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WHY IS MOBILITY IN INDIA SO LOW? SOCIAL INSURANCE, INEQUALITY, AND GROWTH

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ABSTRACT

This paper examines the hypothesis that the persistence of low spatial and marital mobility in rural India, despite increased growth rates and rising inequality in recent years, is due to the existence of sub-caste networks that provide mutual insurance to their members. Unique panel data providing information on income, assets, gifts, loans, consumption, marriage, and migration are used to link caste networks to household and aggregate mobility. Our key finding, consistent with the hypothesis that local risk-sharing networks restrict mobility, is that among households with the same (permanent) income, those in higher-income caste networks are more likely to participate in caste-based insurance arrangements and are less likely to both out-marry and out-migrate. At the aggregate level, the networks appear to have coped successfully with the rising inequality within sub-castes that accompanied the Green Revolution. The results suggest that caste networks will continue to smooth consumption in rural India for the foreseeable future, as they have for centuries, unless alternative consumption-smoothing mechanisms of comparable quality become available.

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1 Introduction

Increased mobility is the hallmark of a developing economy. Although individuals might be tied to the land they are born on and the occupations that they inherit from their parents in a traditional economy, the emergence of the market allows individuals to seek out jobs and locations that are best suited to their talents and abilities. Among developing countries, India stands out for its remarkably low levels of occupational and spatial mobility. Munshi and Rosenzweig (2006), for example, show how caste-based labor market networks have locked entire groups of individuals into narrow occupational categories for generations. India lags behind other countries with similar size and levels of economic development in terms of spatial mobility as well.[1] Figure 1 plots the percent of the adult population living in the city, and the change in this percentage over the 1975-2000 period, for four large developing countries: Indonesia, China, India, and Nigeria (UNDP 2002). Urbanization in all four countries was low to begin with in 1975 but India falls far behind the rest by 2000. Deshingkar and Anderson (2004) show that rates of urbanization in India are lower, by one full percentage point, than countries with similar levels of urbanization, and that the fraction of the population that is urban in India is 15 percent lower than in countries with comparable GDP per-capita.

Data from the Indian census indicates that just one-fifth of the growth in the urban population from 1991 to 2001, which we have seen is relatively low, can be attributed to migration. Indeed, permanent migration of all types - including rural-to-rural and rural-to-urban - has remained low despite the restructuring of the Indian economy during the 1990's. The proportion of individuals in the population that changed residence in the decade preceding the 1991 and 2001 census rounds was roughly constant, and among these migrants less than a third were men seeking jobs. Consistent with these national trends, a sample of Indian households drawn from all the major states in the country that we use for much of the analysis in this paper indicates that in rural areas permanent migration rates of men out of their origin villages were as low as 8.7 percent in 1999.[2] Indeed, it is standard

[1] By spatial mobility we mean a permanent change in residence. Recent evidence indicates that temporary or circular migration - one or more members of a household temporarily moves to an area for work purposes while other family members remain in the same village - has increased in India (Deshingkar and Anderson, 2004), although there are no national statistics on this phenomenon.

[2] This statistic refers to men aged 20-30 in 1999 who had left their rural residences five or more years ago. Women have traditionally migrated outside the village to marry in India. In our data, of the rural women marrying between 1982 and 1999, more than 88 percent had left their origin village by 1999, and marriage is almost always the reason for this exit. Along these lines, the 2001 census indicates that movement due to marriage accounts for roughly 45 percent of all permanent migration in India, while employment, business, and the movement of entire families accounts for just 39 percent of migration (similar statistics are obtained in the 1991 round). We will consequently focus on male out-migration when measuring spatial mobility in this paper.

practice for researchers to ignore out-migration in empirical studies based in rural India, although a coherent explanation for such immobility rooted in the fundamental features of the local economy is lacking.[3]

Low rates of out-migration are not the only indicators of immobility in India. The basic marriage rule in Hindu society is that no individual is permitted to marry outside the sub-caste or *jati*. Social mobility will be severely restricted by this rule because individuals are forced to match within a very narrow pool. Social mobility, as measured by inter-caste marriage, continues to be low in rural India despite the economic changes within and across castes that have taken place over the past decades. Recent surveys in rural and urban India that the authors have conducted indicate that among 25-40 year olds, out-marriage was 7.6% in Mumbai in 2001, 6.2% in South Indian tea plantations in 2003, and 5.8% for the rural Indian population in 16 major states of India in 1999.[4]

Why is mobility in India so low? Many explanations for this phenomenon are possible; for example, one explanation for the low rural-urban migration in India in the 1970's and 1980's is that opportunities in the rural areas expanded with the increase in agricultural productivity that accompanied the Green Revolution, and so the push that drives migration in other economies may have been absent. However, the productivity increases associated with the initial stages of the Indian Green Revolution were not spread evenly across India, increasing disparities in rural wage rates and thus the gains from rural-to-rural migration. Moreover, over the past 15 years or more Indian growth rates, inclusive of the non-agricultural sector, have been high by any standard and male migration and out-marriage continue to be low, at least in rural areas. Similarly, it could be argued that individuals continue to marry within their *jatis* simply because they have a strong preference for partners with the same background and characteristics. However, this cannot explain why out-marriage has not increased despite the increase in within-*jati* inequality that we document below.

The particular (unified) explanation for both low out-marriage and low out-migration that we propose in this paper is that rural *jati*-based networks, which have been active in smoothing consumption for centuries in the absence of well functioning markets, restrict mobility. Marriage ties increase social

[3]The assumption that the rural population is essentially immobile has been made in studies of local governance in rural India (Banerjee *et al.*, 2005), the determinants of rural schooling (Foster and Rosenzweig, 1995), and trade between castes (Anderson, 2005).

[4]The statistic for Mumbai is based on the parents and the siblings of the sampled school children who were aged 25-40. The statistic for the South Indian tea plantations is based on those workers and their children who were in the same age-range. And the statistic for rural India is drawn from a representative sample of rural Indian households, surveyed in 1982 and 1999, that we use for much of the analysis in this paper. This statistic is computed using the siblings and the children of household heads in 1982 who were aged 25-40 in 1999.

interactions within a *jati* and so exclusion from these interactions serves as a natural mechanism to sustain cooperative behavior. Once households out-marry or out-migrate, these interactions will be less frequent and less important, resulting in a commensurate decline in the network's ability to punish. A standard result from the repeated games literature is that if punishments are set to zero and individuals are sufficiently impatient, cooperation cannot be sustained. If this were applicable to our rural Indian setting, then each household would be faced with two choices: (i) participate in the network but then forego the additional utility that comes with mobility, or (ii) out-marry and out-migrate at the cost of losing the services of the network. Without access to alternative consumption-smoothing arrangements of comparable quality, most households appear to have historically chosen the first option and continue to do so today.[5]

We use in this paper newly-available survey data describing the population of rural India over the past three decades that identifies the *jatis* of household heads, their spouses and their immediate relatives and provides detailed information on loans and gifts to (i) examine the hypothesis that caste networks providing mutual insurance play an important role in limiting mobility and (ii) assess the prospects for both the decay of these networks and for increased mobility as economic growth proceeds. A direct test of the hypothesis that rural households forego mobility in return for superior insurance is that those who leave networks are less insured. However, any attempt to estimate the loss of insurance due to out-marriage or out-migration must take account of the fact that both insurance and mobility are endogenously determined. In our view there are no credible instruments for marriage or migration that would identify their effects on insurability. Our strategy instead is to exploit the permanent increase in income inequality within *jatis* that accompanied the agricultural Green Revolution. The model that we describe below identifies households that would be most likely to leave the mutual insurance arrangement in the aftermath of this technological change as well as the *jatis* that would be most vulnerable to such exit. We then proceed to show that it is precisely those households and the members of those vulnerable *jatis* that are observed to have the greatest rates of out-marriage and out-migration.

We begin the analysis in this paper by establishing the importance of caste-based insurance networks in Section 2. Using data from the 1982 and 1999 rounds of the national rural survey that we use

[5]The argument that mobility is accompanied by a loss in network services applies to *unilateral* moves. If a sufficiently large subset of the *jati* moves to the city, for example, it may still be possible to maintain traditional network ties. Consistent with this view, historical and contemporary evidence suggests that occupational and spatial migration in India, although infrequent, occurred and continues to occur under the auspices of the *jati* (Chandravarkar 1985, Damodaran 2008).

for much of the analysis, we show that nearly one-quarter of the households in the sample participated in the insurance arrangement in the year prior to each survey round, giving or receiving transfers. These transfers can be broadly classified into gifts and loans, and although loans account for just 20 percent of all within-caste transactions by value, they are more important than bank loans or moneylender loans in smoothing consumption and in particular for meeting contingencies such as illness and marriage that impose infrequent but very large costs. We also show that caste loans are received on more favorable terms, with respect to both interest rates and collateral requirements, than alternative sources of finance. There is a large literature on credit markets in developing countries that has primarily focused on the interaction between traditional local moneylenders and formal banks. More recently, attention has shifted to micro-finance arrangements. This literature, however, has ignored informal caste-based loans, which we will see are an important source of credit in rural India.

How well do these caste networks function? Based on Townsend's (1994) work in rural India, many studies have implemented a test of full risk-sharing in which a key implication is that household consumption should be completely determined by aggregate consumption in the group around which the mutual insurance is organized and, in addition, should be independent of transitory income shocks. Although individuals may receive loans from moneylenders, employers, and other individuals outside their *jati* with whom they have established close bilateral relations, the interactions that are needed to support collective punishments and sustain cooperative behavior at the level of the group occur predominantly within *jatis*. Previous contributions to the risk-sharing literature that are situated in rural India have treated the village as the social unit, whereas we argue instead that the *jati*, which extends beyond village boundaries, is the relevant unit around which the insurance network is organized.[6] Section 3 of the paper reports results from Townsend's test of full risk-sharing, using a national panel sample of rural households over a three-year period, 1969-71 to assess if household consumption co-moves strongly with aggregate *jati* consumption. An extremely high degree of consumption smoothing is sustained at the level of the *jati*, although we formally reject full risk-sharing, matching the results from many previous studies (see, for example, Townsend 1994, Grimard 1997, Ligon 1998, and Fafchamps and Lund 2000). Additional robustness tests that control for consumption outside the *jati* in the village, and study the co-movement of household consumption with *jati*

[6] An exception is Morduch (2004) who considers sub-caste groupings within villages as mutual-insurance networks. Given the data used, however, he could not implement the robustness checks reported below, which exploit the fact that caste networks extend beyond the village. Grimard (1997) using data from Cote d'Ivoire shows that risk-sharing extends beyond the boundaries of the village and is carried out among spatially-spread households within ethnic lineages. He also presents descriptive evidence that migration patterns are inhibited by ethnic ties.

consumption outside the village, reinforce the claim that the *jati* is the appropriate domain of the insurance network.

Having established the importance of caste networks and their role in smoothing consumption, we next assess within the context of a model the effect of a permanent increase in income inequality within the *jati* on the stability of the insurance arrangement, with accompanying implications for out-marriage and out-migration. The model that we develop in Section 4 is solved in two steps: In the first step, we solve for the expected surplus from participating in the network over autarky for each household. This step closely follows Ligon, Thomas, and Worrall, except that households that deviate from the cooperative arrangement receive a boost to their utility from mobility in autarky. Having computed the surpluses in the first step, households decide whether or not to participate in the insurance arrangement in the second step.

Given the punishments that are in place, consumption-smoothing transfers will be set so that no household ever deviates from the cooperative arrangement and exits *ex post*, once it has chosen to participate. However, a household that stays out of the arrangement to begin with can out-marry and out-migrate without punishment. It follows that the expected surplus could be negative *ex ante* (in step 2) if the benefits of the insurance arrangement are dominated by the gains from mobility. The main result of the model is that conditional on the household's income, a permanent increase in the rest of the network's income following an unexpected technological change will increase its *ex ante* surplus under plausible conditions. If households that traditionally participated in the mutual insurance arrangement are allowed to reconsider their decision following the technological change, this implies that households in relatively wealthy *jatis* will be more likely to continue to participate. Holding incomes constant in the rest of the network, an increase in the household's own income will have the opposite effect on its participation. More importantly for the key hypothesis of this paper, these permanent changes in income should have the opposite effect on mobility.

To test the predictions of the model, we need a source of exogenous variation in income inequality within the *jati* that is uncorrelated with factors, such as access to credit or public amenities in the village, that might directly affect participation in the mutual insurance arrangement or mobility. For this purpose, we exploit two features of the Indian Green Revolution: First, the returns to the new High Yielding Varieties (HYVs) were much greater on irrigated land. Second, only certain parts of the country had access to this superior technology at the onset of the Green Revolution in the late 1960's. Although cross-breeding with local varieties ultimately allowed the new technology to be adopted throughout the country, those areas that had a head start ended up with a different income trajectory than those that followed, particularly those areas with pre-existing irrigation capacities. This spatial variation in income in the aftermath of the Green Revolution increased inequality within historically homogeneous *jatis*, which typically span a wide area. Indeed, comparison of Gini coefficients of the rural income distribution in 1982 and 1999, as presented in Figure 2, indicate that within-*jati* inequality rose by 42 percent over this period. In contrast, within-village inequality rose by 30 percent over the same time-period.[7]

In Section 5 of the paper we estimate the effect of permanent changes in income between 1982 and 1999, for a panel of households and their *jatis*, on participation in the mutual insurance arrangement and mobility. Following the discussion above, the instruments for the change in income are restricted to the interaction of the share of irrigated land in the village in 1971 and access to the new HYV technology in that year, land area inherited by the household head, and the triple interaction of these variables. Our identification strategy allows for the possibility that access to HYV seeds in the village in 1971 at the onset of the Green Revolution and irrigation in that year are endogenously determined, reflecting unobserved variation in local credit access and governance capability. Exploiting the complementarity between irrigation and the new HYV technology, only the coincidental *interaction* of these variables, scaled up by inherited land area, is used to predict changes in income. The instrumental variable estimates match well with the predictions of the model and are robust to the incorporation of variables reflecting local changes in public amenities and credit facilities. In particular, we find that conditional on changes in the household's own income, an increase in the rest of the *jati*'s income *increases* participation in the insurance arrangement and *decreases* the probability that the household will out-marry and out-migrate. These results are difficult to reconcile with alternative explanations that do not involve the *jati* network but are a natural consequence of the tension between network participation and mobility that arises in our framework.

Apart from establishing a link between caste networks and household mobility, the analysis also connects network viability and income inequality to aggregate growth and mobility. The empirical results indicate that when caste networks are active, permanent increases in income brought about by economic growth, with no accompanying increase in within-network inequality, have little effect on mobility. The theoretical model tells us that what matters for changes in mobility is not even

[7] The 1982 and 1999 Gini coefficients are statistically significantly different at the 5 percent level, both for the *jati* and the village.

(exogenous) changes in inequality in the general population, but rather inequality within the *jati*. Our estimates indicate that a *relative* decline in the rest of the *jati*'s income does increase the household's propensity to out-marry and out-migrate, although the magnitude of this effect turns out to be quite small. Although low mobility has negative implications for growth, the resilience of the caste networks in the face of substantial increases in inequality suggests that they will continue to smooth consumption in rural India in the foreseeable future, as they have for centuries, unless alternative market mechanisms of comparable quality become available.

2 Sources of Financial Support in Rural India

In this section we show that transfers from caste members are important and preferred mechanisms through which consumption is smoothed in rural India. Much of the evidence is based on a panel survey of rural Indian households conducted in 1982 and 1999. The baseline survey is the 1982 Rural Economic Development Survey (REDS) carried out by the National Council of Applied Economic Research (NCAER) in 1981-82 in 259 villages located in 16 states (the major states except Assam).[8] The sample of 4,979 households is meant to be representative of all rural households in those states. Subsequently, all households in the 1982 survey (with the exception of those residing in Jammu and Kashmir) in which at least one member remained in the village were resurveyed in 1999. In addition, in that year a random sample of households was also added so that the the sample retains its representativeness.

Both surveys report caste transfers, which include gift amounts sent and received as well as loans originating from or provided to fellow *jati* members. Table 1 reports the percentage of households in the two survey rounds who gave or received caste transfers in the year prior to each survey. The table shows that even in a single year, participation in the caste-based insurance arrangement is high - 25 percent of the households in the 1982 survey and 20 percent in the 1999 round.[9] Although some caste-based transfers may be used for purposes other than consumption-smoothing, we show below that the caste network plays an especially important role in meeting contingencies such as illness and marriage that impose infrequent but very large costs. We would expect multiple households to support the receiving household when such events do occur and consistent with this view, sending households

[8]The 16 states include Andhra Pradesh, Bihar, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Kerala, Madhya Pradesh, Maharashtra, Karnataka, Orissa, Punjab, Rajastan, Tamil Nadu, Uttar Pradesh, West Bengal.

[9]The statistics in Table 1 are weighted using sample weights and thus are population statistics.

contribute 5-7 percent of their annual income on average whereas the corresponding statistic for receiving households is 20-40 percent. Some of these differences arise because sending households have higher income on average than receiving households, indicative of redistribution within the the *jati* that will play an important role in the discussion that follows. Nevertheless, it is easy to verify that the amount sent per household is less than the amount received, although the share of households that gave transfers is not substantially greater than the share that received transfers, suggesting that out-flows may be under-reported.[10]

A key feature of both surveys is that information on source and purpose is provided for every loan that was outstanding at the beginning of the reference period or obtained during the reference period. Although the 1982 and 1999 survey instruments were designed for the most part to permit analysis across the two time periods, some sections did not coincide precisely. For example, the classification of activities that loans are used for is much coarser in 1999 and, in particular, consumption expenses do not appear as a separate category. Because an important role of the caste networks is to smooth consumption, we restrict our description of loans by source and by purpose to the 1982 survey.

The 1982 survey data indicate that although banks are the dominant source of credit, accounting for 64.6 percent of all loans in value, caste members are the dominant source of informal loans, making up 13.9 percent of the total value of loans received by households in the year prior to the survey. This is more than the amount households obtained from moneylenders (7.9 percent), friends (7.8 percent), and employers (5.6 percent). Table 2 reports the proportion of loans in value terms both by source and purpose. As can be seen, caste loans are disproportionately used to cover consumption expenses and for meeting contingencies such as illness and marriage. For example, although loans from caste members were 14 percent of all loans in value, they were 23 and 43 percent, respectively, of the value of all consumption and contingency loans.[11] In contrast, bank loans are by far the dominant source of finance for investment and operating expenses, but account for just 25 percent and 28 percent of loans received for consumption expenses and contingencies.

[10]An important empirical prediction of our model is that conditional on the household's income, an increase in the rest of the *jati*'s income should increase its participation in the caste-based insurance arrangement. Under-reporting of outflows will only bias our estimates if the change in the mismatch between in-flows and out-flows over time is correlated with the change in *jati* income *relative* to the household's income. There is no obvious reason why this should be the case.

[11]Caldwell, Reddy and Caldwell (1986) surveyed nine villages in South India after a two-year drought and found that nearly half (46%) of the sampled households had taken consumption loans during the drought. The sources of these loans (by value) were government banks (18%), moneylenders, landlord, employer (28%), relatives and members of the same caste community (54%), emphasizing the importance of caste loans for smoothing consumption.

Are the statistics in Table 2, representing the rural population of India in 1982, comparable to the current period? Columns 6-10 of Table 2 describe loans by source and purpose using the 2005 India Human Development Survey (IHDS). This survey, conducted on a representative sample of rural households throughout the country, reports loans received over the five years preceding the survey by source. Unfortunately the survey does not use caste-group as a category, although it does identify loans from relatives, which we will assume are within-caste loans. Some interest bearing loans received from caste members will undoubtedly have been listed in the "Moneylender" category and other loans may have been misclassified in the "Other" category, inflating the value of loans received from those sources at the expense of the "Caste" category. Nevertheless, the basic patterns reported from the 1982 survey round in Columns 1-5 remain unchanged. Caste loans, or more correctly loans from relatives, make up 9 percent of all loans by value, more than both friends and employers. Bank loans are less important in the IHDS than in the 1982 REDS survey, but this may simply reflect differences in reporting; notice that the "Moneylender" and "Other" categories account for a disproportionate share of total loans by value.[12] Looking across purposes, we see once again that informal caste loans are most useful in smoothing consumption and meeting contingencies. Moneylender loans are also extremely important for these purposes, although as discussed some of this may reflect misclassified caste loans; as seen below in Table 3 over 70 percent of caste-based loans in the 1982 survey charged interest. Overall, lending patterns have remained fairly constant over the two decades covered in Table 2.[13]

We argue in this paper that caste networks restrict mobility because comparable arrangements are unavailable, particularly for smoothing consumption and meeting contingencies. Table 3 shows that loan terms - the proportion of zero-interest loans, the proportion of loans not requiring collateral, and the proportion of loans not requiring interest or collateral - are substantially more favorable for caste loans on average. It is quite striking that of the caste loans received in the year prior to the 1982 survey, 20 percent by value required no interest payment and no collateral. The corresponding statistic for the alternative sources of credit was close to zero, except for loans from friends where 4 percent of the loans were received on similarly favorable terms. The IHDS does not provide information on

[12]NGO's and credit groups, which have received a great deal of attention in the economics literature in recent years are also included in the "Other" category. However, these sources together account for less than 2.1 percent of all loans by value received by rural households.

[13]The ICRISAT VLS data is another source of information on loan providers, with one source category listed as "fellow caste member". However, in that survey informal loans charging interest, no matter what their source, were classified as from a "moneylender" (Singh *et al.*, 1985).

collateral but does report whether a loan was interest-free. We see in Table 3, Column 5 that caste (extended family) loans are substantially more likely to be interest-free than loans from other sources, matching the corresponding statistics from the 1982 REDS survey in Column 1.[14]

Tables 2 and 3 establish that loans from caste members are important for smoothing consumption and meeting contingencies that make large expenditure demands, and continue to be advantageous to borrowers compared with loans from major alternative sources of finance in rural India. A variety of financial instruments ranging from gifts to loans with varying interest and collateral requirements are used to smooth consumption within the caste, and it is important to reiterate that caste loans, despite their importance, account for just 23 percent of all within-caste transfers by value. The analysis that follows will formally test the efficiency of caste networks with their associated transfers in smoothing consumption.

3 Caste Networks and Consumption Smoothing

In his study of risk and insurance in village India, Townsend (1994) derives a simple test to assess whether households are fully insured. The set of Pareto-optimal consumption allocations with full risk-sharing can be obtained as the solution to the central planner's problem of maximizing a social welfare function

$$W = \sum_{t=0}^{T} \delta^t \sum_{s=1}^{S} \pi_{st} \sum_{i=1}^{N} \lambda_i u_i(c_{it}^s)$$

where $\delta \in [0, 1)$ is a common discount factor, π_{st} is the probability of state s occurring in period t, λ_i is household i's welfare weight, and c_{it}^s is its consumption allocation in state s and period t, subject to the constraint that total consumption in that state and period should not exceed total income, $\sum_i c_{it}^s = \sum_i y_{it}^s$. The infinitely lived, risk-averse household's utility function $u_i(c_{it}^s)$ has the usual properties and the implicit assumption underlying the resource constraint is that there is no storage and no savings.

Combining the first-order conditions obtained for any two households i and j from this constrained maximization problem, full risk-sharing implies the following well known condition:

$$\frac{u_i'(c_{it}^s)}{u_j'(c_{jt}^s)} = \frac{\lambda_j}{\lambda_i}.$$

[14] We also carried out analysis-of-variance tests of whether the incidence of collateral requirements and zero interest rates were statistically significantly different by loan source controlling for loan purpose, with and without loan-size weighting. The results, available from the authors, indicate that, as in the Table 3, caste loans are significantly less likely to charge interest and require collateral compared with loans from any other source.

The ratio of marginal utilities for any two households will be constant in each time period for any state of nature. Assuming common CRRA preferences across all households, taking logs, summing over any subset of households $j = \{1, ..., J\}$, $j \neq i$, and then dividing by J, the number of households in that subset of the network, we obtain:

$$log(c_{it}^s) = \frac{1}{J}\sum_{j=1}^{J} log(c_{jt}^s) + \left[\frac{1}{\gamma}\left(log\lambda_i - \frac{1}{J}\sum_{j=1}^{J} log\lambda_j\right)\right] \quad (1)$$

where γ is the coefficient of relative risk aversion. This condition should hold in each time period, in any state of nature, and so Townsend's test of full risk-sharing can be easily implemented if panel data over successive years are available:

$$log(c_{it}) = \alpha log(y_{it}) + \beta\left[\frac{1}{J}\sum_{j=1}^{J} log(c_{jt})\right] + f_i \quad (2)$$

where $\frac{1}{J}\sum_{j=1}^{J} log(c_{jt})$ measures average log-consumption in the relevant subset of the network and the additional variable that is introduced, $log(y_{it})$, measures the household's income in period t. The household fixed effect f_i collects all the terms in square brackets in equation (1). With full risk-sharing, the household's consumption in any state of the world will be determined by aggregate consumption ($\beta > 0$), but will be independent of its income ($\alpha = 0$). For the special case with CRRA preferences, $\beta = 1$ as in equation (1).

To implement Townsend's test at the level of the *jati*, we need information on each household's *jati* affiliation. The 1982 and 1999 REDS surveys followed an earlier three-year longitudinal survey, also conducted by the NCAER, over the 1969-71 period. This survey covered 4,118 households in the 17 major states of India and was designed to be representative of the entire rural population of the country in those years. The 1982 survey built on the longitudinal study, adding households where necessary to construct a sample that was representative of the rural population at that later time, while the 1999 survey attempted to track all households in the 1982 round, including those that had partitioned. Detailed *jati* information was not collected in the 1969-71 survey or the 1982 follow-up, but this deficiency was rectified in the 1999 survey round. It is consequently possible to assign *jatis* to those households in the 1969-71 panel who were re-surveyed in 1982 and subsequently in 1999. The test of full-risk sharing, over the 1969-71 period, is consequently restricted to the 1,798 households for which *jati* affiliation is available. The subset of households with *jati* information is not a random sample of the 1969-71 households. However, all time-invariant household characteristics (including the welfare weight) are subsumed in the household fixed effect when implementing the Townsend test.[15]

When the caste system was first established many centuries ago, individuals born into a *jati* were locked into the traditional occupation assigned to it over their lifetimes. These restrictions on occupational mobility gradually weakened over time and today some degree of occupational heterogeneity will exist in any *jati*. What maintains the *jati's* salience (and its ability to support networks serving many different roles) is the rule of marital endogamy, which we have noted continues to be maintained.

What is the appropriate geographical domain in which intra-*jati* marriages occur? If we take the idea that each *jati* was originally defined by an occupation seriously, then a *jati* could potentially span the entire country. This is not the case in practice, however, because India's many languages create natural social and spatial boundaries. For example, consider the case of the Patils, a cultivator caste from the Marathi-speaking part of the country, and the Patels, also a cultivator caste, but from the adjacent Gujarati-speaking area. The Patils and the Patels have the same traditional occupation and hold comparable positions in the caste hierarchy; judging from their names, these groups clearly served the same economic role in the distant past. Nevertheless, Patils and Patels do not inter-marry, simply because they speak different languages. Modern Indian states are conveniently organized along linguistic lines and so the *jati* statistic that we use in the paper will be constructed within each state.

To carry out the tests of full insurance within *jatis*, we need to exclude households that are the only sample representative of their *jati*. This reduces the sample by a small amount, to 1,687 households (5,061 observations). Moreover, because we will carry out tests that further subdivide *jati* membership by location, and for the subsequent econometric analyses we need reasonably accurate measures of *jati* characteristics, we carry out most of the tests of full insurance on households that belong to *jatis* with at least 10 sampled households. To assess if sample restrictions based on *jati* size matter, we will first carry out the test of full insurance on households with at least one other household from their *jati* in the sample, which is the minimum criterion for inclusion. This will be followed by tests on households with at least 10 *jati* representatives in the sample. It is possible, for example, that larger *jatis* are

[15]The absence of *jati* information is not because of non-reporting by households, but because certain 1971 household were excluded from the 1982 and thus the 1999 survey rounds. The 1982 sample design excluded households that divided after 1971, usually because of the death of the household head (Foster and Rosenzweig, 2001). Very few households in the 1999 survey, in which *jati* affiliation was first elicited, did not report their *jati*. As an additional robustness check, we carried out the original Townsend-type test, treating the village as the relevant risk-sharing unit, on the samples of households with and without caste-identity information. Estimates from the two sub-samples, available from the authors, are virtually identical.

more capable of providing insurance. Note, however, that the number of sampled households by *jati* does not necessarily indicate which *jatis* are large or small, given the stratified sampling frame. In our data the household sampling weights are actually lower for *jatis* with greater sample representation, and all *jati* sizes appear to be sufficient to meaningfully spread risk. For example, based on the sample weights, the *jati* with two sample households represents 123,444 rural households.[16]

Table 4, Column 1 begins with the basic specification corresponding to equation (2), including average *jati* consumption, net of the household's own consumption, and the household's own income as regressors for the sample of households with at least one other *jati* member represented in the data. The 1969-71 panel survey collected information on a sample of households in a sample of villages located in the major states of the country. *Jati* consumption is thus computed for a subset of households in the *jati*, but as shown above this does not affect the validity of the test of full risk-sharing. The coefficient on *jati* consumption is 0.9 and the coefficient on the household's income is 0.2 in Column 1. In Column 2 we restrict the sample to households in *jatis* with at least 10 sample households. The results are virtually identical, indicative once again of an extremely high degree of consumption smoothing. However, full risk-sharing is formally rejected for both samples – the hypothesis that the own income coefficient is zero and that the *jati* consumption coefficient is one are both rejected at the 5 percent level. Townsend and numerous subsequent studies that have investigated the ability of informal mutual insurance arrangements to smooth consumption in developing economies arrive at essentially the same conclusion.

We have assumed that a typical *jati* spans a state. Although each major regional language is associated with a single Indian state, multiple states are Hindi-speaking. As a robustness check, we drop Hindi-speaking states, across which marriages could conceivably take place, in Table 4, Column 3. As can be seen, the coefficients with this reduced sample of households remain very similar to what we obtained with the full sample in Column 2. An additional concern when implementing the test of full risk-sharing is that household incomes could be measured with error, mechanically biasing the corresponding coefficient towards zero. The co-movement of household and *jati* consumption could be entirely spurious in that case, to the extent that incomes are correlated across members of the *jati*, with *jati*-level consumption picking up aggregate shocks that influence consumption but are incompletely captured in measured income. The robustness check that we report in Table 4, Column 4 accounts for this possibility by including two regressors that are potentially correlated with income shocks in the

[16]Because of sample stratification, all *jati* statistics are computed using sample weights.

village and, hence, with measurement error in the household's income: (i) a binary variable available in the survey data that takes the value one if there was a negative rainfall shock that adversely affected crop production in the village, and (ii) average log consumption in the village *outside* the household's *jati*.[17] Although the coefficients on both variables are precisely estimated, the own-income coefficient in Column 4 differs very little from the corresponding coefficients in Columns 1-3. Moreover, household consumption co-moves much more strongly with *jati* consumption than with aggregate consumption that is outside the *jati* but within the village.

Table 4, Column 5 takes a different approach to deal with the potential measurement error problem by constructing the consumption variable as the average of log consumption among sampled *jati* members residing outside the village.[18] Recall that the test of full risk-sharing can be implemented with any subset of households in the network. The advantage of using aggregate *jati* consumption outside of the village is that this variable will be mechanically uncorrelated with local (village-level) shocks that could have biased the consumption coefficient in Columns 1-3 and perhaps even in Column 4 if the additional regressors did not fully account for such shocks. We see in Column 5 that household consumption co-moves strongly with *jati* consumption outside the village, although the coefficient on this measure of *jati* consumption is smaller than previous estimates. The coefficient on the household's own income differs very little from the corresponding coefficients in Columns 1-4. One concern with the results just reported is that weather shocks, and income shocks more generally, could extend beyond the village, biasing the *jati* consumption coefficient. As in Column 4, we check for this possibility by including the average log consumption of households who are not members of the *jati* and who also reside outside the village (in the same state) as an additional regressor in Column 6. Reassuringly, the coefficient on non-*jati* consumption is insignificant (and negative) whereas the coefficients on *jati* consumption and household income are largely unchanged from Column 5.

Looking across the columns in Table 4 we see that household consumption co-moves strongly with *jati* consumption without exception, while the income coefficient is small and stable across all specifications. These results indicate that an extremely high degree of consumption smoothing was sustained at the level of the *jati* prior to the onset of the Green Revolution. It is possible that these

[17] The income of a household experiencing a village-level adverse weather shock is reduced by a statistically significant 13 percent on average (fixed effect estimate).

[18] The ICRISAT data that Townsend used to carry out his tests based on the assumption that the village was the relevant risk-sharing entity indicate that almost 60 percent of gifts and 27 percent of loans originated outside of the village (Rosenzweig and Stark, 1989). Our data do not provide the location of transaction partners, but we would expect to see a similar pattern since the domain of the *jati* extends far beyond the village.

results falsely reject full insurance. Townsend (1994) notes that failing to account for preference shocks - such as illness and marriage obligations - can lead to false rejection. Moreover, while it is standard practice to assume that risk preferences are homogeneous, Mazzocco and Saini (2008) argue that this assumption can also lead to conservative estimates of the degree of risk-sharing. When this assumption is relaxed, Mazzocco and Saini demonstrate, using ICRISAT data from rural south India, that full risk-sharing is obtained at the level of the *jati* but not the village. This leads them to conclude, as we do, that the correct risk-sharing unit in rural India is the *jati* rather than the village. Our objective in the analysis that follows is to study the stability of this remarkably efficient caste-based arrangement in the face of technological change that permanently introduced income inequality within *jatis*.

4 The Model

The theoretical framework developed in this section is based on Ligon, Thomas, and Worrall's (2002) model of mutual insurance with limited commitment. While Ligon, Thomas, and Worrall (LTW), Coate and Ravallion (1993), Townsend (1994), and a large literature on mutual insurance that has followed these early studies is concerned with the extent to which transitory shocks can be smoothed, we go beyond this literature to study the effect of a permanent increase in income for a subset of households in the network on the continuing stability of the insurance arrangement, with implications for out-marriage and out-migration.

4.1 Household Preferences and Income Realizations

Household preferences are Gorman aggregable, allowing the N-household insurance arrangement to be equivalently described by a sequence of arrangements between each household, which we denote as household 1, and the rest of the network, which we denote as household 2. Households have per-period utility of consumption $u(c_1)$ and $v(c_2)$ respectively, and while only one household needs to be risk averse to generate a demand for insurance we will assume that both $u(c_1)$ and $v(c_2)$ are strictly concave to simplify the discussion that follows. Households are infinitely lived, discount the future with common discount factor δ, and are expected utility maximizers.

The income that each household exogenously receives in period t depends on the production technology regime $\omega = \{L, H\}$ and the state of nature $s = \{1, ..., S\}$. There are two technology regimes: a low-productivity (L) regime corresponding to the traditional agricultural technology in our context, and a high-productivity (H) regime corresponding to the Green Revolution technology.

There is a high degree of state dependence in the technology regime, with the probability of switching regimes from one period to the next close to zero. Thus, while a household operating in a particular regime at a given point in time is aware of the possibility that the technology could switch, it assigns zero probability to that possibility and assumes (correctly in expectation) that the current regime will persist forever in the future.

Within a technology regime, the state of nature follows a Markov process with the probability of transition from state s to state r given by π_{sr} ($\pi_{sr} > 0 \forall s, r$). Suppressing the ω term to simplify notation, regime-specific income realizations for the two households can then be expressed as $y_1(s)$, $y_2(s)$ respectively. Later when we put structure on the change in income associated with the new technology regime, we will assume that income increases for household 2 in all states and, hence, permanently over time but remains unchanged for household 1: incomes in the L-regime will then be denoted by $y_1(s)$, $y_2(s)$ and the corresponding incomes in the H-regime will be $y_1(s)$, $y_2(s) + \Delta y$.

4.2 The Insurance Arrangement

There is no storage and no savings. Within a technology regime, the autarkic ratio of marginal utilities is not the same across all states (in which case autarky would be first-best). Given that both households are risk averse, this implies that they will gain by making transfers in each state that smooth their consumption over time. Suppressing the ω term as well as the time period t to simplify notation once again, let τ_s be the regime-specific transfer between household 1 and household 2 that is used to smooth consumption when state s occurs in period t; $c_1(s) = y_1(s) - \tau_s$, $c_2(s) = y_2(s) + \tau_s$, with $\tau_s > 0$ when transfers flow from household 1 to household 2 and $\tau_s < 0$ when the direction of the flow is reversed. These transfers will be determined endogenously in the model and within a given regime will depend on the history of states, the discount factor δ, and the punishment P that households face when they renege on their obligations.

Following standard practice, we assume that households face a state-specific punishment $P = \{P_1(s), P_2(s)\}$, in addition to being denied future access to the insurance arrangement, when they fail to provide the promised transfer in any period. Exclusion from all social interactions, beyond those associated with insurance provision, has been identified as an important informal punishment mechanism in the sociology literature. This has two implications: First, in each state of nature, the punishment level is determined by the frequency and value of current and future social interactions and, therefore, is not a decision variable. Second, mobility will lower the ability of the network to use this mechanism to punish transgressions from cooperative behavior.[19] Our model extends the standard framework by introducing social and spatial mobility, measured by out-marriage and out-migration respectively. Such mobility increases the household's per-period utility by a factor θ, but also reduces the frequency and importance of its social interactions with the rest of the *jati*. Specifically, we assume that $P = 0$ for households that out-marry or out-migrate. LTW (Proposition 2) show that no non-autarkic contracts can be sustained with $P = 0$ when the discount factor δ lies below a threshold level. We assume that the discount factor lies below that threshold in practice, which implies that each household faces two choices *ex ante*: (i) it can participate in the insurance arrangement and not out-marry or out-migrate, or (ii) it can stay out of the arrangement in which case it will surely be mobile. Our primary objective is to study the effect of a permanent increase in income for a subset of households (household 2), as described above, on this decision.

4.3 The Participation Decision

The model is solved in two steps: In the first step, we solve for each household's expected utility gain over autarky, or *surplus*, conditional on participating in the insurance arrangement. In the second step, households decide whether or not to participate before the arrangement commences, based on the previously computed surpluses.

We begin by characterizing the set of constrained efficient contracts in a given regime, starting from a period in which state s occurs, which in turn allows us to compute the surpluses for households 1 and 2, U_s, V_s, from that period onward. Households expect the current technology regime to persist forever. As LTW note, the Markov structure and the fact that efficient contracts are forward-looking implies that the Pareto frontier will be the same in any period in which the same state occurs. Within a technology regime, given that state s occurs in period t, the Pareto frontier must thus satisfy the following optimality equation:

$$\begin{aligned} V_s(U_s) = \max_{\tau_s, U_r} & \, v(y_2(s) + \tau_s) - (1+\theta)v(y_2(s)) + \delta \sum_r \pi_{sr} V_r(U_r) \\ & + \lambda \left[u(y_1(s) - \tau_s) - (1+\theta)u(y_1(s)) + \delta \sum_r \pi_{sr} U_r - U_s \right] \end{aligned}$$

[19] Coleman's (1988) seminal article on social capital as well as a more recent review of the literature (Portes, 1998) describe alternative social control mechanisms, among them exclusion, that are used to maintain cooperative behavior. Both articles emphasize the importance of network "closure" in increasing social interactions and enforcing collective punishments, noting, moreover, that mobility can threaten the integrity of closed networks. The endogamous *jati*, of course, is a classic example of a closed network.

$$+\delta \sum_r \pi_{sr}\phi_r \left[U_r - \underline{U}_r\right] + \delta \sum_r \pi_{sr}\mu_r \left[V_r(U_r) - \underline{V}_r\right]$$

where $V_s(U_s)$ is the Pareto frontier which solves the problem of maximizing household 2's surplus subject to giving household 1 at least U_s and subject to the sustainability constraints that ensure that neither household deviates in any future state: $U_r \geq \underline{U}_r = -P_1(r)$, $V_r(U_r) \geq \underline{V}_r = -P_2(r)$. We ignore non-negativity constraints on consumption by assuming that the Inada conditions are satisfied.

The optimality equation matches the corresponding equation in LTW except for the θ term, which reflects the additional utility that households outside the arrangement receive from out-marriage and out-migration. As in LTW, this dynamic programming problem can be shown to be a concave problem, yielding the following first order conditions:

$$\frac{v'(y_2(s) + \tau_s)}{u'(y_1(s) - \tau_s)} = \lambda \tag{3}$$

$$-V_r'(U_r) = \frac{\lambda + \phi_r}{1 + \mu_r}, \tag{4}$$

with the Envelope Condition providing the additional equation

$$-V_s'(U_s) = \lambda. \tag{5}$$

Define $\underline{\lambda}_r \equiv -V_r'(\underline{U}_r)$, $\overline{\lambda}_r \equiv -V_r'(\overline{U}_r)$, where $V_r(\overline{U}_r) = \underline{V}_r$. As U_r varies from $\underline{U}_r$ to $\overline{U}_r$, $-V_r'(U_r)$ increases from $\underline{\lambda}_r$ to $\overline{\lambda}_r$. Thus, within a technology regime there exist intervals $\left[\underline{\lambda}_r, \overline{\lambda}_r\right]$ in each state such that λ_t evolves according to the following rule: Let r be the state that occurs in period $t+1$, then

$$\lambda_{t+1} = \begin{cases} \underline{\lambda}_r & \text{if } \lambda_t < \underline{\lambda}_r \\ \lambda_t & \text{if } \lambda_t \in \left[\underline{\lambda}_r, \overline{\lambda}_r\right] \\ \overline{\lambda}_r & \text{if } \lambda_t > \overline{\lambda}_r \end{cases}$$

The ratio of marginal utilities λ in any period will remain unchanged in the next period if it lies within that period's λ-interval. If not, it will shift to the nearest boundary of that interval.[20] Starting in the L-regime, suppose that state s occurs in period 1. Using the preceding rule and starting with a predetermined λ_0, λ and its corresponding τ_s from equation (3) can be derived in period 1. Moving forward in time, λ can be derived in the next period for each state r, with its corresponding τ_r.

[20]The proof of this result (Proposition 1 in LTW) can be summarized as follows: If $\lambda_t < \underline{\lambda}_r$ it follows that $\lambda_t < \lambda_{t+1}$ since $\lambda_{t+1} \in [\underline{\lambda}_r, \overline{\lambda}_r]$. From equation (4) this implies that $\phi_r > 0$, $\mu_r = 0$, which implies in turn that $U_r = \underline{U}_r$. Hence, $\lambda_{t+1} = \underline{\lambda}_r$. A similar argument shows that $\lambda_{t+1} = \overline{\lambda}_r$ if $\lambda_t > \overline{\lambda}_r$. If $\lambda_t \in \left[\underline{\lambda}_r, \overline{\lambda}_r\right]$, we need to rule out both $\phi_r > 0$ and $\mu_r > 0$. Suppose $\phi_r > 0$. This implies $\lambda_{t+1} > \lambda_t$ from equation (4) and, hence, $\lambda_t < \underline{\lambda}_r$ which is a contradiction. A similar argument rules out $\mu_r > 0$. If $\phi_r = \mu_r = 0$, then $\lambda_{t+1} = \lambda_t$ from equation (4), completing the proof.

Continuing with this process and accounting for the probability of occurrence of each state, U_s, V_s can ultimately be derived assuming that the L-regime persists forever. The same procedure could be followed if state s occurred in some period t, starting with λ_{t-1} and then moving forward in time to compute U_s, V_s.

Step 2 of the model characterizes the participation decision based on these computed surpluses. Starting in the L regime, the two households decide whether or not to participate in the insurance arrangement in period 0. Although they are aware of the possibility that the regime could switch exogenously at some point in the future, this probability is close to zero and so both households make their participation decision as if the current regime will persist forever. Recall that this was also the implicit assumption when computing surpluses U_s, V_s in step 1 above. If the technology regime does change at some time T, then the game restarts and the households decide once again whether or not to participate.

Let π_s^0 be the initial distribution of states. Household 1 will choose to participate in period 0 if $\sum_s \pi_s^0 U_s \geq 0$ and stay out otherwise. The corresponding decision for household 2 depends on whether or not $\sum_s \pi_s^0 V_s \geq 0$. U_s, V_s are computed in each state s from period 1 onwards as described in step 1, with λ tracing a path over time that starts at λ_0. When the regime changes in period T, participation decisions at the end of period $T-1$ will depend on whether or not $\sum_r \pi_{sr} U_r \geq 0$, $\sum_r \pi_{sr} V_r \geq 0$, where s is the state of nature in period $T-1$. U_r, V_r will be computed in each state r from period T onwards, with λ tracing a path over time that starts at a predetermined λ_{T-1}.

4.4 Permanent Income Change and Participation

Given the punishments that are in place, consumption-smoothing transfers will be set so that no household ever wants to renege once it has chosen to participate. Recall that a household that stays out of the arrangement can out-marry and out-migrate, boosting its utility in autarky. It is consequently entirely possible that a household's expected surplus *prior* to participation will be negative, despite the fact that transfers conditional on participation are constrained efficient, if the insurance arrangement provides insufficient value. We empirically investigate the stability of a longstanding mutual insurance arrangement in this paper and so both households evidently chose to participate in the L regime in period 0: $\sum_s \pi_s^0 U_s \geq 0$, $\sum_s \pi_s^0 V_s \geq 0$. Our objective is to study the effect of a permanent income change on these expected surpluses when they were recomputed in period $T-1$ at the onset of the H regime. If a household's expected surplus increased from period 0 to period $T-1$ it would certainly choose to participate. If its expected surplus declined sufficiently it would no longer participate, with accompanying implications for out-marriage and out-migration. To analytically compute the changes in expected surplus we make the following assumptions:

A1. *The first-best was achieved in the L regime:* $\lambda_0 \in [\underline{\lambda}_s, \overline{\lambda}_s] \forall s$.

Although we make this assumption for analytical convenience, the evidence obtained by Mazzocco and Saini (2008) for the semi-arid tropics of India and our conservative tests of full insurance reported in Section 3 make it not unreasonable to assume, as a first-order approximation, that the first-best was achieved in the L regime. Numerical solutions that we report below confirm the main analytical result when this assumption is relaxed.

A2. *The initial* λ *in the* H *regime is set at the level maintained in the* L *regime:* $\lambda_{T-1} = \lambda_0$.

The initial λ determines the distribution of the total surplus between the two households and so its level clearly affects the participation decision. With the first-best in particular, λ_0 determines λ in all subsequent periods and so a large enough decline in λ_{T-1} would ensure that the surplus declines for household 1 in the H regime.

The initial λ is determined outside the model by a Central Planner. All members of a sub-caste were historically assigned to the same occupation. Given that there was relatively little spatial variation in agricultural productivity with the traditional technology, we would expect to have seen little permanent variation in household incomes within sub-castes. λ_0 would then have been set to distribute the total surplus evenly across households.

Why would λ_{T-1} not shift to maintain the surplus of the now richer household 2 in the new regime? Once permanent income inequality is introduced in the H regime, a shift in λ_{T-1} to completely account for this change would result in a commensurate increase in consumption inequality. Households with different levels of consumption engage in different leisure activities. Heterogeneity in the level (and pattern) of consumption within the *jati* would thus mechanically lower the frequency of social interactions, with an accompanying decline in the effectiveness of collective punishments. If these effects are sufficiently large, it could be socially optimal to maintain an egalitarian distribution of consumption despite the negative consequences for participation that we derive below, and setting λ_{T-1} equal to λ_0 ensures that this will be the case. There is an extensive anthropological literature that describes the often substantial redistribution of wealth across households in traditional agrarian economies.[21] Our framework provides an efficiency-based explanation for this phenomenon. As we show below, one implication is that the most wealthy or able members of collective arrangements are likely to exit first from them, consistent with prior observations on cooperative groups.[22]

Under the maintained assumptions A1 and A2, the main result of our model can be stated as follows:

Proposition 1. *Leaving household 1's income unchanged across regimes, let household 2's income increase by Δy in each state or, equivalently, in each time period in the H regime. Then the surplus for household 1 will increase in the H regime if punishment P exceeds a threshold that is increasing in Δy.*

The proof proceeds in two steps: First, we show that household 1's surplus increases in the H regime if the first-best continues to be maintained. Second, we show that the first-best will be achieved if P exceeds a threshold that is (weakly) increasing in Δy.

If the first best continues to be maintained in the H regime, the following condition must hold in each state s for any history and for any Δy:

$$\frac{v'(y_2(s) + \Delta y + \tau_s(\Delta y))}{u'(y_1(s) - \tau_s(\Delta y))} = \lambda_0. \tag{6}$$

Differentiating equation (6) with respect to Δy, we obtain

$$\tau_s'(\Delta y) = \frac{-1}{1 + \lambda_0 \left(\frac{u''(y_1(s) - \tau_s(\Delta y))}{v''(y_2(s) + \Delta y + \tau_s(\Delta y))} \right)} < 0. \tag{7}$$

It follows from equation (7) that the per-period surplus for household 1 will be increasing in Δy in any state s:

$$\frac{d}{d\Delta y} \left[u(y_1(s) - \tau_s(\Delta y)) - (1 + \theta) u(y_1(s)) \right] = -u'(y_1(s) - \tau_s(\Delta y)) \tau_s'(\Delta y) > 0.$$

To assess the consequences of this increase for household 1's surplus starting from state s after any history, U_s, examine the expression

$$U_s = [u(y_1(s) - \tau_s(\Delta y)) - (1 + \theta) u(y_1(s))] + \delta \sum_r \pi_{sr} U_r.$$

[21] Scott (1976) is the classic reference in the literature on the "moral economy," but see also Popkin (1979) for an opposing view.

[22] Platteau (1997), for example, documents such patterns of exit from cooperative arrangements among Senegalese fishermen and in a Nairobi slum.

Since the per-period surplus is increasing in Δy for each state, it follows that U_r will be increasing in Δy for all r. U_s is unambiguously increasing in Δy and, hence, increasing from the L regime (with Δy effectively equal to zero) to the H regime when the first-best is maintained.

In contrast, the effect of an increase in Δy on household 2's surplus is ambiguous.[23] To see why this is the case, first compute the change in its per-period surplus:

$$\frac{d}{d\Delta y}\left[v(y_2(s)+\Delta y+\tau_s(\Delta y))-(1+\theta)v(y_2(s)+\Delta y)\right]=v'(y_2(s)+\Delta y+\tau_s(\Delta y))(1+\tau_s'(\Delta y))-(1+\theta)v'(y_2(s)+\Delta y).$$

It is easy to verify from equation (7) that $[1+\tau_s(\Delta y)]\in(0,1)$, which then implies from the preceding expression that household 2's per-period surplus will be decreasing in Δy for $\tau_s>0$. Intuitively, in those states where transfers flow from household 1 to household 2, $\tau_s>0$, the decline in τ_s with Δy will be reinforced by the concavity in the per-period utility function, since household 2's income (and hence consumption) has increased by Δy. When transfers flow in the opposite direction, however, $v'(y_2(s)+\Delta y+\tau_s(\Delta y))>v'(y_2(s)+\Delta y)$ and so the effect of an increase in Δy on the per-period surplus is ambiguous. The decline in τ_s with Δy implies that the (absolute) flow from household 2 to household 1 will increase, but the concavity in the per-period utility function and the increase in income (and hence consumption) by Δy will dampen the negative effect of this increase on household 2's surplus. Inspection of the preceding expression indicates that household 2's surplus, V_s, will nevertheless decline in all states if θ is sufficiently large and its per-period utility function is not too concave. Numerical solutions to the model reported below with log preferences show that V_s is monotonically declining in Δy despite the fact that θ is set to zero. Nevertheless, we will allow for the possibility that V_s is increasing or decreasing in Δy in the empirical analysis and the discussion that follows.

Having established that U_s is unambiguously increasing in Δy, the next step is to show that the first-best will be maintained if punishments P exceed a threshold that is (weakly) increasing in Δy.

Household 1's surplus in any state s after any history is bounded below by

$$\underline{U}_s=[u(y_1(s)-\underline{\tau}_s)-(1+\theta)u(y_1(s))]+\delta\sum_r\pi_{sr}U_r=-P_1(s),\tag{8}$$

where $\underline{\tau}_s$ is the maximum amount that household 1 is willing to transfer to household 2 in that state. Given that U_r is increasing in Δy for all r, it follows immediately that $\underline{\tau}_s$ is increasing in Δy.

[23] This is consistent with previous research which shows that the relationship between relative wealth and participation in collective institutions is ambiguous (Banerjee and Newman 1998, La Ferrara 2002).

The assumption that the first-best was maintained in the L regime implies that $\underline{\tau}_s > \tau_s$ with $\Delta y = 0$ in all states s in which transfers flowed from household 1 to household 2. Since $\underline{\tau}_s$ is increasing in Δy and τ_s was shown to be decreasing in Δy above, the sustainability constraint for household 1 would remain slack for all values of Δy in the H regime when punishments $P_1(s)$ are held at the same level as in the L regime.[24]

Household 2's surplus in any state s after any history is bounded below by

$$\underline{V}_s = [v(y_2(s) + \Delta y - |\overline{\tau}_s|) - (1+\theta)v(y_2(s) + \Delta y)] + \delta \sum_r \pi_{sr} V_r = -P_2(s), \tag{9}$$

where $|\overline{\tau}_s|$ is the maximum amount that household 2 is willing to transfer to household 1 in that state. If $\sum_r \pi_{sr} V_r$ is increasing in Δy, $|\overline{\tau}_s|$ will be increasing in Δy. The sustainability constraint for household 2 that was slack to begin with in the L regime will remain slack in the H regime for all Δy, with the same level of punishment $P_2(s)$ as in the L regime. For the more stringent case in which $\sum_r \pi_{sr} V_r$ is decreasing in Δy, it follows from equation (9) that $|\overline{\tau}_s|$ will be decreasing in Δy.

For the first-best to be achieved, $|\overline{\tau}_s| \geq |\tau_s|$ for all Δy in all states s in which transfers flow from household 2 to household 1.[25] Consider a state s in which $\sum_r \pi_{sr} V_r$ is decreasing in Δy. Figure 3 describes the negative relationship between $|\overline{\tau}_s|$ and Δy just derived for a given P, as well as the positive relationship between $|\tau_s|$ and Δy, which we showed earlier was necessary to maintain a constant λ_0. The downward sloping solid line is associated with a threshold punishment $P_2^0(s)$ that is just sufficient to ensure that the first-best is achieved with $\Delta y = 0$. When we consider a Δy^* to the right of the origin, and continue to focus attention on the solid lines it is evident that $|\overline{\tau}_s| < |\tau_s|$ at that point. An increase in $P_2(s)$ increases $|\overline{\tau}_s|$ at each value of Δy in equation (9), and so a larger punishment $P_2^*(s) > P_2^0(s)$ is associated with the dashed downward sloping line needed to just maintain the first-best with Δy^*. It follows from this discussion and is easy to verify from the figure that the first-best will be achieved as long as the punishment in state s exceeds a threshold that is increasing in Δy. Punishments are determined by the level of social interactions and so will presumably remain the same from the L regime to the H regime. This implies that the first-best

[24] This argument, and the argument we make below for household 2, could alternatively be stated in terms of λ. $\underline{\tau}_s$ pins down $\underline{\lambda}_s$, which can be computed by replacing τ_s with $\underline{\tau}_s$ in equation (6). Since $\underline{\tau}_s$ is increasing in Δy, it follows that $\underline{\lambda}_s$ is decreasing in Δy. We know that $\underline{\lambda}_s < \lambda_0 \forall s$ to begin with, since the first-best was achieved in the L regime. It follows that this condition will hold in the H regime with any Δy.

[25] $|\overline{\tau}_s|$ pins down $\overline{\lambda}_s$ and so will be the same in all periods in which state s occurs (V_r in equation (9) is part of the maximization problem and so will be set accordingly). Although $|\tau_s|$ could vary over time in general, depending on the evolution of λ, it will also be the same in all periods in our case since we focus on the first-best.

will continue to be obtained if there is sufficient slack in the initial regime, with the required slack increasing in Δy.

Do these results hold when the first-best cannot be attained? Figure 4 and Figure 5 present numerical solutions to the model for different punishment levels, relaxing the assumption that the first-best is obtained in both technology regimes.[26] The two households smooth their consumption across three states of nature, $s = \{1, 2, 3\}$. Income realizations for household 1 and household 2, respectively, in these states are (4,2), (3,3), and (2,4). States of nature occur with equal probability and are independently distributed over time. The infinitely-lived households have log preferences, a common discount factor of 0.8, and θ is set to zero. Punishment levels are common across households and states.

The Pareto frontiers in the three states will overlap to different degrees, depending on the level of punishment that is chosen. With three states, five configurations are possible: (i) no overlap, (ii) state 1 overlaps with state 2, (iii) state 2 overlaps with state 3, (iv) state 1 and state 3 do not overlap but state 2 overlaps with both state 1 and state 3, and (v) each state overlaps with the other two states. As punishments increase, the Pareto frontier will expand ($\underline{\lambda}_s$ declines and $\overline{\lambda}_s$ increases), increasing the degree of overlap. It is evident that only the fifth configuration can support the first-best allocation with a constant λ over time.

To derive the constrained-efficient transfers and, hence, the household-specific surpluses corresponding to a given punishment level, we must first determine which configuration is in place. Starting with an initial distribution of the surplus λ_0, λ can only take on one of six values, $\underline{\lambda}_s$, $\overline{\lambda}_s$, $s = \{1, 2, 3\}$ in the future once the sustainability constraint binds in any period. In the discussion that follows it will be convenient to denote each of these extreme points on the state-specific Pareto frontiers as a *node*. With three states, there are six nodes, which we number in decreasing order of household 1's surplus within each state, running from state 1 through state 3. With this notation, it is straightforward to derive expressions for the continuation surplus of each household, in any current state and for any history, assuming that a particular configuration is in place. For example, assuming configuration 1 without any overlap is in place, the continuation surplus for household 1 when state 1 is realized in the current period and node 1 was the last binding constraint can be expressed as

$$U_{11} = log(4 + \tau_{11}) - log(4) + 0.8 \left[\frac{1}{3} U_{11} + \frac{1}{3} U_{21} + \frac{1}{3} U_{31} \right],$$

[26] We are grateful to Andrew Foster for providing us with the numerical solution. Copies of the program used to compute the solution are available from the authors on request.

with the first subscript denoting the current state and the second subscript denoting the node corresponding to the most recent binding sustainability constraint. When the previous node is one and the current state is one, household 1 will achieve its maximum surplus (at node 1) in the current period as well, since λ can maintain its previous level. This is reflected in the transfer τ_{11} that flows to household 1 and the assumption that all the subsequent-period surpluses start from node 1 in the expression above. With three states and six nodes, there are 18 equations of this sort for each household. The sustainability constraints generate 18 additional equations. For example, the sustainability constraints for state 1 are:

$V_{11} = -P$, $U_{12} = -P$, $U_{13} = -P$, $U_{14} = -P$, $U_{15} = -P$, $U_{16} = -P$.

This leaves us with 54 equations and 54 unknowns, allowing us to solve for U_{sn}, V_{sn}, τ_{sn}, $s = \{1, 2, 3\}$, $n = \{1, ..., 6\}$. Once the surpluses are computed in each configuration, it is possible to assess whether the relative levels are consistent with the degree of overlap in the Pareto frontiers that is associated with that configuration. For a given punishment level, consistency will only be achieved with a single configuration. Once that configuration has been identified it is straightforward to compute the expected surplus for each household, starting with an initial distribution of the surplus λ_0, given the assumption that states of nature are independently distributed over time. Permanent increases in income for household 2 with the new technology regime Δy are easily incorporated by repeating the entire process with a fresh set of income realizations. Figure 4 and Figure 5 report the expected surpluses for household 1 and household 2, respectively, for different Δy and different punishment levels P.

We report surpluses with three punishment levels: $P = 1/32, 1/4, 1$ and Δy for household 2 ranging from zero to one. The first-best is sustained across the entire range of Δy with $P = 1$, and so as expected from Proposition 1, household 1's expected surplus $\sum_s \pi_s U_s$ is monotonically increasing in Δy for that punishment level in Figure 4. Figure 4 also shows, however, that the expected surplus of household 1 increases as Δy increases for household 2 even if punishment levels are such that the first-best is not sustained. With $P = 1/4$, for example, although the first-best continues to be obtained for $\Delta y = 0$, the slack is not sufficient to sustain the first-best over the entire Δy range. Once household 2's sustainability constraint binds, the total surplus declines, together with a shift in the distribution of the surplus away from household 1. Although this unambiguously reduces household 1's surplus relative to the first-best benchmark, we see in the figure that its surplus continues to increase in Δy albeit at a slower rate. When $P = 1/32$, the first-best is never achieved but again the expected surplus continues to be increasing in Δy, although it lies strictly below the level achieved with the larger punishments and the surplus is much less sensitive to household 2's permanent income change.

Figure 5 reports the corresponding surpluses for household 2. The patterns are essentially reversed, with the expected surplus for household 2 monotonically declining as its income increases both in the first-best regime and in the regimes in which the first-best cannot be sustained. Thus, when the shift to the new technology regime induces a permanent change in inequality, the households experiencing the permanent income gain are the households most likely to choose to exit from the community insurance scheme. Figure 5 also shows, however, that when the level of punishment that can be administered by the community is low, *ex ante* exit by the household whose income has permanently increased is less likely than when the punishment for reneging within the scheme is high. In general, Figures 4 and 5 show that mobility is less sensitive to permanent increases in inequality within the network the *lower* the level of punishment P.

Our model of mutual insurance focuses on how permanent changes in income for a subset of households within the community affect the integrity of risk-sharing arrangements. In doing so, we make the standard assumption that there is no storage and no savings.[27] Access to credit or a savings technology will increase the utility of all households in autarky. This is equivalent to an increase in outside options θ in the model, which lowers the surplus of all households. In addition, it is easy to verify from the expressions for $\underline{U}_s$, $\underline{V}_s$, that $\underline{\lambda}_s$ will increase and $\overline{\lambda}_s$ will decrease as θ grows, reducing the level of risk-sharing that can be sustained and lowering surpluses even further once sustainability constraints start to bind. Improved access to credit thus can lower participation in the mutual insurance arrangement even when punishments are in place. In particular, as θ increases, households will exit when their surpluses fall below $-P$. It follows that mobility is less sensitive to improvements in outside options the *higher* the level of punishment P, in contrast with the result we derived above for changes in inequality within the *jati*.[28] We will exploit this observation in the concluding section of the paper to interpret the empirical results in the context of underlying punishment levels and to forecast (out of sample) the effect of new, superior forms of insurance on

[27] Including these additional features in the model will not affect the comparative statics derived above as long as the permanent change in income is uncorrelated with changing access to credit and savings. The empirical analysis that follows pays particular attention to this possibility. Although Attanasio and Rios-Rull (2000) and Ligon, Thomas, and Worrall (2000) consider the welfare effects of introducing alternative risk-sharing arrangements, a welfare analysis of this sort is beyond the scope of the paper.

[28] There are two reasons for this: First, sustainability constraints will start to bind at higher levels of θ when P is large. Second, the threshold surplus below which the household exits is lower when P is large.

mobility.

5 Empirical Analysis

5.1 Specification and Identification

The prediction of the model is that conditional on the household's own income, a permanent increase in its partner's income - the income of the rest of the *jati* - should increase its propensity to participate in the insurance arrangement, with an accompanying decline in the probability of out-marriage and out-migration. Conditional on average *jati* income, however, a permanent increase in the household's income is likely to have the opposite effect on participation and mobility.

The stylized model assumes that technological change occurs at a single point in time for all households and that the permanent components of income instantaneously adjust, following which households update their participation decisions. In practice, all areas of the country did not benefit immediately from the new High Yielding Varieties (HYVs) of wheat and rice. The early rice HYVs, in particular, were unsuitable for cultivation in many areas, and it was only by cross-breeding with local varieties that the new technology could be adopted throughout the country (see Munshi, 2004, for details). In addition, credit constraints prevented growers from responding immediately when the HYV technology did become available because complementary investments in irrigation were required to fully exploit the enhanced potential of the new seeds. Allowing incomes to change over an extended period in the aftermath of the Green Revolution, with accompanying changes in participation and mobility, we use the following specification to test the predictions of the model:

$$\Delta M_{it} = \pi_1 \Delta y_{it} + \pi_2 \Delta \overline{y}_{jt} + \Delta \epsilon_{it}, \tag{10}$$

where ΔM_{it} measures the change in household i's participation or mobility between the 1982 and 1999 survey rounds, Δy_{it} measures the change in the permanent component of the household's income over the same period, $\Delta \overline{y}_{jt}$ is the corresponding change in (average) income in the rest of the *jati*, and $\Delta \epsilon_{it}$ measures changes in the unobserved determinants of M_{it}. The model predicts $\pi_1 < 0$, $\pi_2 > 0$ with the change in participation as the dependent variable and $\pi_1 > 0$, $\pi_2 < 0$ with the change in out-marriage and out-migration as the dependent variables.

Equation (10) eliminates any fixed determinants of participation and mobility, such as the household's risk aversion or productivity, that are unobserved by the econometrician. However, time-varying determinants of ΔM_{it} that are correlated with changes in income must still be accounted for. We focus on two important determinants of ΔM_{it} in the discussion that follows: First, as discussed in the previous section, changes in credit will determine changes in the household's decision to participate in the mutual insurance arrangement. Second, changes in local public amenities will change mobility decisions. Changes in access to credit or the quality of local public goods will also determine changes in income, biasing the estimates of π_1 and π_2. To obtain consistent estimates of the income effects in equation (10) we consequently construct instruments for the *change* in household and *jati* income that are attentive to the presence of these time-varying, persistent unobservables. The instrumental variable strategy we employ exploits (i) technological features of the Green Revolution, (ii) the observation that initial advantages in income have long-term consequences when credit markets function imperfectly, and (iii) the availability of both village and household information at the onset of the Green Revolution for households in the 1982 and 1999 survey rounds.

We make use of three technological features of the Indian Green Revolution: First, only certain parts of the country had access to the new HYV seeds at the onset of the Green Revolution. Second, the returns to investing in the HYV technology are much greater on irrigated land. And, third, the returns to irrigation are much greater using HYV than using traditional seeds. To construct a parsimonious set of instruments, we make the stronger assumptions that HYV technology can only be adopted on irrigated land and that cultivating the traditional technology on irrigated land is not cost effective. Under these conditions, household i endowed with L_i units of land and F_i working members would receive a flow of income in period 0 at the onset of the Green Revolution that can be characterized by the expression

$$y_{i0} = L_i(\gamma + \beta S_{i0} \cdot HYV_{v0}) + F_i(\eta + \nu S_{v0} \cdot HYV_{v0}), \tag{11}$$

where S_{i0} is the share of the household's land that was irrigated in period 0, HYV_{v0} is a binary variable indicating whether the new technology was available in the village in period 0, and S_{v0} is the share of village land that was irrigated in period 0. The first term in parentheses in equation (11) is the expected income per unit of land. Given the assumptions made above, households in villages without access to HYV in period 0 ($HYV_{v0} = 0$) would certainly not invest in irrigation ($S_{i0} = 0$), generating income per unit of land γ. Access to credit was severely restricted at the onset of the Green Revolution and so households with access to HYV ($HYV_{v0} = 1$) would have invested in irrigation (S_{i0})

to the extent that their resources permitted. The $\beta S_{i0} \cdot HYV_{v0}$ term thus represents the *additional* income that households with access to HYV received on their irrigated land. The second term in parentheses in equation (11) is the wage income per adult worker. Following the preceding argument, η measures the wage in a village without access to HYV ($HYV_{v0} = 0$). Workers are more productive on (irrigated) land allocated to HYV. The $\nu S_{v0} \cdot HYV_{v0}$ term represents the wage premium that a worker receives in an area with irrigated land and HYV seeds, with the wage premium higher the greater the share of irrigated land S_{v0}.

In an economy with imperfectly functioning credit markets, the additional income that a household received from planting HYV in period 0 would have allowed it to invest in additional irrigation in the subsequent period. This process of incremental investment would generate a link between period-0 income and income in any subsequent period as well as the *change* in income between any two subsequent periods. The diffusion of the new HYV technology was complete by the early 1980s and so households in villages that did not have access to HYV in period 0 would ultimately have gained access to the new technology. However, their investment in irrigation would have commenced at a later point in time, giving rise to a different income trajectory. It follows that y_{i0}, as described in equation (11), would predict the change in income Δy_{it} across any two subsequent time periods for all households in the sample.

Although y_{i0} may be a strong predictor of Δy_{it}, it must also be uncorrelated with changes in access to credit and the quality of local amenities, which are included in $\Delta\epsilon_{it}$, to be a valid instrument. Some components of y_{i0}, such as the household's ability to invest in irrigation S_{i0}, will clearly be correlated with its unobserved access to credit in period 0 and, by extension, to changes in credit if the unobserved variable is serially correlated. We consequently proceed to extract those components of y_{i0} – on the right hand side of equation (11) – that are plausibly uncorrelated with $\Delta\epsilon_{it}$ to use as instruments for Δy_{it}.

The first component of initial-period income is L_i, which we measure by the amount of land that was inherited by the household head, as reported in the 1982 survey. Land markets are extremely thin in rural India (Rosenzweig and Wolpin 1993), with households rarely selling off their land. The 2005 IHDS reports, for example, that in the five years prior to that survey less than 2.75 percent of all landowning households sold any land to pay off a loan or meet expenses. It thus seems reasonable to assume that this historically-determined variable is uncorrelated with individual traits, such as reliability, that determined access to credit in period 0, and was also unaffected by credit market conditions or the quality of informal networks at that time. Initial land area is mechanically correlated with changes in wealth, which will determine changes in the household's access to credit and, hence, changes in participation and mobility. Note, however, that land area only determines these outcomes *through* household wealth, which is an important component of our permanent income measure Δy_{it} in equation (10), thus satisfying the conditions for a valid instrument.

In contrast with inherited land area, investments in irrigated land S_{i0} are chosen by the household. These investments will depend on the *availability* of credit in the village in period 0 as well as the household's ability to *access* credit, which will depend on its wealth as described above and individual unobserved traits such as reliability. More reliable households will build a reputation with their banks over time, which implies that S_{i0} could be correlated with changes in access to credit. To account for this possibility we replace S_{i0} with S_{v0}, the share of irrigated land in the village in the 1971 survey round, when constructing instruments from equation (11). Burgess and Pande (2004) show that banking regulations in India led to a convergence in the availability of credit (measured by proximity to banks) over time. S_{v0} would then be correlated with changes in the availability of credit, and so we will include S_{v0} as an additional independent regressor in equation (10).

By a similar argument, HYV_0, which is constructed as a binary variable that takes the value one if any household in the village adopted the new technology in the 1971 survey round, will depend on agroclimatic conditions as well as whether the district was targeted for early adoption. If districts that were more open to new technologies and to change more generally were targeted first, then HYV_0 could be correlated with the quality of local amenities in period 0 to the extent that these amenities were similarly targeted. If the quality of local public goods is serially correlated, then HYV_0 would be correlated with the change in their quality and so we will also include HYV_0 as an independent regressor in equation (10). The only remaining term in equation (11), F_i, reflects endogenous fertility choices that could be correlated with household traits that determine access to credit in period 0 as well as local public goods (such as health clinics) in that period. Following the preceding arguments, fertility choices could then be correlated with changes in access to credit and local public goods. We consequently replace F_i with $\overline{F}$, the average across all households in the sample, when constructing instruments from equation (11).

Collecting all terms in equation (11) and accounting for the modifications described above, we are left with three instruments for Δy_{it}: L_i, $S_{v0} \cdot HYV_{v0}$, $L_i \cdot S_{v0} \cdot HYV_{v0}$. Instruments for $\Delta \overline{y}_{jt}$ are similarly constructed by taking the *jati*-level averages of the household instruments. Once S_{v0} and HYV_{v0} (with their *jati* averages) are included as regressors in the instrumental variable regressions, we identify the effect of permanent income changes on participation and mobility from the *interaction* of S_{v0} and HYV_{v0}, scaled up by the amount of land inherited by the household L_i. The instrumental variable strategy thus exploits the technological complementarity between irrigation and HYV, allowing for the possibility that the availability of HYV technology and well developed irrigation facilities in period 0 reflect village-level unobservables that persist over time by including them in the second stage. The identifying assumption is that their *joint* presence is independent of $\Delta\epsilon_{it}$. To provide support for this assumption, we will verify that the instrumental variable estimates are qualitatively unaffected by the inclusion of a large number of village characteristics representing public goods provision or credit access in 1971 or, alternatively, the change in those village characteristics from 1982 to 1999, as additional regressors.

5.2 Descriptive Statistics

To construct our panel of households, we started with the 1982 households represented in the 1999 survey round. Because of household partitioning, many 1982 household members are distributed among different 1999 households. We thus aggregated any and all the households in 1999 that split-off from the 1982 households, resulting in a balanced sample of 3,441 households in each of the two years. To increase the precision of *jati*-level aggregates, we eliminated all households in *jatis* with less than 10 surveyed households, leaving us with a balanced two-year panel of 2,341 households. Table 5, Panel A reports the share of households that participated in the mutual insurance arrangement and the incidence of out-marriage and out-migration, separately in 1982 and 1999, for the panel sample.

Participation is a binary variable that takes the value one if the household sent or received caste-transfers (gifts or loans) in the year preceding each survey round. Based on the panel sample, we see that participation rates declined from 0.23 to 0.15, which is broadly comparable with the statistics reported for the full sample in Table 1. The measures of out-marriage and out-migration are constructed from the 1999 retrospective histories on the marriages and migration of all of the siblings and children of each household head in the sample. From these histories we created a variable indicating whether whether any unmarried child of the household head married outside the *jati* in the 10-year period prior to each survey date. The measure of out-migration is whether any male aged 20-30 at the time of each survey and residing in the household prior to the survey date had left the village permanently by the survey date. Based on these measures, the out-marriage rate increased from 0.05

to 0.07 and out-migration increased from 0.05 to 0.09 between the 1982 and 1999 survey rounds. As discussed in the Introduction, mobility remains extremely low in rural India.

The model derives the effect of a permanent change in income within the *jati* on the participation and mobility of its members. Income is not usually well-measured in surveys. To verify the robustness of our results, we constructed two measures of income using independent sets of variables. The first measure computes permanent (expected) income as 5 percent of the household's total asset holdings at the beginning of the reference period (one year before each survey round) plus "full" income - the village-level daily agricultural wage multiplied by 312 days and the number of adults in the household. This measure of income thus only varies with contemporaneous common shocks, such as in rainfall, because of the responsiveness of wages to village-level productivity changes. Our second income measure is simply the household's reported total income (excluding transfers) in the crop years 1981-82 and 1998-99, which will also reflect household-specific shocks to output, wages and labor supply. Using these household income measures, we constructed aggregate *jati* income measures by taking the sample-weighted average of the incomes of the other members of each household's *jati*.

It is evident, based on either income measure in Table 5, Panel B that there was considerable growth in income over the sample period. The wealth-based income measure increases three-fold or four-fold, depending on whether we use the household or the *jati* average between 1982 and 1999. Reported total income, averaged across households or *jatis*, doubles over this period.[29] Although the means of the two income measures are different, the cross-sectional correlation between them is 0.63 and the correlation between their 17-year changes is 0.54. We report income effects with both measures, but the wealth-based measure is immune to household-specific shocks, which increases the power of our instruments and will therefore be our preferred measure of permanent income change in the discussion that follows.

All the instrumental variable regressions include a binary variable indicating whether anyone in the village used HYV in 1971 as well as the share of irrigated land in the village in 1971 (together with the corresponding *jati* averages) as independent regressors. These statistics are reported in Table 5, Panel C where we see that roughly 60 percent of the panel households belong to a village with some HYV cultivation in 1971 and that 40 percent of cultivated land was irrigated in the sampled households' villages (comparable numbers are obtained for the corresponding *jati* averages).

[29]The household and *jati* averages for a given income measure do not coincide for two reasons: (i) the household is excluded when computing average income in its *jati*, and (ii) the *jati* statistic is computed using sample weights.

Robustness checks discussed above will include additional 1971 village characteristics and the change in village characteristics from 1982 to 1999 separately in the instrumental variable regressions. Recall that these characteristics are meant to directly predict unmeasured changes in credit and public goods in the village. The 1971 characteristics include whether the village was situated in an area covered by the Intensive Agricultural Area Programme (IAAP), whether agricultural extension service was active in the village, whether the village was covered by the Intensive Agricultural District Programme (IADP), and whether a bank, school, and health center were present in the village in that year. These data are obtained from the 1971 survey and we see in Table 5, Panel C that there is substantial variation in village characteristics in the sample. Changes in village characteristics are based on the 1982 and 1999 surveys, with these characteristics including the presence of a health center, whether a bank was located nearby (less than 10 kilometers away), whether there was a public secondary school, and whether there was a family planning clinic in the village. There is substantial change in each of these variables in Table 5, Panel C, consistent with the infrastructure improvements that occurred in rural India in this period. We will see that the included village characteristics jointly determine participation and mobility in a number of specifications. However, the estimated income effects are qualitatively unaffected by their inclusion.

5.3 Participation and Mobility Estimates

Appendix Table 1A reports the first stage parameter estimates corresponding to each second-stage specification, with Δy_{it}, $\Delta \overline{y}_{jt}$ as the dependent variables and $S_{v0} \cdot HYV_{v0}$, $L_i \cdot S_{v0} \cdot HYV_{v0}$, L_i (with their *jati* averages) as the excluded variables. The coefficients on $L_i \cdot S_{v0} \cdot HYV_{v0}$ (at the *jati* level) and L_i (at the household level) are positive and significant across almost all specifications and the F-statistic testing the joint significance of the excluded variables is large (the p-values are below 0.01) without exception.

Table 6 reports the instrumental variable estimates for our basic specification, including S_{v0}, HYV_{v0} (with their *jati* averages) as additional regressors. Columns 1-3 use the wealth-based measure of income, while Columns 4-6 use the actual income realization. Because we are instrumenting with fixed historical characteristics, we estimate the effect of permanent (expected) changes in income in either case. Both sets of estimates support the joint hypothesis that conditional on the household's own income an increase in *jati* income increases the probability of participating in the insurance arrangement and lowers the probability of out-marriage and out-migration.

With respect to the effect of the household's own income, we noted in Section 4 that a relative increase in the household's income was likely to reduce participation and increase mobility. Although the opposite effect could be obtained if the household were sufficiently risk averse, our simulations reported in Figure 5 suggested that for all punishment levels a permanent increase in income did reduce the household's surplus. However, a change in a household's income or wealth (independent of the influence of income in the rest of the *jati*) could directly affect out-marriage and out-migration other than through network effects.[30] Keeping these caveats in mind, we see in Table 6 that an increase in a household's own income, conditional on its *jati* income, does have the effect that the model would generally predict - households with relatively high income are less likely to participate in the insurance arrangement and are more likely to out-marry and out-migrate.[31]

Table 7 subjects the results to greater scrutiny by including a number of village characteristics measured in 1971 as additional regressors in Columns 1-3. In a related test we include the change in a number of village characteristics from 1982 to 1999 in Columns 4-6. Although these additional regressors are jointly significant in a number of specifications, the estimated income effects (using the wealth-based income measure) are very similar to those reported for the more parsimonious specifications in Table 6, Columns 1-3. The pattern of coefficients in Table 6 and Table 7 thus provides strong support for the hypothesized link between participation in insurance arrangements and mobility. The (conditional) *jati* effects suggesting that increased *jati* incomes raise participation levels and reduce exit, in particular, are difficult to reconcile with alternative explanations of immobility that do not require a role for the caste network.[32]

What do the point estimates imply for the effect of economic growth and changing inequality on mobility? As seen in Table 5, average *jati* (wealth and wage-based) income increased from Rs. 1560 in 1982 to Rs. 6863 in 1999.[33] Because economic growth increases both the household's income and

[30]For example, illiquid land markets make it difficult for wealthy farmers to migrate, or wealth facilitates the financing of migration and perhaps even out-marriage.

[31]The coefficients on household income and *jati* income with our preferred wealth-based measure in Columns 1-3 are jointly statistically significant. The χ^2 values are 5.56 (participation), 6.23 (migration), 5.13 (marriage). The associated p-values are 0.06, 0.04, 0.07.

[32]Although we focus on caste-based insurance arrangements in this paper, networks organized around the *jati* have also historically supported migration in India. If wealthier households are tied more strongly to their rural origins, the negative *jati*-income coefficient in the migration regression could simply reflect the fact that households belonging to wealthier *jatis* have access to weaker migrant networks. This alternative explanation, however, would not explain the negative *jati*-income coefficient that we obtain in the marriage regression as well.

[33]As noted, the *jati* figures use sample weights and thus better reflect the changes in incomes in the rural population. The wealth-based income measure is more immune to household-specific fluctuations than is realized income and so is our preferred measure of permanent income.

jati income, the net effect of an overall increase in income is obtained by adding the own income and *jati* income coefficients. The summed point estimates in Table 6, Columns 1-3, indicate that the more than fourfold increase in real income between 1982 and 1999 would have reduced participation by just 1.0 percentage point (4.4 percent), while increasing out-marriage by only 0.03 percentage points (5.8 percent) and increasing out-migration by only 0.08 percentage points (16 percent). The point estimates in Table 6, Columns 1-3 indicate that changes in inequality also do not have strong effects on mobility. Allowing only *jati* income to increase, leaving the household's own income unchanged, the household's participation would increase by 1.7 percentage points (7.5 percent), while out-marriage and out-migration would decrease by less than 0.6 percentage points (11 percent). These estimates thus suggest that neither high levels of growth nor large changes in inequality would substantively increase the historically low levels of mobility in rural India in the absence of other structural changes.

Finally, although the traditional caste networks have evidently been robust to economic growth in the short run, our estimates do indicate that exit is more likely among the relatively wealthy within the network, consistent with the mutual insurance model. This selective exit will over time lower the average income of the network. The estimates of the *jati* income effect in Table 6, Columns 1-3 permit an assessment of the effect of this decay in the network on future mobility. The average *jati* income in the 1999 round was Rs. 7,000. Picking the *jati* with at least 20 sampled households whose average income was closest to that number, we discarded the top 15 percent of households from its income distribution and re-computed the average income. The re-computed average income in that *jati* declined substantially (by 23 percent) from Rs. 9001 to Rs. 6905. This decline in average *jati* income, however, would have reduced participation by only 0.7 percentage points (5 percent), while increasing out-marriage and out-migration by even less - 0.2 percentage points (3 percent and 2 percent, respectively). The extremely small network decay effects suggest that the rural caste networks will remain firmly in place, and that mobility will continue to be low in the future, unless alternative arrangements of comparable quality become available.[34]

6 Conclusion

In this paper we have examined the hypothesis that the persistence of low spatial and marital mobility in rural India, despite increased growth rates and rising inequality in recent years, is due to the presence

[34] Alternative arrangements may not have emerged precisely because the caste networks are so effective. Kranton (1996) provides a formal model that describes this tension between market and non-market institutions.

of caste networks that provide mutual insurance to their members. Unique panel data identifying sub-caste (*jati*) membership and providing information on income, assets, transfers, consumption, marriage, and migration are used to link caste networks to household and aggregate mobility. The main empirical result is that conditional on household income, a permanent increase in income in the rest of the *jati* increases its participation in the caste-based insurance arrangement, while at the same time lowering mobility (out-marriage and out-migration).

Although these results connect caste networks to immobility, they do not indicate the extent to which mobility would increase if an alternative credit arrangement of comparable quality became available. As noted in Section 4, the viability of traditional collective arrangements in the face of improved outside options will depend to a large extent on the strength of existing punishments. Recall from Figures 4-5 that household surpluses were less responsive to internal changes in inequality once sustainability constraints started to bind. The fact that mobility did not increase substantially despite the increase in within-*jati* inequality that accompanied the Green Revolution thus indicates that there was little slack in collective punishments in the traditional regime. With little slack in punishments, it follows from the discussion in Section 4 that the caste-based insurance arrangements should be especially vulnerable to secular improvements in outside options. Although an experiment that exogenously increased access to insurance in rural India is unavailable, the preceding argument suggests that networks should be vulnerable to improvements in outside options in other contexts as well.

Munshi and Rosenzweig (2006) describe how caste-based labor market networks historically assisted their members in finding well-paying jobs in particular occupations in Mumbai (formerly Bombay) city. They also document restrictions on mobility that were imposed by these networks, and the historically low out-marriage that is consistent with the presence of such restrictions. Outside options for the members of these networks improved dramatically with the restructuring of the Indian economy in the 1990's and the availability of new economic opportunities outside of the traditional caste occupations. Munshi and Rosenzweig (2006) showed how these changes led to a substantial increase in inter-generational mobility.

The same data used by Munshi and Rosenzweig (2006) also permit an assessment of the resilience of the urban caste networks, as measured by out-marriage, in the face of these threats to their integrity. As a basis for comparison, we first present in Figure 6 rates of out-marriage in rural India for the children and siblings of household heads over the 1950-1999 period, based on retrospective information collected in the 1999 round of the rural survey. We see that out-marriage is less than 6 percent of all marriages and has remained stable for 50 years in rural areas, consistent with the results reported in this paper. Figure 7 displays out-marriage rates in Mumbai, based on a survey of school children conducted by the authors in 2001. To be comparable with Figure 6, the statistics in Figure 7 are computed using the parents and siblings of the sampled school children. As in rural areas, in the 1970's and 1980's out-marriage in Mumbai was very rare. However, in contrast with the stability that we observed in Figure 6 for rural households, out-marriage increased steeply over time in Mumbai, particularly in the 1990's, starting at 2 percent in the early 1970's and reaching as high as 12 percent by the late 1990's. The urban experience suggests that if the rural caste networks ceased to be salient because of the availability of new, superior forms of insurance, mobility could surge in rural India in the future as well. Although such mobility would be growth-enhancing, it is important to recognize that alternative risk-smoothing mechanisms would not necessarily provide the subsidized insurance to the poor that is a key feature of the caste network.

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Figure 1: Change in Percent Urbanized, by Country, 1975-2000

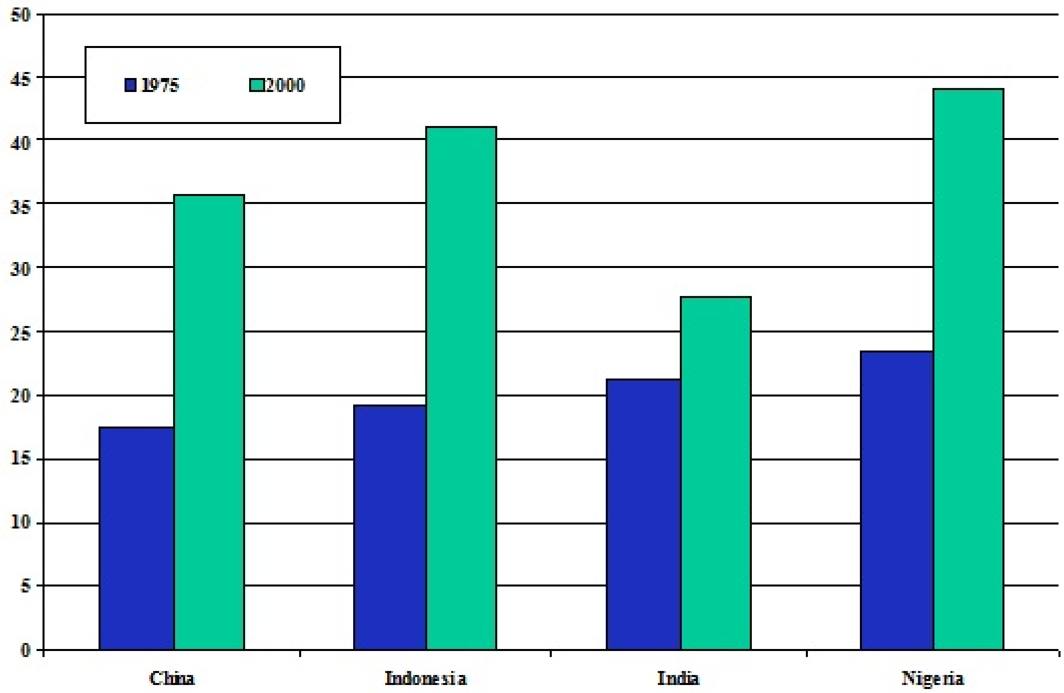

Figure 2: Change in Gini Coefficients for Wealth 1982-1999: Within Villages and *Jatis*

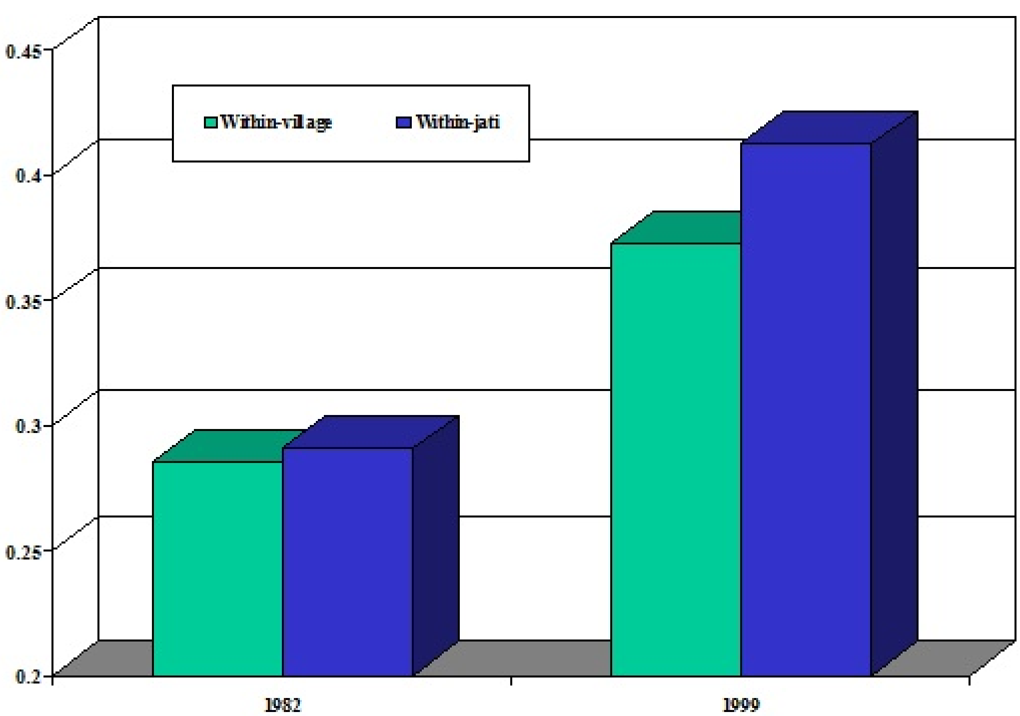

Figure 3: The Effect of a Permanent Change in Income for Household 2 on Transfers

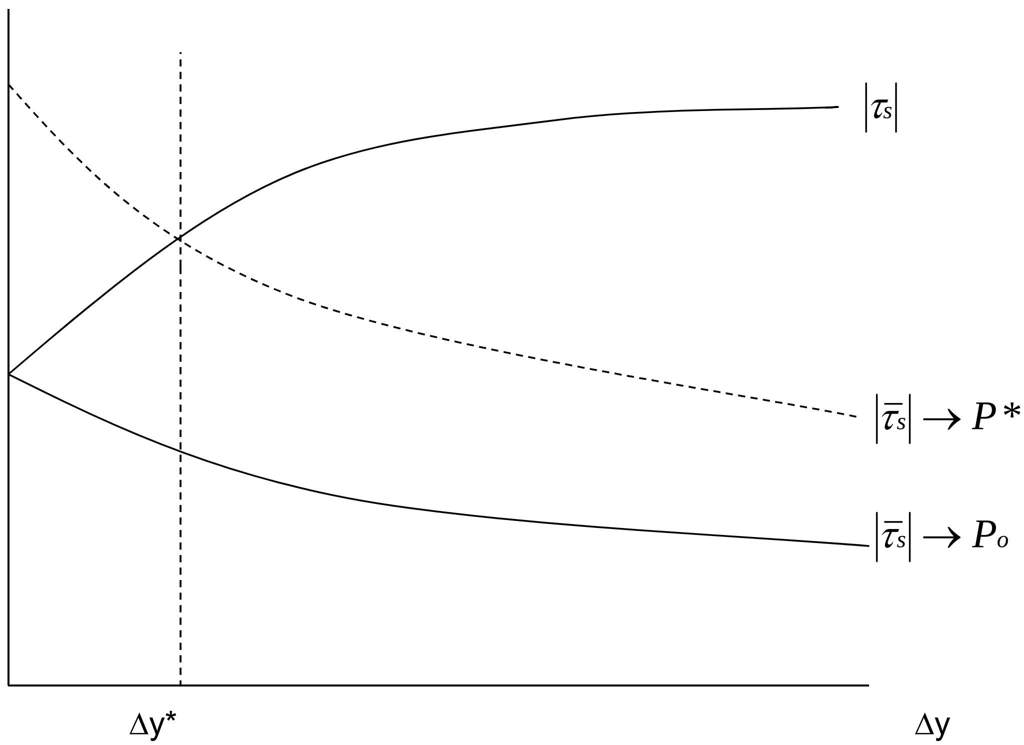

Figure 4: The Effect of a Permanent Increase in Income for Household 2 on the Expected Surplus of Household 1, by Punishment Level P

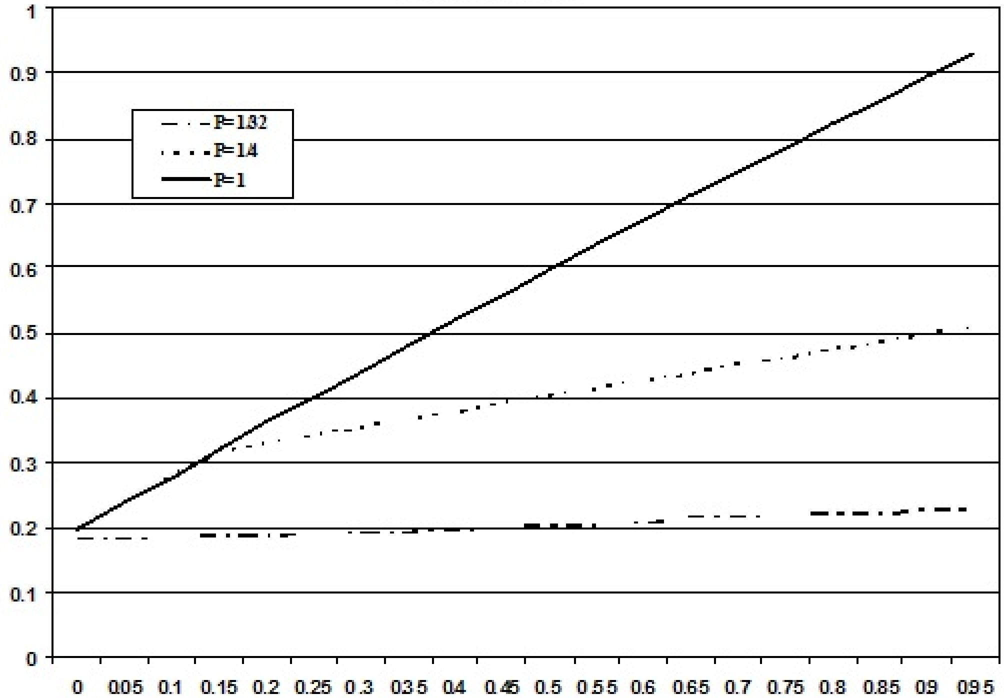

Figure 5: The Effect of a Permanent Increase in Income for Household 2 on the Expected Surplus of Household 2, by Punishment Level P

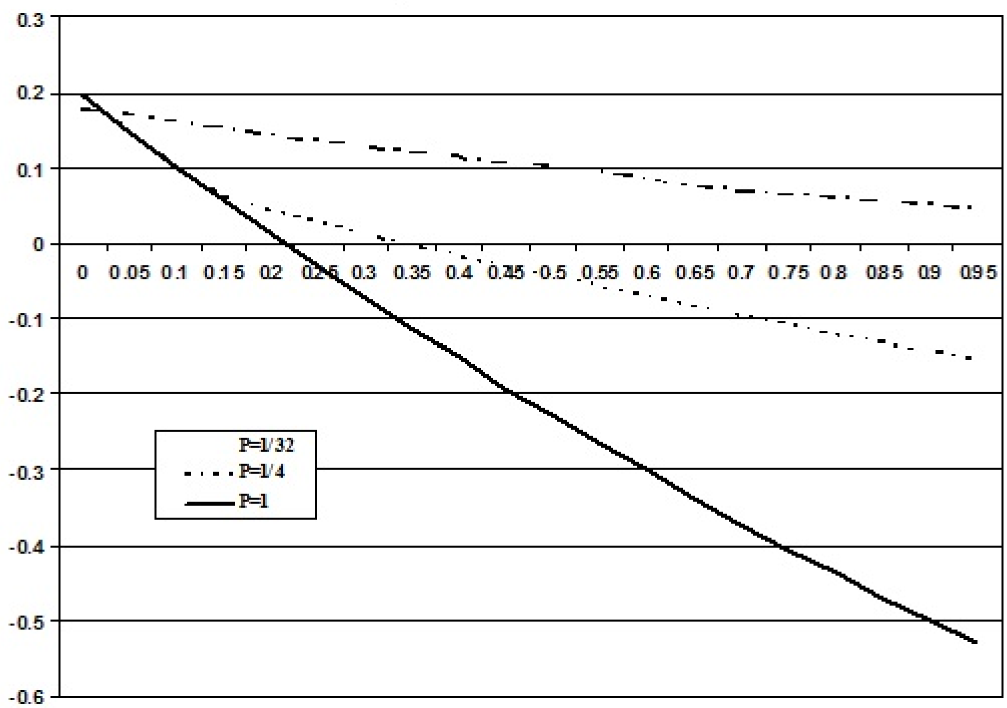

Figure 6: Rates of Out-Marriage, by Decade, Rural India 1950-1999 (*N*=31,529)

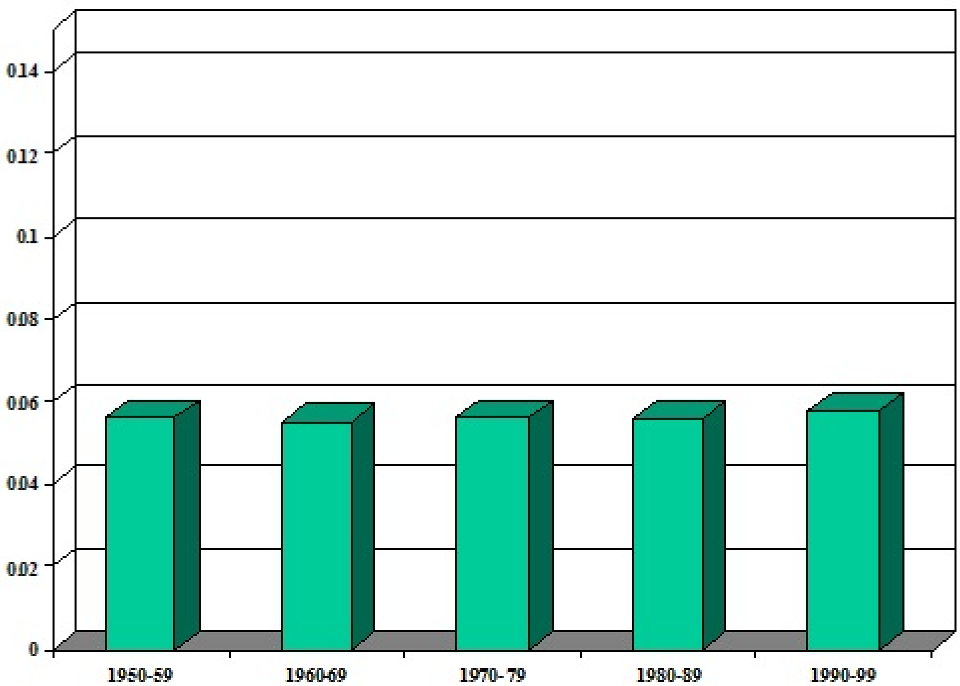

Figure 7: Rates of Out-Marriage, by Quinquennia, Mumbai 1970-2002 (*N*=5,406)

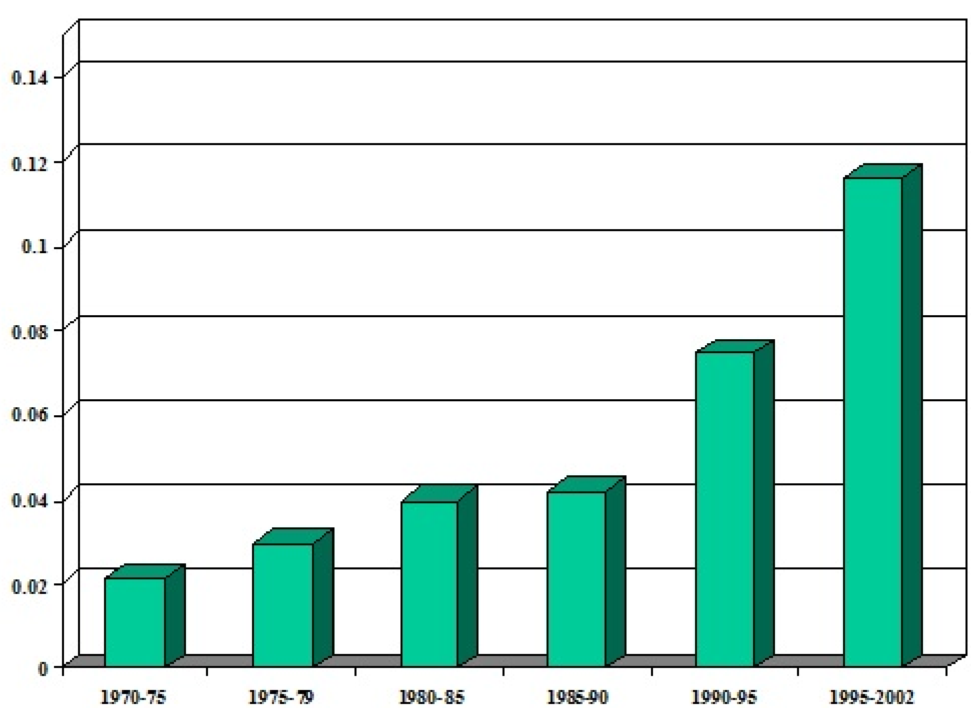

Table 1: Participation in the Caste-Based Insurance Arrangement

Survey year:	1982	1999
	(1)	(2)
Households participating (%)	25.44	19.62
Households giving (%)	12.36	5.46
Households receiving (%)	10.19	10.82
Income of senders	5678.92	19956.29
	(7617.55)	(22578.95)
Percent of income sent	5.28	8.74
Income of receivers	4800.29	10483.84
	(4462.63)	(13493.68)
Percent of income received	19.06	40.26
Number of observations	4981	7405

Note: Standard deviations in parentheses.
Participation in the insurance arrangement includes giving or receiving gifts and loans.
Participation measured over the year prior to each survey round.
Income is measured in 1982 Rupees.

Table 2: Percent of Loans by Purpose and Source

Data source:	1982 REDS					2005 IHDS				
Purpose:	investment	operating expenses	contingencies	consumption expenses	all	investment	operating expenses	contingencies	consumption expenses	all
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Source:										
Bank	64.11	80.80	27.58	25.12	64.61	46.79	62.49	18.78	19.82	46.70
Caste	16.97	6.07	42.65	23.12	13.87	7.82	4.11	19.64	14.24	9.12
Friends	2.11	11.29	2.31	4.33	7.84	6.01	3.33	8.28	7.09	5.38
Employer	5.08	0.49	21.15	15.22	5.62	3.31	0.54	1.11	1.85	1.23
Moneylender	11.64	1.27	5.05	31.85	7.85	20.69	12.82	46.80	53.65	24.67
Other	0.02	0.07	1.27	0.37	0.22	15.38	16.71	5.39	3.35	12.90
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Note: Statistics are weighted by the value of the loan and sample weights.
Columns 1-5 computed using 982 loans receivedin the year prior to the 1982 survey round.
Column 6-10 computed using 12,066 rural loans received in the year prior to the 2005 India Human Development Survey.
IHDS 2005 reports loans received from relatives rather than caste.
Investment includes land, house, business, etc.
Operating expenses are for agricultural production.
Contingencies include marriage, illness, etc.

Table 3: Percent of Loans by Type and Source

Data source:	1982 REDS			2005 IHDS
Loan type:	without interest	without collateral	without collateral or interest	without interest
	(1)	(2)	(3)	(4)
Source:				
Bank	0.57	23.43	0.38	0.00
Caste	28.99	60.27	20.38	44.62
Friends	9.35	91.72	3.89	21.5
Employer	0.44	65.69	0.44	10.75
Moneylender	0.00	98.71	0.00	0.27

Note: Statistics are weighted by the value of the loan.
Columns 1-3 computed using 982 loans received in the year prior to the 1982 survey round.
Column 3 computed using 12,066 rural loans received in the 5 years prior to the 2005 IHDS.
IHDS 2005 reports loans received from relatives rather than caste.

Table 4: Test of Full Risk-Sharing

Dependent variable:	log own-consumption					
Jati sample size criterion:	N>=2	N>=10				
Sample:	all states	all states	non-Hindi states	all states		
	(1)	(2)	(3)	(4)	(5)	(6)
Log own-income	0.184	0.207	0.167	0.194	0.241	0.246
	(0.045)	(0.053)	(0.057	(0.051)	(0.060)	(0.060)
Jati log-consumption	0.873	0.892	0.930	0.716	--	--
	(0.04)	(0.043)	(0.037)	(0.071)		
Village log-consumption (outside jati)	--	--		0.278	--	--
				(0.084)		
Negative weather shock	--	--		0.072	--	--
				(0.022)		
Jati log-consumption (outside village)	--	--		--	0.549	0.608
					(0.119)	(0.121)
Non-jati log-consumption (outside village)	--	--		--	--	-0.212
						(0.116)
R-squared	0.782	0.752	0.83	0.771	0.707	0.708
Number of observations	5,061	3,543	2,184	3,501	3,432	3,432

Note: regressions use three years of data 1969-71 for each household.
All regressions include household fixed effects.
Standard errors in parentheses are clustered at the state-year level.
Jati log-consumption is computed without the household itself.

Table 5: Descriptive Statistics, Panel Sample

Year:	1971	1982	1999
	(1)	(2)	(3)
Panel A: Network Participation, Out-Marriage and Out-Migration			
Participation	--	0.23	0.15
		(0.44)	(0.39)
Out-marriage	--	0.05	0.07
		(0.19)	(0.23)
Out-migration	--	0.05	0.09
		(0.19)	(0.25)
Panel B: Income variables			
Household income (wealth-based measure, 1982 rupees)	--	2175.03	6435.58
		(3112.17)	(10294.68)
Jati income (wealth-based measure, 1982 rupees)	--	1560.46	6862.75
		(1417.23)	(12267.58)
Household income (actual, 1982 rupees)	--	7659.59	17815.58
		(8110.79)	(23787.34)
Jati income (actual, 1982 rupees)	--	6325.13	15133.57
		(3760.35)	(14463.32)
Panel C: Initial conditions and Infrastructure (proportion of households)			
Residing in the village where anyone used HYV	0.62	--	--
	(0.48)		
Share of village land irrigated	0.41	--	--
	(0.38)		
Residing in an IAADP district	0.42	--	--
	(0.49)		
Residing in a village with Agricultural Extension Serv.	0.47	--	--
	(0.50)		
Residing in an IADP district	0.19	--	--
	(0.39)		
Residing in a village with a bank	0.09	--	--
	(0.29)		
Residing in a village with a school	0.92	--	--
	(0.27)		
Residing in a village with a health center	0.21	0.15	0.25
	(0.41)	(0.36)	(0.43)
Residing in a village with a bank nearby (<10 km.)	--	0.85	0.96
		(0.35)	(0.19)
Residing in a village with a public secondary school	--	0.40	0.65
		(0.61)	(0.70)
Residing in a village with a family planning clinic	--	0.03	0.07
		(0.17)	(0.25)

Standard deviations in parentheses. All statistics are computed using sample weights.
Statistics are computed using households in the 1982-1999 panel.
Statistics computed for *jatis* with at least 10 households in sample and households with heads at least age 18 in 1982.

Table 6: FE-IV Participation, Out-Marriage, and Out-Migration Estimates

Income variable:	wealth- and wage-based measure			actual income		
Dependent variable:	participation	out-marriage	out-migration	participation	out-marriage	out-migration
	(1)	(2)	(3)	(4)	(5)	(6)
Household income	-5.20	1.66	2.62	-5.15	2.10	4.07
	(6.80)	(0.74)	(1.72)	(9.90)	(1.83)	(1.86)
Jati income	3.27	-1.11	-1.10	11.00	-2.92	-3.60
	(1.39)	(0.66)	(0.45)	(8.37)	(1.73)	(1.86)
Time trend	0.01	0.03	0.06	0.04	0.01	0.03
	(0.13)	(0.02)	(0.02)	(0.15)	(0.01)	(0.03)
Number of observations	2,335	998	1,049	2,316	994	1,047

Standard errors in parentheses are robust to clustering at the state level. All coefficients should be multiplied by 10^{-6}.

Additional regressors: whether anyone in the village used HYV and share of village land irrigated in 1971 (household and jati average).

Excluded variables: inherited land, interaction of any HYV and irrigation share, interaction of inherited land, any HYV and irrigation share (household and jati average).

Sample restricted to *jatis* with at least 10 households in sample and households with heads at least age 18 in 1982.

Table 7: FE-IV Participation, Out-Marriage and Out-Migration Estimates (with infrastructure variables)

Infrastructure variables:	1971 values			change from 1982 to 1999		
Dependent variable:	participation	out-marriage	out-migration	participation	out-marriage	out-migration
	(1)	(2)	(3)	(4)	(5)	(6)
Household income	-7.68	1.36	2.68	-4.52	1.76	1.85
	(7.68)	(0.64)	(2.25)	(6.51)	(0.74)	(1.83)
Jati income	4.34	-0.97	-1.26	3.50	-1.12	-1.28
	(1.88)	(0.54)	(0.58)	(1.37)	(0.70)	(0.44)
Time trend	0.07	0.03	0.02	-0.02	0.02	0.09
	(0.17)	(0.02)	(0.03)	(0.12)	(0.02)	(0.02)
Joint sig. of infrastructure variables:						
χ^2	4.85	11.12	5.97	15.96	9.27	26.24
p-value	0.43	0.05	0.31	0.00	0.05	0.00
Number of observations	2,335	998	1,049	2,320	987	1,041

Standard errors in parentheses are robust to clustering at the state level. All coefficients should be multiplied by 10^{-6}.

Additional regressors: whether anyone in the village used HYV and share of village land irrigated in 1971 (household and jati average) and infrastructure variables.

1971 infrastructure: IAADP, IADP, AES, bank, school, health center.

Change in infrastructure: bank less than 10 km. away, public secondary school, health center, family planning clinic.

Excluded variables: inherited land, interaction of any HYV and irrigation share, interaction of inherited land, any HYV and irrigation share (household and jati average).

Sample restricted to *jatis* with at least 10 households in sample and households with heads at least age 18 in 1982.

All regressions use wealth-based income measure.

Table A1: First Stage Estimates

Income variable:	wealth-based measure		actual income		wealth-based measure			
Dependent variable:	hh income change	jati income change	hh income change	jati income change	hh income change	jati income change	hh income change	jati income change
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Anyone in the village used HYV (household)	-2787.65	20369.17	265.11	1803.6	-2618.00	21688.62	-3378.44	20365.2
	(3719.06)	(17642.30)	(2608.56)	(810.60)	(3752.89)	(18895.51)	(3721.42)	(17525.41)
Anyone in the village used HYV (jati average)	-3348.87	-42467.91	8859.6	12466.2	-2980.29	-41498.62	-3289.83	-41474.91
	(4990.63)	(39691.53)	(4028.17)	(3987.48)	(5114.41)	(39925.88)	(5224.94)	(39795.92)
Share of village land irrigated (household)	-56.24	5578.18	636.14	1167.55	198.57	4087.9	159.3	6436.22
	(4063.92)	(9886.26)	(3099.13)	(1212.10)	(4478.07)	(6180.60)	(3970.31)	(10663.09)
Share of village land irrigated (jati average)	-4094.89	-22929.07	2285.12	4211.44	-3886.51	-13027.33	-4579.71	-24996.78
	(3144.29)	(32659.12)	(4240.46)	(3514.20)	(2013.12)	(23948.68)	(3481.08)	(34253.30)
HYV*irrigation share (household)	1844.46	-26942.14	1517.91	-2488.38	576.35	-24266.29	1782.07	-27448.49
	(5847.23)	(22377.58)	(4494.42)	(1713.16)	(6549.65)	(19556.85)	(5842.80)	(22838.26)
HYV*irrigation share (jati average)	-1646.46	24413.53	-10470.36	-11867.65	-1546.83	15127.19	-1678.86	25028.11
	(6428.40)	(45272.26)	(7932.12)	(7731.53)	(6223.32)	(39138.00)	(6310.56)	(46625.24)
inherited land (household)	3.48	-5.32	3.95	-0.87	3.44	-5.99	3.41	-5.3
	(1.12)	(4.55)	(3.50)	(0.44)	(1.17)	(4.92)	(1.12)	(4.49)
inherited land (jati average)	6.48	24.11	5.31	15.99	7.96	24.72	4.97	18.92
	(7.88)	(43.01)	(5.47)	(7.60)	(9.05)	(45.61)	(7.71)	(40.70)
HYV*irrigation share*inherited land (household)	3.44	6.58	2.24	1.38	3.24	9.10	3.71	6.45
	(6.06)	(14.78)	(6.94)	(1.71)	(6.22)	(16.25)	(6.11)	(14.92)
HYV*irrigation share*inherited land (jati average)	41.09	140.68	21.43	27.58	41.15	131.82	46.42	151.59
	(19.56)	(37.31)	(7.87)	(10.45)	(19.91)	(37.13)	(21.68)	(41.24)
Constant	8084.81	25683.28	3573.44	-1737.43	12131.81	27469.61	8827.06	28055.6
	(2828.20)	(20544.49)	(3070.46)	(2981.01)	(2985.38)	(20626.17)	(3106.47)	(22540.73)
initial infrastructure conditions (1971)	No	No	No	No	Yes	Yes	No	No
change in infrastructure (1982-1999)	No	No	No	No	No	No	Yes	Yes
F statistic (excluded variables)	104.96	12.28	18.31	10.39	35.16	13.24	84.65	10.12
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R-squared	0.02	0.07	0.04	0.21	0.02	0.08	0.02	0.07
Number of observations	2335	2335	2316	2316	2335	2335	2320	2320

Standard errors in parentheses are robust to clustering at the state level.

Dependent variables are computed as the change between 1982 and 1999.

Excluded variables: HYV*irrigation, inherited land, HYV*irrigation*inherited land (household and jati average)

Regressions restricted to jatis with at least 10 households in sample and households with heads at least age 18 in 1982.