Informal Finance, Risk Sharing, and Networks: Evidence from Hunter-Gatherers*

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Abstract

This paper analyzes the relationship between informal finance and the risk-sharing properties of networks. I show that in addition to sharing idiosyncratic risk, network members can also support one another in dealing with aggregate shocks. To identify this, I use data from an Amazonian foraging-farming society, and exploit a flood shock in 2006. Villagers outside the network demanded significantly more credit following the flood than did network members, suggesting that networks allow their members to cope with aggregate shocks through non-financial resources rather than through costly loans. The increased credit demand by villagers outside the network was in turn served through a temporary extension of network benefits across the two groups.

JEL classification: G21, O12, O16

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1 Introduction

Economists have been able to amass great amounts of knowledge and insights into lending channels in corporate and consumer loan markets in developed financial markets. Ever since, these studies have been extended to include the evolution of financial institutions in less developed countries. However, far less is known about informal lending among the most rural populations that are entirely left out of the normal credit-channeling networks. According to Demirgüç-Kunt and Klapper (2013), 50 percent of the world's population are excluded from such more formal lending channels and, instead, rely on informal networks as sources of financing.

Informal networks, such as kinship and other family networks, can substitute for poorly-performing institutions in developing countries, and there exists ample documentation of the benefits of such networks (e.g., Rosenzweig (1988); Grimard (1997); Bayer, Ross, and Topa (2008)). One such benefit is the ability to share risk more efficiently across households, which is all the more valuable as insurance tends to be incomplete in developing countries (e.g., Kinnan (2014)). As suggested by Munshi and Rosenzweig (2016), risk sharing in networks can operate through informal lending and borrowing. While the idea of an informal-finance dimension of risk sharing seems plausible, there exists little empirical evidence attesting to how informal finance contributes to the level of risk sharing within and between networks.

To shed light on these issues, this paper considers the supply and demand of informal loans in response to idiosyncratic and aggregate shocks, and the role of networks therein. I argue that informal loans have a twofold function in characterizing the benefits of risk-sharing networks: networks use informal loans to share idiosyncratic risk in normal times, whereas they are able to cope with aggregate shocks without having to access informal credit markets in bad times, when loans would be costly. The presumably less costly alternative is to rely on other resources and non-financial help from fellow network members.

I provide evidence for the informal-loans dimension of risk sharing in two steps. First, I confirm the existence of insurance against idiosyncratic shocks within networks, and show that informal loans contribute to it. Second, and most importantly, I compare credit demand by members and non-members of networks within villages following a major flood. In this manner, I establish that network members can cope with aggregate shocks through non-financial resources, and thereby avoid using loans when they are costly.

To elucidate the interrelation between the allocation of informal credit and network structures, I use data on hunter-gatherers in the Bolivian Amazon, where each village is segregated by a mating network of villagers who participate in cross-cousin marriage. This paper is one of the first to use transaction-level data on informal loans in an extremely underdeveloped and poor society, which enables me to trace the allocation of informal credit and its sources following an aggregate shock. An aggregate flood shock in this setting allows me to identify increased credit demand by villagers who are not members of the mating network, whereas members of the mating network can fall back on other resources and non-financial help from fellow network members to recover from aggregate shocks.

My analysis is based on nine-year panel data – from 2002 to 2010 – from an in-depth account of recorded activities in 13 villages in Amazonian Bolivia, where the Tsimane' reside. Each village is split into two groups: roughly two-thirds of the population practice cross-cousin marriage, and deem any deviation from that practice unacceptable, whereas the remainder do not. Naturally, traditional villagers are less likely to opt out of the practice of cross-cousin marriage, for example to connect with the outside world. Therefore, members of the mating network should display a lower degree of openness towards outsiders – such as loggers, farmers, and cattle ranchers who trade with, and sometimes employ, the Tsimane' – compared to the remaining villagers. Nevertheless, I find very few differences in terms of observable characteristics between the two groups.

While similar along observable means, the two groups follow significantly different paths in terms of consumption variability. This reflects the fact that members of the mating network reap risk-sharing benefits. I show this to hold true in general insofar as households in the mating network are better insured against idiosyncratic shocks, especially income shocks and variability in household size, than villagers outside the mating network in the same village. Then, I provide evidence that risk sharing, at least in part, operates through informal loans. Namely, households that borrow from fellow villagers exhibit significantly lower consumption-growth volatility than do households that receive loans from outside the Tsimane' community. This effect pertains primarily to households in the mating network, which I show is not driven by the potentially different sources of income of the two groups. Thus, intra-village loans feature an insurance or equity-like component,[1] which contributes to the overall level of risk sharing in the mating network.

After establishing the risk-sharing quality of the mating network's informal loans, I examine the allocation of informal credit among villagers inside and outside the mating network after an aggregate shock. In the summer of 2006, the Tsimane' villages were hit by one of the worst floods of the last two decades, which required the villagers to direct their efforts towards rebuilding their houses and restoring their agricultural plots. The flood also adversely impacted access to resources outside the villages, including loans from and other contact with outsiders, due to physical damages. The running hypothesis of this paper is that the mating network was differentially affected by the flood compared to the remaining villagers, as the two groups' demand for informal financing should vary with the extent to which they received other, non-financial help from fellow villagers in coping with the flood. I employ a difference-in-differences strategy for villagers inside vs. outside the mating network to identify a differential impact of the flood on their demand for informal finance.

There are two financing sources: intra-village and outside credit. After controlling for individual and village-year fixed effects, which allow me to capture any covariate shocks to the supply of outside credit due to the interruption by the flood, I find no (differential) effect on the villagers' demand for outside credit. When applying the same empirical strategy to intra-village finance, one faces the limitation that intra-village credit is provided by those that were themselves directly affected by the flood. Under the assumption that credit supply did not increase in the villages, identification of any shock to the demand for intra-village finance can be achieved only for differential increases, but not decreases, in demand for

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

intra-village credit by villagers inside vs. outside the mating network.

I show that intra-village credit increased only for villagers outside the mating network, whereas members of the mating network did not demand any more intra-village credit after the flood. I also show that villagers outside the mating network were less engaged in helping fellow villagers, and had to visit market towns significantly more often after the flood. These findings attest to the idea that the mating network, besides sharing idiosyncratic risk, also organizes its members so as to not require financial resources to cope with aggregate shocks.

Furthermore, I provide evidence that the increase in intra-village credit received by villagers outside the mating network came from loans granted by members of the mating network. Therefore, the mating network was not just cushioned against the flood shock in terms of credit demand, but also had the capacity to temporarily extend its network benefits, in the form of intra-village loans, to non-members in the same village. As a consequence, the two groups were not differentially affected by the flood in terms of consumption. The provision of intra-village credit by the mating network is a positive externality that was instrumental in smoothing consumption not just within but also beyond the mating network.

Finally, I attempt to rationalize why the mating network was willing to serve as a temporary lender to the remaining villagers after the flood. To this end, I scrutinize whether villagers outside the mating network exerted more effort so as to improve their repayment capacity. If not due to greater indebtedness, they would be incentivized to do so if they faced higher interest rates charged by the mating network. In that case, the flood led to a shift in bargaining power in favor of the mating network, thereby making it more attractive for its members to act as lenders of intra-village credit to the remaining villagers.

Exploring this possibility, I face the limitation that the data, due to the informal nature of the loans, do not record any explicit or implicit interest rates. Instead, I fathom whether villagers outside the mating network started to invest in activities that improved their earnings potential and, hence, their repayment capacity. For this purpose, I consider changes in the villagers' Spanish fluency, as learning Spanish would help to enter into wage labor, which pays more than foraging-farming, after an initial post-flood period.[2]

I find that following the flood, villagers outside the mating network invested significantly more in learning Spanish than members of the mating network. By using between-village variation in access to market towns, I verify that this effect varies with the strength of the flood and with the receipt of credit, but not with different returns to human capital in villages close to market towns. This renders it more likely that the post-flood debtors from outside the mating network invested in human capital so as to improve their repayment capacity, in response to the increase in bargaining power of – and, thus, interest rates potentially demanded by – the mating network in their role as post-flood lenders.

Besides the above-mentioned literature on risk sharing (such as Kinnan (2014)), this paper is also related to previous work on, first, informal finance and, second, networks in developing countries. The closest study to this paper is that by Binzel, Field, and Pande (2013), who scrutinize the relationship between access to formal finance and informal risk sharing in Indian village networks. More generally, previous research on informal finance focussed on its role in supporting firm growth, especially in China (but also elsewhere, see Djankov, McLiesh, and Shleifer (2007)) as an example of an economy that lacks more formal financing channels and legal mechanisms (Allen, Qian, and Qian (2005); Ayyagari, Demirgüç-Kunt, and Maksimovic (2010); Degryse, Lu, and Ongena (2016)). This paper extends this literature by the perspective of households in a foraging-farming society, where the role of informal finance is fundamentally different – and, potentially, even more crucial – due to the non-existence of a private sector that the households could participate in. This characteristic of the setting at hand also differentiates this paper from other studies of informal finance used by households in developing countries with some financial and non-financial institutions in place (Besley and Levenson (1996) as well as Kan (2000)). In this paper, intra-village credit has an insurance or equity-like component, which pertains to transactions involving the mating network. To the extent that the mating network comprises both de-facto and potential relatives, as well as like-minded friends, this paper is also related to theoretical

[2] The Tsimane' do not speak Spanish, the national language of Bolivia, as their first language, but learning it opens doors to wage-labor agreements with outsiders.

considerations – such as those laid out by Lee and Persson (2016) – about the feasibility of favorable loan conditions within these networks.

The literature on networks is multifaceted, and covers 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, Mobius, Rosenblat, and Szeidl (2009); Leider, Moebius, Rosenblat, and Do (2009); Alger and Weibull (2010)). As these traits help to 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 (2014); Angelucci, de Giorgi, and Rasul (2016)). Through these channels, social networks can affect a wide range of economic outcomes, most notably financial access (Banerjee and Munshi (2004), Kinnan and Townsend (2012)), as is the case in this paper.

2 Context and Data

In this paper, I study the relationship between informal finance and risk-sharing networks in a foraging-farming society, the Tsimane' of the Bolivian Amazon. To do so, I use a panel data set from a team of anthropologists who recorded the socioeconomic activities of the villagers from 2002 to 2010, complemented by a data set on loan transactions among villagers as well as between villagers and outsiders. In the following, I will give some background on the Tsimane' and the 2006 flood, describe the data, and provide summary statistics.

2.1 Background on the Tsimane'

The Tsimane' are a small-scale foraging-farming society in the Bolivian Amazon (Department of Beni), and live in 95 villages. My sample consists of 13 villages observed over the period from 2002 to 2010. As is typical of native Amazonian societies, the Tsimane' fish, hunt game, and practice slash-and-burn agriculture by clearing plots from the forest.[3] Also, most Tsimane' have sufficient land to farm (5.7 ha per person according to Godoy et al. (2006)). In this manner, they can generate income from barter and from selling forest and farm goods, e.g., to outsiders (such as traders coming down the river).

Overall, the Tsimane' are a highly autarkic society. 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, lasting until 1985.

Protestant missionaries offer training in Spanish and, simultaneously, promote the returns to schooling: gaining some command of Spanish can serve as an entry ticket to the outside labor market, and lead to eventual integration into the market economy evolving around the Tsimane' villages. Relevant employment opportunities arise from interactions with loggers, farmers, and cattle ranchers. Thus, wage labor constitutes an alternative source of income, besides barter trade and income generated from the sale of forest and farm goods.

Despite the relatively small size of the villages, the social structure of the Tsimane' exhibits some variation in the extent to which villagers rely on one another, rather than on other channels such as those offered by the market towns, most notably San Borja. 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). This mating norm splits each village into two groups: one that practices cross-cousin marriage and deems any deviation from said norm unacceptable, and one that does not impose this mating rule.[4] As can be seen in

[3] See Godoy et al. (2005) for a more detailed account of the traits and developments among the Tsimane'.

[4] In fact, Tsimane' who practice cross-cousin marriage believe that upon death, those who did not comply with this norm are reborn as jaguars and eat living people (Godoy et al. (2008)).

Table 1, about two-thirds of the Tsimane' population practice cross-cousin marriage, which I henceforth label as the "mating network." I define individuals as members of the mating network by using the responses of the respective household heads to a survey question on the need for marrying a cross cousin in the first year of the data set.

As I will show, the mating network offers risk-sharing benefits, in part through informal loans. Before moving to the summary statistics for individuals inside vs. outside the mating network, I next describe the 2006 flood.

The 2006 flood. In the summer of 2006, the Tsimane' villages were hit by a major flood, which is considered the worst flood of the last two decades. Villages in the plains were most heavily flooded. This is due to the fact that floods affecting villages in the plains cannot drain down rivers swiftly.[5] In my sample of 13 villages, the villages of Campo Bello, San Antonio, and Puerto Mendez are in the plains, at the western end of the expansive Moxos savannah, and were, thus, most heavily flooded.[6] Figure 1 marks these villages, and the remaining ones from a total 13 villages in my sample, on a map of the study area.

Besides destroying agricultural plots, the flood impeded the ability of the Tsimane' to access resources outside their villages, including (but not limited to) loans from loggers, farmers, cattle ranchers, shops in one of the market towns (e.g., San Borja), or banks. Virtually all households were affected materially by the flood, which holds for households inside and outside the mating network: 92.4% and 95.0%, respectively, received institutional help from the government, missionaries, medical doctors, the Red Cross, or any other sources.

This implies that the wealth loss inflicted by the aggregate shock was the same inside and outside the mating network. However, this leaves open the question as to how the two groups dealt with the flood: through financial resources or through non-financial help. Against this background, I analyze whether members of the mating network were differentially affected by the flood along various dimensions, most notably their loan portfolios.

[5] This is in contrast to the remaining villages in my sample, which lie at the lower edge of the Andean foothills, straddling rivers with relatively sharp inclines.

[6] As far back as colonial times, the settlements in the western edge of the Moxos savannah were hard to reach during the rainy season, owing to widespread flooding (Block (1994), pp. 53-54).

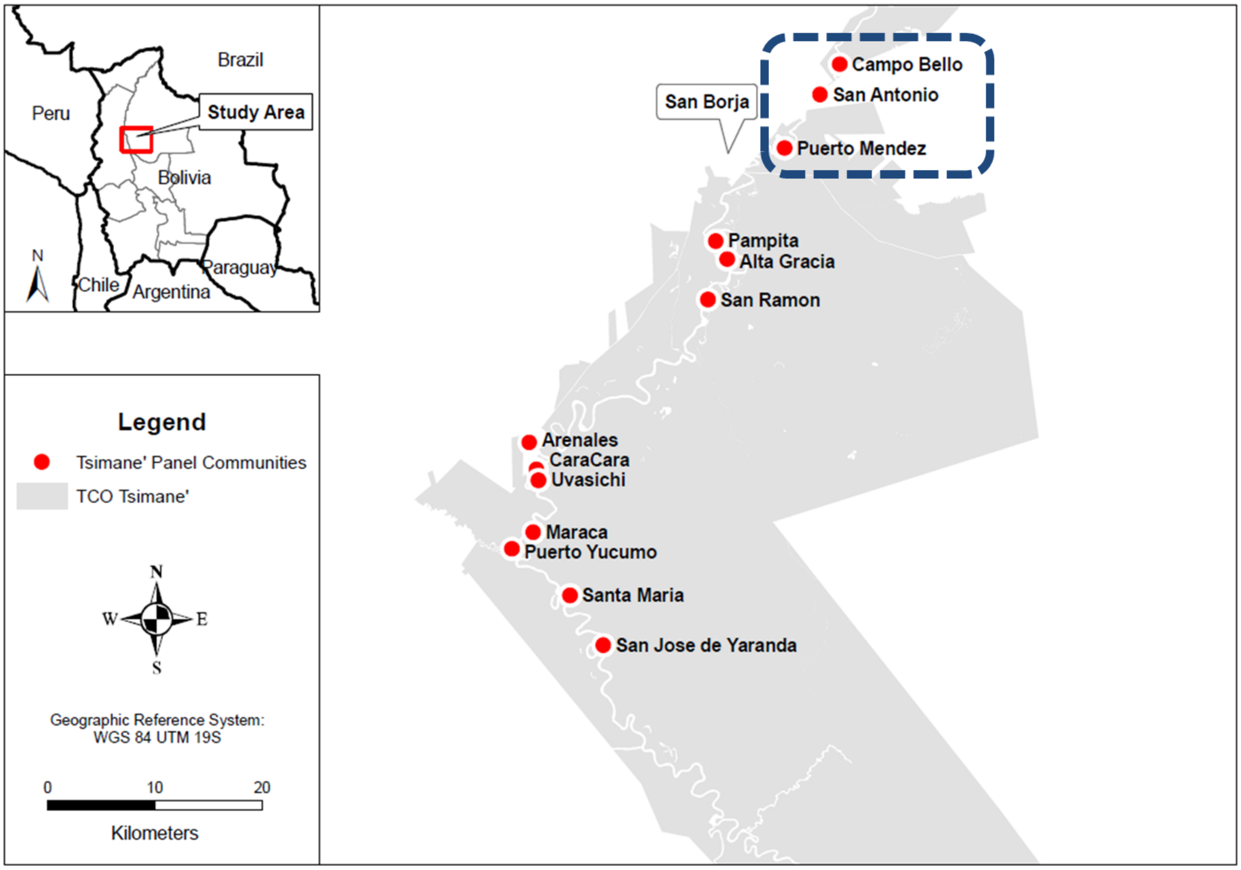

Figure 1: **Map of Study Area.** San Borja is the closest market town. Campo Bello, San Antonio, and Puerto Mendez lie in the plains and were, thus, flooded most heavily in 2006.

2.2 Data Description

My main data source is the most recent edition of The Tsimane' Amazonian Panel Study (TAPS) for the years 2002 to 2010, comprising nine years of data on Tsimane' living in 13 villages. I complement this data set with hand-collected data on individuals' borrowing (available from 2002 to 2010) and lending (available from 2005 to 2010) activities.

The villagers were interviewed each year during the dry season (June to September). Thus, the post-flood period typically starts in the year 2007 of the data. As my analysis is centered on informal finance, I merge the two data sets, and limit the sample to the intersection of Tsimane' villagers for whom I have information on their credit received. As a consequence, my sample covers only adults,[7] for whom I have comprehensive data on

[7] Note that Tsimane' start setting up independent households by the age of 16, reflecting the lower bound of age in my sample.

their income composition, asset wealth, measures of human capital and other socioeconomic activities, as well as demographic information.

The key variables stem from the informal-loans data.[8] The respective variables record loan transactions, and how much an individual has borrowed from, or lent to, a fellow villager or a group of outsiders in the course of the previous year. A drawback of the data is that there is no specific information on *which* villagers were engaged in a loan transaction, other than the identity of the borrower. That is to say, one can only ascertain whether an individual, who is known to be either inside or outside the mating network, received a loan from a fellow villager, but it is not clear whether the loan was provided by somebody in the mating network or not. In the analysis below, I will shed some light on this issue by correlating village-level (i.e., aggregate) measures of loans received and given out by members of the mating network and the remaining villagers.

Loans from outsiders are provided by any one of the following groups: ranchers, loggers, colonists, traders, shops and inhabitants in the market town (San Borja), banks, and the government. In sum, I will differentiate between *intra-village credit* provided by fellow villagers and *outside credit* provided by one of the before-mentioned outsiders over the course of one year, for each individual and year in the data.

2.3 Summary Statistics

When conditioning on the availability of credit and asset-wealth variables (alongside basic demographical variables that will be used as controls in regressions) both before and after the flood (but not necessarily for the entire period of nine years), the regression sample comprises 530 individuals from 210 households located in 13 villages. When conditioning only on the availability of said variables before, but not after, the flood (i.e., until and including 2006), the regression sample consists of 701 individuals from 284 households.[9]

[8] Note that informal loans do not include emergency transfers, for instance those by the Red Cross.

[9] As the ratio between the number of individuals and that of households is roughly 2.5, one can infer that the regression sample captures adults other than household heads.

Table 2 displays pre-flood summary statistics, i.e., for individuals with at least one observation in the period from 2002 to 2006, separately for members of the mating network and the remaining group of villagers. Note that in contrast to intra-village and outside credit, most variables are measured for one or two weeks prior to the interview. At the individual level, as can be seen in the top panel, there are very few differences along observables between villagers inside and outside the mating network. The only three statistically significant differences are, however, characteristic of the degree of openness of the two groups towards outsiders. Namely, members of the mating network earned less income, and significantly so with respect to the sale of forest and farm goods. More strikingly, members of the mating network worked fewer days – only two-thirds in relative terms – for outsiders (e.g., loggers, farmers, and cattle ranchers) than did the remaining villagers. This is also reflected in the fact that members of the mating network visited the market town of San Borja significantly less frequently.

To some extent, these differences are indicative of the idea that members of the mating network hold a more conservative view of the market economy evolving around them. While not statistically significant, the same qualitative difference holds for wage-labor income; and with respect to asset wealth, the largest difference exists for modern assets, which are acquired primarily outside the villages. Similarly, members of the mating network exhibit lower Spanish fluency, which is measured as the sum of the two scores for speaking and reading skills, each of which ranges from 0 to 2. The respective difference is significant only at the 25% level, however.

Over half of the villagers received informal loans.[10] Credit is meaningful: in an average year in which an individual received non-zero credit from fellow villagers or outsiders, total credit amounted to US$25.36 and US$33.06 (in 2010 terms) for members inside and outside the mating network, respectively. These figures measure up, for instance, with the average stock of traditional assets at the individual level, or roughly ten weeks' income from foraging and farming (through the sale of forest and farm goods).

[10] This is due to the fact that having information on informal loans does not exclude individuals with zero borrowing and lending activity throughout.

Given that the villagers outside the mating network seem to borrow more from outsiders, in conjunction with the fact that they earn more from wage labor, one can characterize them as relying more on resources outside their communities. They are, thus, potentially affected more heavily by the flood than the mating network. On the other hand, the economic activities of the members of the mating network suggest that they focus on foraging and farming, and are less exposed to outsiders. A potential reason for this is that the mating network offers benefits that render it unnecessary to reach out to outsiders. As I will show in the next section, one such benefit lies in risk sharing, in part operationalized through a particular form of informal loans.

When considering the summary statistics at the household level in the bottom panel of Table 2, there is no difference in household consumption (the respective data are available starting only in 2004) between the two groups, despite the individual-level evidence that members of the mating network earn less. This lends further support to the possibility of risk-sharing benefits in the mating network. In addition, there is no difference in the degree to which households inside vs. outside the mating network are exposed to idiosyncratic shocks, as measured in terms of monetary costs (available starting only in 2005). Lastly, the two groups' average household sizes are also similar.

Next, I scrutinize the existence of risk-sharing benefits in the mating network. In particular, I relate consumption-growth volatility to intra-village and outside credit of both the mating network and the remaining villagers in order to ascertain whether intra-village loans provide distinct insurance or other equity-like features.

3 Informal Finance and Risk Sharing in the Mating Network

Are informal loans from fellow villagers different from those granted by outsiders? And if so, does intra-village credit exhibit features that are consistent with risk-sharing benefits in the mating network? To explore this possibility, I examine a household's consumption-growth volatility, and relate its smoothness to different household-level credit sources, namely intra-village and outside credit.

This is an implicit test for whether intra-village credit has insurance or equity-like features that enable households to smooth consumption. Naturally, a more direct test would be to analyze the actual loan contract. Given the informal nature of loans in the setting at hand, this is infeasible. This also implies that I have no explicit data on interest rates or any other information on repayment schedules. If, however, repayment varies with realized income, then this should lead to smoother consumption. Therefore, the following regression specification helps to test whether intra-village finance is associated with lower consumption-growth volatility and, thus, exhibits equity-like features compared to outside finance, and whether this holds especially for members of the mating network:

$$\begin{aligned}\sigma_{\hat{c}_h} \quad = \quad & \beta_1 \overline{Intra - village\ credit}_h + \beta_2 \overline{Intra - village\ credit}_h \times Mating\ network_h \\ & + \beta_3 \overline{Total\ credit}_h + \beta_4 \overline{Total\ credit}_h \times Mating\ network_h \\ & + \beta_5 Mating\ network_h + \beta_6' Other\ controls_h + \beta_7 Years\ data_h + \theta_v + \epsilon_h, \qquad (1)\end{aligned}$$

where $\sigma_{\hat{c}_h}$ denotes the volatility of annual growth in the value of consumption of household h over all years of available data (starting in 2004), $\overline{Intra - village\ credit}_h$ is the average amount of intra-village credit borrowed by household h anytime in or after 2004, $\overline{Total\ credit}_h$ is the average amount of total (i.e., the sum of intra-village and outside) credit borrowed by household h anytime in or after 2004, $Mating\ network_h \in \{0, 1\}$ is an indicator for whether household h practices cross-cousin marriage, $Other\ controls_h$ is a vector that includes logged average traditional assets, animal wealth and modern assets (all at the household level), and the maximal household size over the time period under consideration. $Years\ data_h$ controls for the number of available observations per household, θ_v denotes village fixed effects, and standard errors are clustered at the household level.

The results from estimating (1) are in Table 3. By including the amounts of intra-village and total credit on the right-hand side, and by virtue of total credit being equal to the sum of intra-village and outside credit, the coefficient on $\overline{Intra-village\ credit}_h$ indicates whether intra-village credit is associated with different consumption-growth volatility compared to outside credit. In the first column, one can see that intra-village credit is associated with significantly *lower* consumption-growth volatility than outside credit. This is robust to including village fixed effects in the second column.

In the third column, I include interactions with the mating-network indicator, and find that the consumption-smoothing effect of intra-village finance holds particularly – i.e., significantly more – for households in the mating network: the coefficient on the interaction term $\overline{Intra-village\ credit}_h \times Mating\ network_h$ is significant at the 2% level. The coefficient is virtually unaltered, and remains significant at the 3% level after including other household-level controls in the fourth column. The sum of the coefficients on $\overline{Intra-village\ credit}_h$ and $\overline{Intra-village\ credit}_h \times Mating\ network_h$ indicates that for households in the mating network, intra-village finance is associated with significantly (at the 1% level) less consumption-growth volatility than outside finance. In terms of economic significance, the consumption-smoothing effect of intra-village credit for households in the mating network that, on average, borrowed, for instance, US\$10 (in 2010 terms) per year over the entire duration of the data amounts to $0.1 \times (0.079 + 0.386) = 0.047$, which corresponds to over one-eighth of a standard deviation of the dependent variable.

Thus, intra-village credit has equity-like qualities that accrue to members of the mating network. The feasibility of such equity-like loans rests, at a minimum, on the observability of income and the enforceability of repayments that are proportional to the debtor's observed income. These two assumptions can well justify why equity-like loans are available inside but not outside the villages, and are prominent among members of the mating network. Kinnan (2014) provides empirical evidence supporting these assumptions by showing that hidden income is a more likely explanation for incomplete insurance than limited commitment or moral hazard. In the context at hand, hidden-income issues are alleviated because of the observability of the income realizations of fellow network members.

The evidence in the first four columns of Table 3 is in line with this explanation, but does not allow one to pin down the precise mechanism as to what enables the mating network to provide equity-like loans. In principle, the coefficient on the interaction $\overline{Intra-village\ credit}_h \times Mating\ network_h$ could be driven by other characteristics at the household level that are correlated with a mating-network affiliation. From Table 2, the only consistent observable difference between the mating network and the remaining villagers is the openness of the latter towards the outside economy, their wage-labor participation, and the resulting difference in the income profiles. These differences are also consistent with (unobserved) heterogeneity in risk aversion.

In the last column of Table 3, I explore whether the different income profiles have implications for consumption smoothing under intra-village finance. To this end, I include interactions with the ratio of average income from the sale of forest and farm goods earned by all household members over the sum of the average sales income and the average income from wage labor earned by all household members ($Sales\ proportion_h \in [0, 1]$), the availability of which reduces the number of observations.

Under the assumption that income from the sale of forest and farm goods is better observable than that derived from wage labor, i.e., from working for an outsider, one would expect the consumption-smoothing effect of intra-village finance to be pronounced for households with relatively high $Sales\ proportion_h$. This is, however, not the case: both interaction effects with $Sales\ proportion_h$ are insignificant. This renders it unlikely that the consumption-smoothing effect of intra-village credit provided to households in the mating network is due to their distinct income profile and the resulting observability of their income. Hence, informal loans appear to be a means of risk sharing in the mating network.

I next provide further support of the general existence, and benefit, of risk sharing in the mating network. To test whether households in the mating network are better insured against idiosyncratic shocks than their counterparts in the same village, I run risk-sharing regressions in the spirit of Cochrane (1991), Mace (1991), and Townsend (1994), separately for households inside and outside the mating network:

$$\Delta \ln(c_{ht}) = \beta_1 \Delta \ln(c_{vt}) + \beta_2 \Delta \ln(Income_{ht}) + \tau_t + \lambda_h + \epsilon_{ht}, \tag{2}$$

where $\Delta \ln(c_{ht})$ and $\Delta \ln(c_{vt})$ denote the growth rate of consumption at the household level and at the village level (excluding household h) in year t, respectively, $\Delta \ln(Income_{ht})$ is the growth rate of the sum of income from wage labor and from the sale of forest and farm goods by all earners in household h in year t, τ_t and λ_h denote year and household fixed effects, respectively, and standard errors are clustered at the household level.

The results for households in the mating network and the remaining households are in the top and bottom panel of Table 4, respectively. Comparing the estimates in the first two columns across the two panels (without and with year fixed effects), idiosyncratic income shocks, after controlling for aggregate consumption c_{vt}, significantly impact household-level consumption c_{ht} only for households *outside* the mating network. The coefficient on income is very close to zero for households in the mating network, however. This remains true after including village-year fixed effects, instead of aggregate consumption, in the third column.

Similarly, in the fourth column, I implicitly assume a unit coefficient of aggregate consumption – and, thus, subtract aggregate consumption from household consumption on the left-hand side – to avoid a bias of the coefficient on aggregate consumption due to a possible correlation with the error term (Mace (1991)). The coefficients on income remain similar. In the fifth column, I add household size on the right-hand side, variations of which constitute idiosyncratic shocks to the structure of the household, such as the number of earners (following a death shock, for example). Consistent with my differential estimates of the income coefficient, the coefficient on household size is insignificant for members of the mating network, but significant at the 1% level for the remaining households in the bottom panel.

The evidence in this section suggests that households in the mating network share idiosyncratic risk in general, and provide loans with equity-like features in particular. The latter can, thus, be considered a specific example of the risk-sharing benefits in the mating network. Using data on informal loans enables an individual-level analysis of the allocation of credit and informal insurance in the villages. Furthermore, using the 2006 flood as an aggregate shock, one can identify differential increases (but not decreases) in demand for credit by villagers inside vs. outside the mating network, to which I turn next.

4 Impact of the 2006 Flood on Credit Demand, Allocation of Informal Finance, and Real Effects

In this section, I estimate the impact of the 2006 flood on credit for villagers inside and outside the mating network. I will first outline the identification strategy before turning to the results for intra-village and outside credit, most notably the differential increase in demand for intra-village credit by villagers outside the mating network. I will also show that members of the mating network relied more on intra-village help and non-financial resources after the flood.

Last, I will discuss evidence suggesting that increased demand for intra-village credit by villagers outside the mating network was reciprocated by the mating network with potentially higher (but otherwise unobserved) interest rates, as the non-mating-network debtors invested significantly more in human capital after the flood, presumably so as to improve their repayment ability.

4.1 Empirical Strategy and Regression Specification

I use the 2006 flood to estimate its impact on loan amounts received by individuals inside and outside the mating network by estimating the following difference-in-differences specification:

$$\begin{aligned}\ln(1+Credit_{it}) &= \beta_1 Mating\ network_i \times After_t(2006) + \beta_2' Other\ controls_{it} \\ &\quad + \eta_{vt} + \mu_i + \epsilon_{it}, \qquad (3)\end{aligned}$$

where $Credit_{it}$ is the total loan amount borrowed by individual i (residing in village v) from a fellow villager and/or an outsider in year t, $Mating\ network_i \in \{0, 1\}$ is an indicator for whether in the first year of the data (2002), i belonged to a household that practices cross-cousin marriage, $After_t(2006) \in \{0, 1\}$ is an indicator for the post-flood period from 2007 to 2010, $Other\ controls_{it}$ is a vector that includes the logged value of i's total assets (i.e., the sum of i's traditional assets, animal wealth, and modern assets) in year t, i's age in year t, household size in i's household in year t, and the logged value of all other household members' total assets in i's household in year t. η_{vt} and μ_i denote village-year and individual fixed effects, respectively, and standard errors are clustered at the household level.

The inclusion of village-year fixed effects allows me to control for covariate shocks, such as the direct effect of the flood experienced by all villagers, or changes in the availability of opportunities for interacting with outsiders. When considering outside credit on the left-hand side, it is reasonable to assume that village-year fixed effects capture any changes in credit supply, as long as outsiders do not discriminate among the Tsimane'. In this case, β_1 identifies changes in credit demand by villagers inside vs. outside the mating network.

For intra-village credit as outcome variable, the previous assumption is less likely to hold, and village-year fixed effects do not necessarily control for changes in credit supply, because villagers who demand credit may also be simultaneously on the supply side. Then, one of two cases can arise: either intra-village credit increases more for one group than the other (Case 1), or it decreases more for one group than the other (Case 2). As, due to physical damages, the 2006 flood should not have been associated with any increases in credit supply by outsiders or fellow villagers, β_1 identifies an increase in intra-village credit demand by one group compared to the other under Case 1, unless credit supply increased for said group but decreased (even more) for the other. Under Case 2, because overall credit supply should have decreased, β_2 is essentially unidentified: that is, any decrease in intra-village credit can be due to a drop in demand or in supply.

I will show that Case 1 holds in the data, and that villagers outside the mating network received more intra-village credit – not just compared to members of the mating network, but also compared to pre-flood levels – so that β_1 reflects their increased intra-village credit demand vis-à-vis the mating network. While I cannot rule out that credit supply by fellow villagers has increased specifically for villagers outside, but not inside, the mating network after the 2006 flood, it is difficult to argue that this was the case in the absence of increased intra-village credit demand, which shifts the bargaining power in favor of the lending villagers of the mating network.

To provide evidence that the villagers outside the mating network found themselves in a situation in which their loan providers from the mating network gained bargaining power, I consider human capital investment as a means of increasing one's repayment capacity. I find that the debtors from outside the mating network also invested significantly more in human capital after the flood, which is consistent with their facing potentially higher interest rates demanded by the mating network after the flood.

4.2 Results

Impact on intra-village and outside credit. Table 5 reports the results from estimating (3) for intra-village credit in the first two columns (without and with other controls), and for outside credit in the last two columns (without and with other controls). The difference-in-differences estimate β_1 is significant at the 6% level for intra-village credit, but insignificant for outside credit. That is, after the flood, villagers outside the mating network borrowed about 16% more from their fellow villagers than did the members of the mating network, while there is no differential effect on credit raised from outsiders.

Note that while these regressions are run at the individual level, given the loan-data requirement, the respective sample comprises mostly adults. In fact, 3,516 out of 4,513 observations stem from household heads. This, in turn, implies that the interpretation of the findings applies also to the more aggregate household level.

As argued in Section 4.1, the interpretation of the difference-in-differences estimates in the first two columns depends on whether intra-village credit has increased not just in relative but also in absolute terms for the villagers outside the mating network. Then, the difference-in-differences estimates identify an increase in demand for intra-village credit on the part of the villagers outside vis-à-vis those inside the mating network.

To confirm that this is the case, Figure 2 plots the combined residuals from the regression in the second column of Table 5, separately for villagers inside and outside the mating network. While members of the mating network generally relied more on intra-village credit than the remaining villagers, the development of their intra-village credit was unaffected by the flood. On the other hand, villagers outside the mating network borrowed significantly less from their fellow villagers until 2005/6,[11] but not thereafter.

Other than a slight increase in intra-village credit for villagers outside the mating network between 2005 and 2006, which may be due to the fact that the flood coincided with the end of the 2006 interview period, the two groups exhibit parallel trends in the pre-flood period. This is important insofar as selection into the mating network – unlike the incidence and extent of the 2006 flood – cannot be assumed to be exogenous. So, in order for the difference-in-differences estimate to be identified, one has to safeguard that in the absence of any network segregation, the average change in intra-village credit would have been the same for both groups. The observed parallel pre-flood trends buttress this assumption.

The post-flood development of intra-village credit confirms the difference-in-differences estimate: intra-village credit increased only for villagers outside the mating network, so that the difference to the mating network's intra-village credit is insignificant throughout the entire post-flood period (whereas it was significant in the pre-flood period). Hence, the difference-in-differences estimate identifies increased credit demand by villagers outside the mating network.

Similarly, one can analyze the behavior of outside credit for the two groups. In Figure 3, with the potential exception of the year 2007, one observes parallel trends throughout, with the villagers outside the mating network attaining significantly more outside credit than members of the mating network (the difference is significant at the 1% level throughout the

[11] The difference is significant at the 2%, 3%, and 5% level in the years 2002, 2004, and 2005, respectively.

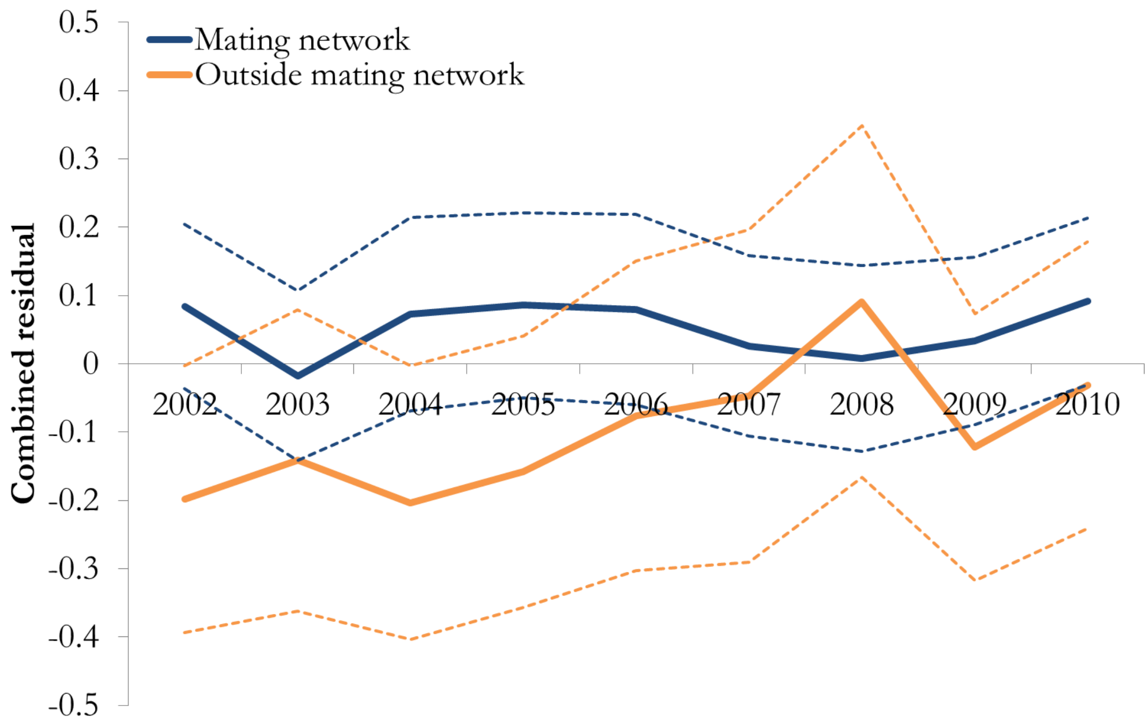

Figure 2: **Intra-village Credit Inside vs. Outside the Mating Network over Time.** The graph plots the combined residuals from the regression in the second column of Table 5, with individual fixed effects and the logged amount of intra-village credit received as dependent variable, separately for members of the mating network and individuals outside the mating network. Dashed lines indicate 95% confidence intervals, constructed using standard errors that are clustered at the household level.

entire period). There is no differential change in outside credit after the flood, however, which reflects the previously documented insignificant difference-in-differences estimate.

The reason why credit demand increased among villagers outside the mating network may be their general lack of insurance, such as that available in the mating network, but could also be due to their greater reliance on outside resources in general. The two explanations may even be interwoven with each other, as greater reliance on outside resources also implies greater involvement with income activities that are more difficult to insure. Generally speaking, different income processes for villagers inside vs. outside the mating network could translate into differential income losses due to the flood shock. Indeed, pre-flood exposure to wage labor, the frequency of visits to the market town of San Borja, and the resulting income structure were the only significant differences between the two groups in Table 2.

Figure 3 displays some evidence that speaks against the possibility that villagers outside

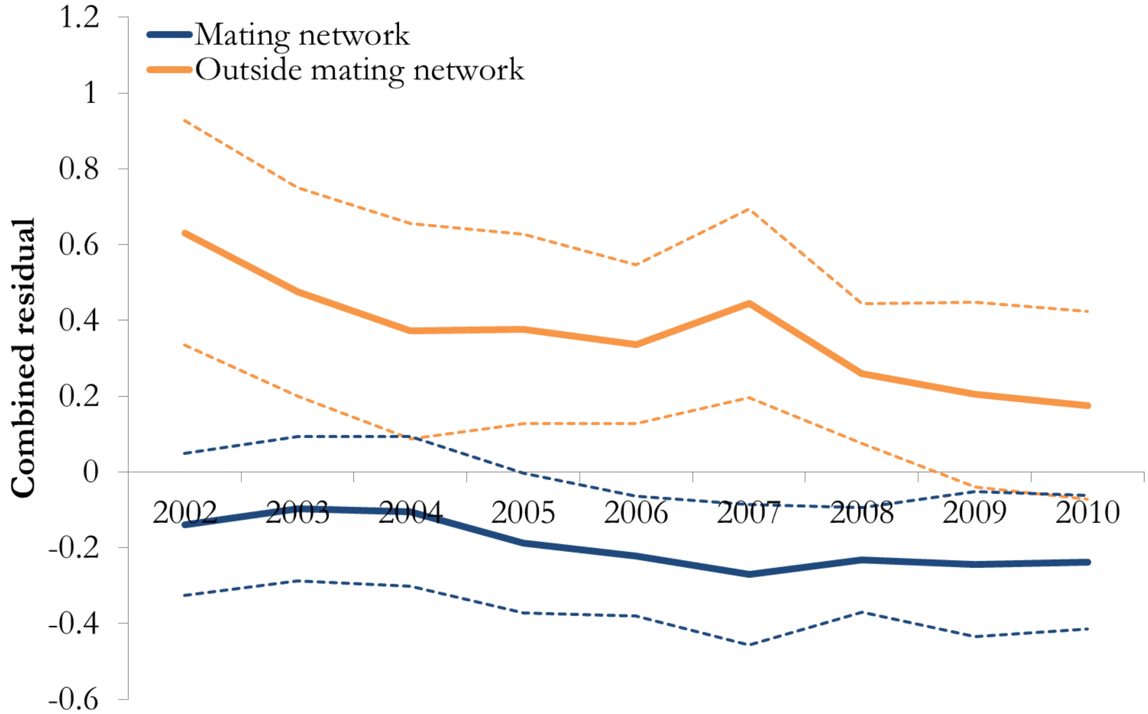

Figure 3: **Outside Credit Inside vs. Outside the Mating Network over Time.** The graph plots the combined residuals from the regression in the fifth column of Table 5, with individual fixed effects and the logged amount of outside credit received as dependent variable, separately for members of the mating network and individuals outside the mating network. Dashed lines indicate 95% confidence intervals, constructed using standard errors that are clustered at the household level.

the mating network were differentially affected by the flood because of their greater pre-flood involvement with outsiders, as their access to outside funds, while elevated in levels, exhibits the same slope as that by villagers inside the mating network.

This motivates further tests as to whether pre-flood differences, while few in numbers, have any explanatory power for differential demand for intra-village credit for villagers inside vs. outside the mating network after the flood. For instance, loan demand and pre-flood differences could interact over time if said differences are any indication of the actual use of funds.

To explore this possibility, in Table 6, I re-run the regressions from Table 5, and in the first and third column include an interaction term of the post-flood dummy with an individual's ratio of total pre-flood income from the sale of forest and farm goods over the sum of total pre-flood sales income and total pre-flood income from wage labor (similar to the last column in Table 3).[12] This variable, *Sales proportion*$_i$, should reflect an individual's (inverse) propensity to engage with the outside labor market via wage labor before the flood. However, it has no impact on post-flood credit outcomes.

Similarly, in the second and fourth column, I include an interaction term of the post-flood dummy with the average number of days an individual worked for an outsider during the pre-flood period, which is extremely close to zero. Most importantly, throughout all columns in Table 6, the difference-in-differences estimates for villagers inside vs. outside the mating network is virtually unaltered compared to those in Table 5.

In addition, in Table 7, I include interactions with the average number of pre-flood town visits, as a proxy for an individual's contact frequency with the outside world, and Spanish fluency, which serves as an entry ticket to the outside labor market, while potentially boosting income from selling forest and farm goods to outsiders as well. Once again, the difference-in-differences estimates are very similar to those in Table 5. This renders it unlikely that the two groups' differential exposure to the outside world and resulting income profiles led to their differential treatment by the flood, at least with respect to their demand for intra-village credit.

Thus far, I have shown that network members did not demand any more intra-village, or even outside, credit after the flood. This suggests that network members did not depend on financial resources to cope with the aggregate shock. To provide evidence that they, instead, relied on non-financial help from fellow villagers, I re-run the regressions from the first two columns of Table 5, and use as dependent variable a continuous variable between 0 and 1 that indicates the proportion of a villager's week spent on helping others. The results are in the first two columns of Table 8, and reveal that members of the mating network helped others after the flood significantly (at the 9% level) more than did the remaining villagers.

As it is unobserved *which group of villagers* received said help by the mating network, I next show that villagers outside the mating network actually had to venture outside the villages – despite the difficulties imposed by physical damages – in order to attain resources

[12] Note that sample sizes vary depending on the availability of data for the additional interaction terms.

to cope with the flood. For this purpose, in the last two columns of Table 8, I use as dependent variable the logged number of visits to the market town of San Borja in a given year. Indeed, villagers outside the mating network visited San Borja more often after the flood than did the members of the mating network. The effect is significant at the 3% level. This lends further support to the hypothesis that members of the mating network were able to rely more on help offered by others in the mating network.

Conversely, villagers outside the mating network were in need of credit. As said credit appears to have been sourced from within, rather than from outside, the villages (see first two vs. last two columns of Table 5), this suggests that it was provided by the mating network, which can be considered a temporary extension of network benefits across the two groups within the villages.

Note, however, that there is a caveat attached to this statement, as the data do not provide any information on whether the *provider* (not the recipient) of an intra-village loan is in the mating network or not. This may not be a problem if one is willing to assume that the group of villagers outside the mating network, due to its relatively small size, does *not* exhibit heterogenous treatment effects to the extent that a fraction of this relatively small group demands credit and the other fraction supplies it. As this assumption – despite its plausibility – is not directly testable in the setting at hand, I seek evidence that the increase in intra-village loans extended to villagers outside the mating network was indeed made possible by the provision of said loans by members of the mating network. Given the data limitations, the only way to provide evidence for this is by correlating aggregate loan volumes at the group level within the villages in a given year, namely loans received and given out by villagers inside and outside the mating network. In this manner, one yields four statistics per village-year and 78 village-years in total (i.e., 13 villages times 6 years, which is due to the fact that I have data on credit given out, rather than credit received, for the years 2005 to 2010, rather than 2002 to 2010).[13]

[13] Standard errors should be, and are, clustered at the village level. However, the number of villages is relatively small. That given, I confirm that the results are similar if I estimate wild bootstrapped standard errors that are clustered at the village level.

Table 9 correlates intra-village credit received by the mating network and by other villagers (in the first three and the last three columns, respectively) with credit given out by these two groups at the village-year level. In the first column, after including village and year fixed effects, one can see that intra-village credit received by the mating network correlates positively only with total credit given out by the mating network, and bears virtually no correlation with total credit given out by the remaining villagers. In the second column, I split total credit into intra-village and outside credit, as per the lenders' report, and find that the most significant and positive correlation pertains to intra-village credit given out by the mating network. After including further controls at the village-year level in the third column, it remains to hold true that intra-village credit received by the mating network correlates positively with credit given out by the mating network, although the correlation with intra-village credit given out dropped and that with outside credit given out by the mating network increased. As the two are mechanically correlated (overall financial strength is reflected in both measures simultaneously), the evidence in the third column still speaks to the conclusion that intra-village credit received by the mating network is primarily related to intra-group lending.

Conversely, intra-village credit received by villagers outside the mating network, in the last three columns of Table 9, is not as clearly correlated with either credit given out by the mating network or credit given out by villagers outside the mating network. For example, the difference between the coefficients on total credit from the mating network and that from the remaining villagers (see fourth column) is a bit less than half the difference in the first column. Furthermore, the last column suggests that intra-village credit received by villagers outside the mating network exhibits the strongest positive correlation – and significantly so – with outside credit from the mating network.

In summary, members of the mating network receive intra-village credit primarily from fellow villagers in the mating network, with the insurance or equity-like features documented in Table 3, whereas villagers outside the mating network source intra-village credit from both groups, if not more heavily from the mating network.

Aggregate-shock exposure and impact on household-level consumption. The findings presented so far imply that the mating network did not require financial resources to cope with the aggregate flood shock, which I have shown by identifying higher demand for intra-village credit by villagers outside, but not inside, the mating network. In addition, as laid out in the previous section, these funds came most likely from the mating network. While the flood shock affected villagers both inside and outside the mating network, those outside the mating network sought informal credit from the mating network to deal with it. That is to say, the mating network acted as a post-flood lender to the remaining villagers and, thus, temporarily shared its network benefits with the remainder of the village.

To evaluate whether the post-flood allocation of informal loans inside the villages potentially helped to equalize the consumption consequences stemming from the flood across the two groups, I re-run the same specifications as in Table 5 at the household level with the value of household consumption as dependent variable. As can be seen in the first two columns of Table 10, the difference-in-differences estimates are insignificant and very close to zero, implying that households inside and outside the mating network were not affected differentially by the flood in terms of their consumption.

In the last two columns of Table 10, I replace the dependent variable by a household's total costs from various shocks (animal loss, crop loss, health, death, fire, flood, house destruction, theft, etc.). This is to fathom whether the two groups were indeed equally exposed to the flood shock, even before the post-flood allocation of informal loans inside the villages. Across both columns, the difference-in-differences estimate is insignificant. This also lends further evidence to the idea that any potential differences in income profiles between villagers inside and outside the mating network did not translate into different levels of wealth loss or other damages due to the flood shock.

Impact on human capital investment. The evidence suggests that the mating network, while using informal loans to share idiosyncratic risk in normal times, refrains from demanding any such loans in bad aggregate times. In addition, I find that members of the mating network helped the remaining villagers through the provision of informal loans, as extra-village credit supply did not increase and, thus, did not suffice to serve the needs of the villagers outside the mating network.

I next attempt to rationalize the mating network's decision to serve as a temporary lender to the remaining villagers after the shock. In particular, I investigate whether this transaction was associated with a shift in bargaining power in favor of the mating network, making it more attractive for its members to extend informal credit to non-members. Informal loans from fellow villagers arguably increased in value after the flood due to the generally worsened access to outside finance, and possibly due to the insurance or equity-like features of intra-village credit which were all the more valuable after the flood.

When scrutinizing whether these conditions contributed to strengthened bargaining power on the part of the mating network in its role as liquidity provider, a binding data limitation is that I do not observe any interest rates due to the informal nature of lending. However, given the simple structure of the Tsimane' economy, it is possible to identify shifts in individual economic behavior, most notably a shift from foraging and farming, the traditional income-generating activity of the Tsimane', towards wage labor, which pays more. As laid out in Section 2.1, learning Spanish is the prevalent form of human capital investment that helps to connect with the outside labor market. Identifying greater human capital investment by villagers outside the mating network following the flood could therefore be interpreted as their intention to increase their repayment capacity, e.g., in response to higher interest rates charged by the mating-network members.

Furthermore, due to the negative effect of the flood on outside-credit supply (see Figure 3), overall indebtedness did not change for villagers outside the mating network. Therefore, incentives for increasing their repayment capacity could respond only to the flood-induced increase in the proportion of intra-village financing in their loan portfolios.

Alternatively, a differential desire to invest in human capital after the flood could indicate that villagers outside the mating network started preparing their eventual out-migration so as to no longer be exposed to such shocks. This is, however, not likely, as I found that villagers outside the mating network were not differentially affected by the flood in terms of their consumption.[14]

Generally speaking, human capital investment can increase because of varying beliefs about the usefulness of learning Spanish. This contrasts with the proposed channel of human capital investment reflecting villagers' efforts to increase their repayment capacity after borrowing more following the flood. The setting at hand offers the opportunity to – at least qualitatively – shed light on which one of the two components is driving the results. For this purpose, I make use of the fact that villages in the plains were flooded the most, but are also among a group of seven villages that have road access to a market town, such as San Borja. The rationale is that in villages close to market towns, the differential involvement of the two groups of Tsimane' with outsiders and, thus, the potential for differential returns to human capital investment should be more pronounced.

In order to disentangle whether any effect on human capital investment by villagers outside the mating network is driven by the severity of the flood shock or the proximity to a market town, one can estimate the difference-in-differences estimate for the most heavily flooded villages (Campo Bello, San Antonio, and Puerto Mendez), and distinguish it from the corresponding estimate for the superset of seven villages with road access to market towns by estimating:

$$\begin{aligned} Spanish\ ability_{it} &= \beta_1 Mating\ network_i \times After_t(2006) \\ &\quad + \beta_2 Mating\ network_i \times Plains_v \times After_t(2006) \\ &\quad + \beta_3 Mating\ network_i \times Market_v \times After_t(2006) \\ &\quad + \beta_4 Other\ controls_{it} + \eta_{vt} + \mu_i + \epsilon_{it}, \end{aligned} \tag{4}$$

where $Market_v \in \{0,1\}$ denotes the seven villages with continuous road access to a market town, three of which are in the $Plains_v \in \{0,1\}$ and were, thus, flooded the most in 2006. The remaining explanatory variables are defined as in specification (3).

For this test, I limit the sample to individuals that did not move between villages during

[14] Indeed, in untabulated regressions, which are available upon request, I find no differential impact of the flood on out-migration by villagers inside vs. outside the mating network.

the run-time of the data, so there is no need to include interactions between Mating network$_i$ and Plains$_v$ as well as Market$_v$, which would otherwise vary over time at the individual level.[15] Then, $\beta_1 + \beta_3$ is the difference-in-differences estimate for villages that are within reach of a market town, $\beta_1 + \beta_2 + \beta_3$ is the difference-in-differences estimate for the most heavily flooded villages, and β_2 is the difference between the latter and the former.

To show that the villagers outside the mating network improved their Spanish fluency after the flood, I re-run the regressions from the first two columns of Table 5 with rated Spanish ability (in speaking and reading, from 0 to 4 in total) as dependent variable. The results in the first two columns of Table 11 show that villagers outside the mating network invested significantly more in Spanish – by a score of 0.14 to 0.15 – than their counterparts in the mating network. This is a sizable effect, given that the pre-flood difference between the two groups amounted to 0.135 (see Table 2). In terms of identification, the inclusion of village-year fixed effects controls for village-wide shocks to the availability of teachers or other learning resources. To the extent that the returns to human capital investment are reaped primarily outside the villages, village-year fixed effects also capture fluctuations in the attractiveness of wage labor (e.g., developments in wages offered by outsiders).

In the third column of Table 11, I estimate specification (4). One can see that the difference-in-differences estimate is not significantly different – and is actually weakest – in the villages with road access to market towns. Conversely, the corresponding estimate for the most heavily flooded villages in the plains is large – negative 0.372 – and significant at the 3% level. This effect is economically significant as well: it corresponds to more than one-quarter of a standard deviation of the pre-flood Spanish fluency of villagers outside the mating network (see Table 2).

As $Plains_v$ is a subset of $Market_v$, the negative coefficient on $Mating\ network_i \times Plains_v \times After_t(2006)$, which is significant at the 13% level, indicates that the effect is (borderline) significantly different in the plains than in villages with access to market towns. This renders

[15] This simplification is innocuous – in part due to the relatively small number of movers, but most importantly, because in untabulated tests, I fail to find any differential impact of the flood on between-village migration by villagers inside vs. outside the mating network. Note also that the sample selection still allows for the possibility of out-migration, e.g., into the towns.

it unlikely that human capital investment by villagers outside the mating network was driven by differential returns or job prospects. As differential human capital investment by villagers outside the mating network was more pronounced in heavily flooded areas, with equal access to market towns, this supports the notion that they responded to their need to repay the mating-network lenders after the flood.

To provide further evidence of the lending channel driving human capital investment by the villagers outside the mating network, I re-run the regressions from the second and third columns for the subsample of individuals with non-zero debt in the pre-flood period from 2002 to 2006. The difference-in-differences estimate in the fourth column suggests that the effect is somewhat stronger in said subsample, compared to that in the second column. In addition, the results in the last column of Table 11 reveal that the difference-in-differences estimate is much more negative in the plains and – at negative 0.456 ($= -0.233 - 0.464 + 0.241$) – significantly different from the difference-in-differences estimate for the villages with road access to market towns.

Finally, in Table 12, I provide two robustness checks. In the first column, I verify that the previous difference-in-differences estimate of 0.14 is not reduced after including measures of school attendance on the right-hand side, namely total years of education and an indicator for whether an individual attended school in the year in question. The opposite is actually the case, but the stronger effect may be driven by the drop in the sample of individuals due to the availability of the variables in question.

In the remaining columns, I re-run the regression from the fourth column in Table 11, but increase the amount of pre-flood credit in steps of five dollars. Comparing across estimates, one can see that the resulting difference-in-differences estimates are monotonically increasing in the amount of pre-flood credit. In summary, the evidence in this section shows that villagers outside the mating network responded differentially to the aggregate shock by learning more Spanish, and their motivation for doing so was interrelated with their general propensity to use credit.

5 Concluding Remarks

In this paper, I analyze the relationship between informal finance and networks, and the extent to which informal finance contributes to the level of risk sharing among extremely poor populations. To shed light on this issue, I use data on socioeconomic behavior and informal lending and borrowing in 13 villages of a foraging-farming society in the Bolivian Amazon, where the Tsimane' reside. I establish that villagers that are members of a mating network experience the benefit of risk sharing, which is in part operationalized through informal loans with insurance or equity-like features. This ability to share idiosyncratic risk is also symptomatic for the mating network's capacity to cope with aggregate shocks: pursuant to a flood shock in 2006, villagers outside the mating network had higher demand for funding, whereas villagers inside the mating network were able to fall back on intra-village resources and other non-financial help.

My findings attest to the idea that networks make use of informal loans to share idiosyncratic risk in good times, but have the ability to refrain from using them in bad aggregate times when informal loans are most costly. This paper is only a starting point for scrutinizing the informal-loans dimension of risk sharing in developing countries. It suggests that by collecting data on and analyzing informal-loan transactions, one can ascertain how (effectively) and under what circumstances networks can help to cushion their members against different kinds of shocks. Informal finance is a distinct contracting feature in the nexus of implicit contracts in social and other networks. Against this background, a fruitful avenue for future research would be to more fully characterize informal financial contracting in networks by addressing the endogenous relationship between network formation and the ability to lend and borrow informally, even in the absence of formal credit markets.

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6 Tables

Table 1: **Proportion of Households Practicing Cross-Cousin Marriage**

Village	Proportion mating network	# of households
Village 1	0.345	29
Village 2	0.514	35
Village 3	0.519	27
Village 4	0.474	19
Village 5	0.677	31
Village 6	0.769	13
Village 7	0.800	15
Village 8	0.889	9
Village 9	0.765	17
Village 10	0.813	32
Village 11	0.786	14
Village 12	0.923	26
Village 13	0.621	29
All villages	0.655	296

Notes: A household is defined as practicing cross-cousin marriage if in the first year of the data (2002) all household heads report that marrying anyone but a cross cousin is unacceptable. If the answer to the underlying survey question is not available for any household head in the first year of the data, then a household is defined as practicing cross-cousin marriage if 100% of the remaining household members, for whom a response was recorded, report that marrying anyone but a cross cousin is unacceptable. The group of villagers practicing cross-cousin marriage is labeled as the "mating network."

Table 2: **Pre-flood Summary Statistics**

Variable	Mating network Mean (Std. dev.)	Mating network N	Remaining group Mean (Std. dev.)	Remaining group N	p-value
Wage-labor income (in 2010 \$ in two weeks)	7.096 (14.250)	460	7.621 (14.184)	241	0.643
Days worked for outsider over two weeks	1.720 (3.088)	460	1.862 (3.178)	241	0.568
Days worked for outsider over two months	4.802 (11.851)	460	7.068 (14.646)	241	0.023
Sales income (in 2010 \$ in two weeks)	5.535 (10.617)	460	7.275 (13.204)	241	0.059
Barter income (in 2010 \$ in two weeks)	1.180 (1.918)	460	1.185 (1.968)	241	0.976
Any credit $\in \{0, 1\}$	0.557 (0.497)	460	0.535 (0.500)	241	0.592
Intra-village credit ($\neq 0$, in 2010 \$ in a year)	7.620 (10.693)	130	7.811 (9.062)	72	0.898
Outside credit ($\neq 0$, in 2010 \$ in a year)	17.743 (45.408)	201	25.244 (63.679)	93	0.250
Helped others $\in [0, 1]$	0.044 (0.075)	452	0.039 (0.068)	237	0.405
Town visits over one year	2.149 (1.718)	460	2.513 (1.728)	241	0.008
Traditional assets (in 2010 \$)	37.803 (30.461)	460	34.344 (29.054)	241	0.147
Animal wealth (in 2010 \$)	22.247 (69.736)	460	23.411 (68.582)	241	0.833
Modern assets (in 2010 \$)	99.431 (109.220)	460	108.496 (110.627)	241	0.299
Spanish ability ($0-4$, max available)	1.711 (1.441)	450	1.846 (1.415)	235	0.240
Math score ($0-4$, max available)	1.277 (1.561)	451	1.318 (1.614)	239	0.747
Years of schooling (latest available)	2.385 (2.501)	454	2.456 (2.673)	237	0.732
Proportion of years in school	0.184 (0.353)	447	0.223 (0.365)	235	0.176
Male	0.496 (0.501)	460	0.523 (0.501)	241	0.495
Age in years (latest available)	37.454 (19.832)	460	37.222 (19.051)	241	0.881
Household consumption (in 2010 \$ in a week)	91.928 (36.822)	164	93.165 (31.901)	88	0.790
Total household shock costs (in 2010 \$)	21.130 (65.504)	184	23.843 (52.208)	100	0.721
Household size	5.905 (2.671)	184	5.783 (2.738)	100	0.718

Notes: In the top panel, all variables are averaged for each individual for all available pre-flood years (from 2002 to 2006). The bottom panel displays summary statistics for variables defined at the household level. The last column indicates the p-values from two-sided difference-in-means tests between members of the mating network and the remaining villagers.

Table 3: **Equity-like Financing in the Mating Network**

	Consumption-growth volatility				
Avg. intra-village credit	-0.208**	-0.195*	-0.115	-0.079	-0.793
	(0.093)	(0.100)	(0.118)	(0.138)	(0.630)
Avg. intra-village credit × Mating netw.			-0.392**	-0.386**	
			(0.164)	(0.169)	
Avg. total credit	0.057	0.061	0.028	-0.009	0.016
	(0.071)	(0.069)	(0.124)	(0.147)	(0.092)
Avg. total credit × Mating netw.			0.055	0.078	
			(0.145)	(0.169)	
Mating network			-0.030	-0.030	
			(0.054)	(0.056)	
Avg. intra-village credit × Sales prop.					0.890
					(1.062)
Avg. total credit × Sales prop.					0.147
					(0.347)
Sales proportion					-0.040
					(0.081)
Village FE	N	Y	Y	Y	Y
Other controls	N	N	N	Y	Y
Mean of dependent variable	0.723	0.723	0.723	0.723	0.713
Std. dev. of dependent variable	0.359	0.359	0.359	0.359	0.347
N	243	243	243	243	231

Notes: All regressions are run at the household level (one observation per household). The dependent variable is the volatility of annual growth in the value of consumption, starting in 2005 (because household consumption is available starting only in 2004). The number of available observations for consumption per household are controlled for separately. Average total (intra-village) credit equals the average amount of credit in 100 2010 $ borrowed in total (from fellow villagers) by each household anytime in or after 2004. *Mating network*$_h$ is an indicator for whether a household practices cross-cousin marriage. *Sales proportion*$_h$ is between 0 and 1, and denotes the ratio of average income from the sale of forest and farm goods by all household members (starting in 2004) over the sum of the average sales income and the average income from wage labor by all household members, the availability of which reduces the number of observations. Other controls include logged average traditional assets, animal wealth and modern assets (all at the household level), and the maximal household size over the time period under consideration. Robust standard errors (clustered at the household level) are in parentheses.

Table 4: **Risk Sharing in the Mating Network**

Panel A: Only households h *inside* the mating network of village v

		$\Delta\ln(c_{ht})$		$\Delta\ln(c_{ht}) - \Delta\ln(c_{vt})$	
$\Delta\ln(c_{vt})$	0.814***	0.821***			
	(0.058)	(0.072)			
$\Delta\ln(Income_{ht})$	0.003	0.007	0.007	0.001	0.000
	(0.023)	(0.023)	(0.021)	(0.022)	(0.022)
Household size					0.013
					(0.022)
Household FE	Y	Y	Y	Y	Y
Year FE	N	Y	N	Y	Y
Village-year FE	N	N	Y	N	N
N	526	526	526	526	526

Panel B: Only households h *outside* the mating network of village v

		$\Delta\ln(c_{ht})$		$\Delta\ln(c_{ht}) - \Delta\ln(c_{vt})$	
$\Delta\ln(c_{vt})$	0.861***	0.907***			
	(0.077)	(0.084)			
$\Delta\ln(Income_{ht})$	0.070**	0.061**	0.087***	0.059**	0.057**
	(0.027)	(0.027)	(0.032)	(0.028)	(0.028)
Household size					0.055***
					(0.021)
Household FE	Y	Y	Y	Y	Y
Year FE	N	Y	N	Y	Y
Village-year FE	N	N	Y	N	N
N	313	313	313	313	313

Notes: All regressions are run at the household level, and include household fixed effects. $\Delta\ln(c_{ht})$ and $\Delta\ln(c_{vt})$ denote the growth rate of consumption at the household level and at the village level (excluding household h) in year t, respectively. $\Delta\ln(Income_{ht})$ is the growth rate of the sum of income from wage labor and from the sale of forest and farm goods by all earners in household h in year t. Robust standard errors (clustered at the household level) are in parentheses.

Table 5: **Impact of Flood on (Sources of) Informal Finance**

	ln(1+Intra-village credit)		ln(1+Outside credit)	
Mating network × After(2006)	-0.161*	-0.164*	0.083	0.075
	(0.085)	(0.086)	(0.106)	(0.107)
ln(Total assets)		0.024		0.053
		(0.029)		(0.039)
Age in years		0.003		-0.001
		(0.003)		(0.004)
Household size		-0.008		-0.018
		(0.010)		(0.016)
ln(Total assets of all other HH members)		-0.014		-0.052
		(0.034)		(0.037)
Individual FE	Y	Y	Y	Y
Village-year FE	Y	Y	Y	Y
N	4,513	4,513	4,513	4,513

Notes: All regressions are run at the individual level, and include individual and village-year fixed effects. In the first two columns, the dependent variable is the logged amount of credit received from fellow villagers. In the last two columns, the dependent variable is the logged amount of credit received from outsiders. *Mating network*$_i$ is an indicator for whether in the first year of the data (2002), an individual belonged to a household that practices cross-cousin marriage. *After*$_t(2006) \in \{0, 1\}$ is an indicator for the post-flood period from 2007 to 2010 (the last year in the data). *Total assets*$_{it}$ is the sum (of values) of an individual's traditional assets, animal wealth, and modern assets in year t. Robust standard errors (clustered at the household level) are in parentheses.

Table 6: **Impact of Flood on (Sources of) Informal Finance – Robustness I**

	ln(1+Intra-village credit)		ln(1+Outside credit)	
Mating network × After(2006)	-0.182*	-0.169**	0.082	0.082
	(0.095)	(0.085)	(0.121)	(0.109)
Sales proportion × After(2006)	-0.018		0.242	
	(0.114)		(0.187)	
Avg. no. days worked × After(2006)		-0.004		0.005
		(0.004)		(0.010)
ln(Total assets)	0.054*	0.030	0.031	0.049
	(0.032)	(0.030)	(0.048)	(0.041)
Age in years	0.001	0.002	-0.002	-0.001
	(0.003)	(0.003)	(0.005)	(0.004)
Household size	0.001	-0.007	-0.010	-0.016
	(0.012)	(0.011)	(0.017)	(0.017)
ln(Total assets of all other HH members)	-0.019	-0.015	-0.051	-0.047
	(0.039)	(0.035)	(0.042)	(0.038)
Individual FE	Y	Y	Y	Y
Village-year FE	Y	Y	Y	Y
N	3,675	4,274	3,675	4,274

Notes: All regressions are run at the individual level, and include individual and village-year fixed effects. In the first two columns, the dependent variable is the logged amount of credit received from fellow villagers. In the last two columns, the dependent variable is the logged amount of credit received from outsiders. *Mating network*$_i$ is an indicator for whether in the first year of the data (2002), an individual belonged to a household that practices cross-cousin marriage. $After_t(2006) \in \{0, 1\}$ is an indicator for the post-flood period from 2007 to 2010 (the last year in the data). *Sales proportion*$_i$ is between 0 and 1, and denotes the ratio of total pre-flood (i.e., from 2002 to 2006) income from the sale of forest and farm goods over the sum of total pre-flood sales income and total pre-flood income from wage labor by an individual (all measured in 2010 \$). *Avg. no. days worked*$_i$ is equal to the average number of days an individual worked for an outsider, as measured over two months in the pre-flood years 2002 to 2006. *Total assets*$_{it}$ is the sum (of values) of an individual's traditional assets, animal wealth, and modern assets in year t. Robust standard errors (clustered at the household level) are in parentheses.

Table 7: **Impact of Flood on (Sources of) Informal Finance – Robustness II**

	ln(1+Intra-village credit)		ln(1+Outside credit)	
Mating network × After(2006)	-0.166*	-0.155*	0.074	0.080
	(0.086)	(0.087)	(0.107)	(0.109)
Avg. no. town visits × After(2006)	0.039		0.061*	
	(0.032)		(0.037)	
Spanish fluency × After(2006)		0.006		-0.024
		(0.031)		(0.042)
ln(Total assets)	0.028	0.038	0.046	0.048
	(0.030)	(0.031)	(0.041)	(0.042)
Age in years	0.002	0.002	-0.001	-0.001
	(0.003)	(0.003)	(0.004)	(0.004)
Household size	-0.007	-0.008	-0.016	-0.015
	(0.011)	(0.011)	(0.017)	(0.016)
ln(Total assets of all other HH members)	-0.011	-0.009	-0.047	-0.065*
	(0.035)	(0.035)	(0.038)	(0.038)
Individual FE	Y	Y	Y	Y
Village-year FE	Y	Y	Y	Y
N	4,274	4,229	4,274	4,229

Notes: All regressions are run at the individual level, and include individual and village-year fixed effects. In the first two columns, the dependent variable is the logged amount of credit received from fellow villagers. In the last two columns, the dependent variable is the logged amount of credit received from outsiders. *Mating network*$_i$ is an indicator for whether in the first year of the data (2002), an individual belonged to a household that practices cross-cousin marriage. $After_t(2006) \in \{0, 1\}$ is an indicator for the post-flood period from 2007 to 2010 (the last year in the data). *Avg. no. town visits*$_i$ is equal to the average number of times an individual has reported to have visited the market town of San Borja in a given year during the pre-flood years 2002 to 2006. *Spanish fluency*$_i$ is equal to the maximal value of an individual over the pre-flood years 2002 to 2006 for the sum of two scores for speaking and reading skills, each of which ranges from 0 to 2, giving a total range from 0 to 4. *Total assets*$_{it}$ is the sum (of values) of an individual's traditional assets, animal wealth, and modern assets in year t. Robust standard errors (clustered at the household level) are in parentheses.

Table 8: **Impact of Flood on Non-financial Help and Reliance on Extra-village Resources**

	Helped others $\in [0,1]$		ln(1+Town visits)	
Mating network × After(2006)	0.021*	0.021*	-0.160**	-0.157**
	(0.012)	(0.012)	(0.072)	(0.072)
ln(Total assets)		0.005		-0.032*
		(0.005)		(0.019)
Age in years		-0.000		-0.001
		(0.000)		(0.002)
Household size		-0.000		0.010
		(0.002)		(0.010)
ln(Total assets of all other HH members)		0.005		-0.001
		(0.005)		(0.020)
Individual FE	Y	Y	Y	Y
Village-year FE	Y	Y	Y	Y
N	4,010	4,010	4,513	4,513

Notes: All regressions are run at the individual level, and include individual and village-year fixed effects. In the first two columns, the dependent variable is the proportion of a week spent on helping others measured over one week in a given year. In the last two columns, the dependent variable is the logged number of visits to the market town of San Borja in a given year. *Mating network*$_i$ is an indicator for whether in the first year of the data (2002), an individual belonged to a household that practices cross-cousin marriage. *After*$_t$(2006) $\in \{0, 1\}$ is an indicator for the post-flood period from 2007 to 2010 (the last year in the data). *Total assets*$_{it}$ is the sum (of values) of an individual's traditional assets, animal wealth, and modern assets in year t. Robust standard errors (clustered at the household level) are in parentheses.

Table 9: **Credit Transfers within and between Groups at the Village Level**

	ln(Intra-village credit received)					
	by mating network			by other villagers		
ln(Total credit from network)	0.445***			-0.016		
	(0.136)			(0.138)		
ln(Total credit not from network)	-0.024			0.213		
	(0.110)			(0.176)		
ln(Intra-village credit from network)		0.449***	0.237		-0.145	0.005
		(0.098)	(0.299)		(0.114)	(0.253)
ln(Intra-village credit not from network)		-0.089	0.158		0.049	0.060
		(0.134)	(0.402)		(0.232)	(0.318)
ln(Outside credit from network)		0.166	0.298*		0.116	0.380**
		(0.094)	(0.142)		(0.178)	(0.174)
ln(Outside credit not from network)		0.213**	-0.355		0.133	0.273
		(0.092)	(0.319)		(0.154)	(0.324)
Village FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Other controls	N	N	Y	N	N	Y
N	78	78	78	78	78	78

Notes: All regressions are run at the village level, and include village and year fixed effects. The dependent variable in the first three columns is the logged amount of intra-village credit received by all members of the mating network in a given village and year, whereas the dependent variable in the last three columns is the logged amount of intra-village credit received by all other villagers in the same village in a given year, starting in 2005 (because data on credit given out, rather than received, by villagers is available starting only in 2005). For the independent variables, I differentiate among intra-village and outside credit (or their sum, i.e., total credit) given out by members of the mating network and by villagers outside the mating network in the same village. Note that for both credit received and given out, the classification as intra-village or outside credit relies on an individual's reported source or recipient of a loan. Other controls include village-level buying prices for all foods, other forest and farm goods, foraging-farming equipment, modern assets, and any other goods. Robust standard errors (clustered at the village level) are in parentheses.

Table 10: **Impact of Flood on Household Consumption and Total Cost of Shocks**

	ln(HH consumption)		ln(1+Total HH-level shock costs)	
Mating network × After(2006)	0.005	0.007	-0.059	-0.073
	(0.046)	(0.045)	(0.258)	(0.250)
ln(Total assets)		0.018		0.214
		(0.031)		(0.141)
Average age of HH in years		0.001		0.009
		(0.002)		(0.010)
Household size		0.036***		0.101**
		(0.009)		(0.040)
Household FE	Y	Y	Y	Y
Village-year FE	Y	Y	Y	Y
N	1,508	1,508	1,928	1,928

Notes: All regressions are run at the household level, and include household and village-year fixed effects. In the first two columns, the dependent variable is the logged value of household consumption. In the last two columns, the dependent variable is the logged total amount of costs due to any, including flood-related, shocks at the household level. $\textit{Mating network}_h$ is an indicator for whether a household practices cross-cousin marriage. $\textit{After}_t(2006) \in \{0, 1\}$ is an indicator for the post-flood period from 2007 to 2010 (the last year in the data). $\textit{Total assets}_{ht}$ is the sum (of values) of a household's traditional assets, animal wealth, and modern assets in year t. Robust standard errors (clustered at the household level) are in parentheses.

Table 11: **Impact of Flood on Human Capital Investment**

	Spanish ability in speaking & reading $(0-4)$				
Mating network × After(2006)	-0.140**	-0.147**	-0.156**	-0.164**	-0.233***
	(0.062)	(0.062)	(0.065)	(0.066)	(0.079)
Mating network × Plains × After(2006)			-0.306$^{(*)}$		-0.464*
			(0.202)		(0.244)
Mating network × Market × After(2006)			0.090		0.241
			(0.135)		(0.157)
ln(Total assets)		0.035*	0.033	0.044**	0.043*
		(0.019)	(0.021)	(0.022)	(0.024)
Age in years		-0.002	-0.001	-0.000	-0.000
		(0.002)	(0.002)	(0.002)	(0.002)
Household size		-0.023***	-0.024***	-0.029***	-0.030***
		(0.008)	(0.008)	(0.009)	(0.009)
ln(Total assets of all other HH members)		0.015	0.042*	0.013	0.033
		(0.024)	(0.025)	(0.024)	(0.025)
Individual FE	Y	Y	Y	Y	Y
Village-year FE	Y	Y	Y	Y	Y
Sample	All	All	No move	Pre-credit >0 bs	No move, pre-credit >0 bs
Test: sum of first three rows = 0 (p-value)			0.024		0.027
N	3,173	3,173	2,827	2,164	1,900

Notes: All regressions are run at the individual level, and include individual and village-year fixed effects. The dependent variable is an individual's Spanish ability, measured as the sum of two scores for speaking and reading skills, each of which ranges from 0 to 2, giving a total range from 0 to 4. *Mating network*$_i$ is an indicator for whether in the first year of the data (2002), an individual belonged to a household that practices cross-cousin marriage. $After_t(2006) \in \{0, 1\}$ is an indicator for the post-flood period from 2007 to 2010 (the last year in the data). $Market_v \in \{0, 1\}$ denotes the seven villages with continuous road access to a market town, three of which are in the $Plains_v \in \{0, 1\}$ and were, thus, flooded the most in 2006. *Total assets*$_{it}$ is the sum (of values) of an individual's traditional assets, animal wealth, and modern assets in year t. The sample in the third column is limited to individuals that did not move between villages during the run-time of the data. The sample in the fourth column is limited to individuals with non-zero debt in the pre-flood period (until and including the year 2006). The sample in the fifth column is the intersection of the samples in the third and fourth columns. Robust standard errors (clustered at the household level) are in parentheses.

Table 12: **Impact of Flood on Human Capital Investment – Robustness**

	Spanish ability in speaking & reading $(0-4)$			
Mating network × After(2006)	-0.393**	-0.255***	-0.264**	-0.317**
	(0.178)	(0.086)	(0.118)	(0.137)
ln(Total assets)	0.031	0.075**	0.105***	0.106**
	(0.027)	(0.030)	(0.038)	(0.042)
Age in years	-0.003	0.000	-0.000	-0.003
	(0.003)	(0.003)	(0.003)	(0.003)
Currently in school	0.002			
	(0.074)			
Years of schooling	-0.010			
	(0.030)			
Household size	-0.030***	-0.037***	-0.033**	-0.041**
	(0.010)	(0.012)	(0.013)	(0.017)
ln(Total assets of all other HH members)	0.013	0.000	-0.008	0.021
	(0.030)	(0.031)	(0.037)	(0.037)
Individual FE	Y	Y	Y	Y
Village-year FE	Y	Y	Y	Y
Sample	All	Pre-credit > $5	Pre-credit > $10	Pre-credit > $15
N	2,225	1,377	1,063	793

Notes: All regressions are run at the individual level, and include individual and village-year fixed effects. The dependent variable is an individual's Spanish ability, measured as the sum of two scores for speaking and reading skills, each of which ranges from 0 to 2, giving a total range from 0 to 4. *Mating network*$_i$ is an indicator for whether in the first year of the data (2002), an individual belonged to a household that practices cross-cousin marriage. *After*$_t$(2006) $\in \{0, 1\}$ is an indicator for the post-flood period from 2007 to 2010 (the last year in the data). *Total assets*$_{it}$ is the sum (of values) of an individual's traditional assets, animal wealth, and modern assets in year t. *Currently in school*$_{it}$ $\in \{0, 1\}$ is an indicator for whether an individual attended school in year t. Similarly, *Years of schooling*$_{it}$ is the number of years, up to and including any attendance in year t, that an individual spent in school. The samples in the second, third, and fourth columns are limited to individuals with debt balances of over $5, $10, and $15 (in 2010 terms) in the pre-flood period (until and including the year 2006). Robust standard errors (clustered at the household level) are in parentheses.