^L)X^L}{2pX^H}\right)^2 + X^L\Delta\widetilde{X}} \Rightarrow c^2\frac{pX^H}{pX^H-X^L} + cX^L > X^L\Delta\widetilde{X} \Leftrightarrow \frac{c}{\Delta\widetilde{X}-c} > \frac{X^L}{c\left(1+\frac{X^L}{pX^H-X^L}\right)} \Rightarrow \frac{c}{\delta\Delta\widetilde{X}-c} > \frac{X^L}{\delta X^L+c}$. Algebraic transformations then yield: $\frac{c}{\delta\Delta\widetilde{X}-c} > \frac{X^L}{\delta X^L+c} \Leftrightarrow 1+\frac{(1-\delta)c}{\delta\Delta\widetilde{X}-c} > 1+\frac{(1-\delta)X^L}{\delta X^L+c} \Leftrightarrow \frac{\delta\left(\Delta\widetilde{X}-c\right)}{\delta\Delta\widetilde{X}-c} > \frac{X^L+c}{\delta X^L+c} \Leftrightarrow \ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-c}{X^L+c}\right) > \ln\left(\frac{p}{1-p}\frac{\delta\Delta\widetilde{X}-c}{\delta(\delta X^L+c)}\right) \Rightarrow e_{fb}^* > e_e^*$. ■

Proof of Proposition 4 Given the lender's risk aversion, one has:

$$U(I-W) \geq pU\left(e_d^*\left(\Delta\widetilde{R}^* + X^L\right) + (1-e_d^*)\,X^L\right) + (1-p)U\left((1-e_d^*)\,X^L\right)$$

and

$$U(I-W) \geq pU\left((1-\delta^*)\left(e_e^* X^H + (1-e_e^*)\,X^L\right)\right) + (1-p)U\left((1-\delta^*)\,(1-e_e^*)\,X^L\right)$$

where $e_d^* > e_e^*$ denote the borrower's optimal portfolio weights with debt and equity, respectively, granted by the risk neutral lender.

Denote $G\left(\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}\right) \equiv pU\left(e\left(\Delta\widetilde{R} + X^L\right) + (1-e)\,X^L\right) + (1-p)U\left((1-e)\,X^L\right)$ as well as $H\,(1-\delta) \equiv pU\left((1-\delta)\left(eX^H + (1-e)\,X^L\right)\right) + (1-p)U\left((1-\delta)\,(1-e)\,X^L\right)$.

Now, for $\frac{\partial G\left(\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}\right)}{\partial\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}}$ to be negative, it is sufficient to show that

$K\left(\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}\right) \equiv \frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}}\left(R^H - 2X^L\right) + 2X^L$ is decreasing in $\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}$, the proof of which is similar to that of Proposition 3, and is conducted in two steps. First, $\text{sign}\left(\frac{\partial e_d^*}{\partial\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}}\right) = \text{sign}\left(\frac{\Delta\widetilde{X}}{\Delta\widetilde{X}-\Delta\widetilde{R}}\left(\frac{R^H-2X^L}{\Delta\widetilde{X}-\Delta\widetilde{R}-c} - \left(X^H-2X^L\right)\frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}}\right)\right) < 0$ due to A3. Then:

$$\text{sign}\left(\frac{\partial K}{\partial\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}}\right) =$$
$$\text{sign}\left(\frac{\Delta\widetilde{X}}{\Delta\widetilde{X}-\Delta\widetilde{R}}\left(\frac{R^H-2X^L}{\Delta\widetilde{X}-\Delta\widetilde{R}-c} - \left(X^H-2X^L\right)\frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}}\right) + \frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}}\Delta\widetilde{X}\right) < 0$$

because

$$\frac{\Delta\widetilde{X}}{\Delta\widetilde{X}-\Delta\widetilde{R}}\left(\frac{R^H-2X^L}{\Delta\widetilde{X}-\Delta\widetilde{R}-c} - \left(X^H-2X^L\right)\frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}}\right) + \frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}}\Delta\widetilde{X} < 0$$

$$\Leftrightarrow \frac{R^H-2X^L}{\Delta\widetilde{X}-\Delta\widetilde{R}-c} - \left(X^H-2X^L\right)\frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}} < \frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}}\left(\Delta\widetilde{R}-\Delta\widetilde{X}\right)$$

$$\Leftrightarrow \frac{R^H-2X^L}{\Delta\widetilde{X}-\Delta\widetilde{R}-c} < \left(R^H-2X^L\right)\frac{\ln\left(\frac{p}{1-p}\frac{\Delta\widetilde{X}-\Delta\widetilde{R}-c}{c}\right)}{\Delta\widetilde{X}-\Delta\widetilde{R}},$$

which holds, as seen in the proof of Proposition 3.

Hence, as $G\left(\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}\right) > H\,(1-\delta)$[19] and $e_d^* > e_e^*$ if $\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}} = 1-\delta$, one can infer that $\frac{\Delta\widetilde{R}^*}{\Delta\widetilde{X}} > 1-\delta^*$ in equilibrium. Next, note that even if $e_d = e_e$, then:

[19]This is because if $\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}} = 1-\delta$ and, thus, $e_d^* > e_e^*$, then $e_d^*\left((1-\delta)\Delta\widetilde{X} + X^L\right) + (1-e_d^*)\,X^L = (1-\delta)e_d^*\left(X^H - X^L\right) + X^L > (1-\delta)e_e^*\left(X^H - X^L\right) + (1-\delta)X^L = (1-\delta)\left(e_e^* X^H + (1-e_e^*)\,X^L\right) \Rightarrow G\left(\frac{\Delta\widetilde{R}}{\Delta\widetilde{X}}\right) > H\,(1-\delta)$.

$$e_d\left(R^{H*}-X^L\right)=e_e\left(R^{H*}-X^L\right)>e_e\left((1-\delta^*)X^H-X^L\right)\geq$$
$$(1-\delta^*)e_e\left(X^H-X^L\right)-\delta^*X^L\Rightarrow G\left(\frac{\Delta\widetilde{R}^*}{\Delta\widetilde{X}}\right)>H\left(1-\delta^*\right)\Big|_{e_d=e_e}.$$

Therefore, it must hold that $e_d^* < e_e^* < e_{fb}^*$ in equilibrium, and the borrower's utility is increasing in e^*, as shown in the proof of Proposition 3. ■