

# ***JEEA-FBBVA LECTURE 2019: CONSUMPTION INSURANCE IN NETWORKS WITH ASYMMETRIC INFORMATION: EVIDENCE FROM TANZANIA***

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## **Abstract**

This paper uses a dataset from Tanzania with information on consumption, income, and income shocks within and across family networks. Crucially and uniquely, it also contains data on the degree of information existing between each pair of households within family networks. We use these data to construct a novel measure of the quality of information both at the level of household pairs and at the level of the network. We also note that the individual level measures can be interpreted as measures of network centrality. We study risk sharing within these networks and explore whether the rejection of perfect risk sharing that we observe can be related to our measures of information quality. We show that households within family networks with better information are less vulnerable to idiosyncratic shocks. Furthermore, we show that more central households within networks are less vulnerable to idiosyncratic shocks. These results have important implications for the characterisation of the empirical failure of the perfect risk-sharing hypothesis and point to the importance of information frictions. (JEL: D15, D52, D82)

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## **1. Introduction**

In many developing countries, risk is very pervasive. The lack of economic development implies not only that individuals have access to a much lower level of resources but also that life is much riskier. Substantial shocks to resources, when one's living standards are close to subsistence levels, can have important and dramatic consequences. The presence of risk is particularly salient in rural contexts, where

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individuals are exposed to large and frequent shocks to their livelihoods. Many of these shocks are idiosyncratic, implying that insurance can be very valuable and very important. Formal insurance markets, however, rarely exist. Informal insurance arrangements are common and, according to the available evidence, do provide some level of insurance (see, for instance Townsend (1994) and, more recently, Kinnan and Townsend (2012)). The observed allocations, however, are very different from those that would prevail under perfect risk sharing and complete markets.

Informal insurance in village economies has received considerable attention, both because it can enable individuals to smooth out idiosyncratic shocks and because its presence interacts with (and sometimes limits) formal insurance and its development (see, for instance, Attanasio and Rios-Rull (2000) and Munshi and Rosenzweig (2016)). The presence of perfect risk-sharing arrangements has been rejected in many contexts (see, for instance, Rosenzweig (1988), Udry (1994) and the recent paper by Kinnan (2020) and the reference therein). An important and interesting research question is, therefore, the identification of the imperfections and frictions that prevent perfect risk sharing. A better understanding of these imperfections and identification of specific frictions as being particularly salient is important not only from a research point of view, but also for informing policy reforms and different policy interventions.

The literature has looked at different types of frictions and imperfections, including the lack of enforceability of informal insurance contracts and imperfect information.<sup>1</sup> Information frictions are the focus of this paper. Studies that have looked at them include Udry (1994), Ligon (1998), Cole and Kocherlakota (2001), and Attanasio and Pavoni (2011). Information frictions could prevent full risk sharing because of the difficulty in contracting on specific income shocks and/or to moral hazard behaviour. In what follows, we relate measures of risk sharing in family networks to measures of the quality of information in these networks. The type of informational frictions we consider most closely resemble the local information constraints in Ambrus, Gao, and Milan (2020). Although we do not map explicitly the imperfections they consider on specific transfers and consumption data, our paper is among the first to consider an empirical measure of imperfect information and relate it to risk sharing in a way that is consistent with the model considered by Ambrus, Gao, and Milan (2020).

Informal insurance arrangements are based on individual transactions and transfers. Data on these transfers are difficult to collect and in most of the available data sets, the information on them is very limited and imprecise. The approach proposed by Townsend (1994) to test for perfect risk sharing is particularly attractive because it only requires information about consumption allocations (the object that is being insured) and income or income shocks. Although the approach is silent about the specific

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1. Studies that focus on the lack of contract enforceability include Foster and Rosenzweig (2001), Kocherlakota (1996), Ligon, Thomas, and Worrall (2002), Attanasio and Rios-Rull (2000), Albarran and Attanasio (2003), and, more recently, Ambrus, Mobius, and Szeidl (2014) and Bold and Broer (2018). A few papers have considered models with both asymmetric information and limited commitment: Atkinson (1991), and more recently, Broer, Kapicka, and Klein (2017), and Denderski and Stoltenberg (2020).

mechanisms that are used in practice to implement the observed resource allocations, it can be useful to characterise the extent to which such allocations differ from perfect insurance. If such a benchmark arrangement is rejected, one can model deviations from perfect risk sharing allocations and gain insights on the nature of the imperfections and frictions that generate the available evidence.

In this paper, we use a unique data set which contains longitudinal data, following family networks in Tanzania for nearly 20 years. Within each family network, all individual households are asked about their own wealth (including about ownership of a variety of different assets) and about the wealth of all other households in their family network. These rich data provide a unique opportunity to construct measures of the quality of the information within each family.

The paper makes two original contributions. First, we propose a new methodology to convert the data on the wealth of each household as perceived by all the other households in the family network into a measure about the quality of information in the family network. As we discuss in Section 4, we construct both measures about the quality of information about each household in the network and about the overall quality of information in a network. As for the former we obtain measures both of the quality of the information that the rest of the network has about the wealth of every household and of the quality of information that each household has about the wealth of the rest of the network. These concepts are related, as we discuss, to measures of network centrality.

Second, we use the measures of the quality of information we derive to check whether they are related to deviations from perfect risk sharing. Starting from a regression similar to those estimated by Townsend (1994), which relates changes in consumption to idiosyncratic shocks after controlling for network level shocks, we check whether this relationship is affected by the quality of information.

We find that our measures of the quality of information exhibit a substantial amount of variation across the network and, when considering dyads of households, the measures covaries with a number of observables (such as the geodesic distance or the frequency of contact between two households in the family network) in the expected fashion. Given the novelty of the type of measures we use, this result is important and reassuring.

As for the level of risk sharing, we first document that, as in other contexts, perfect risk sharing within a network is rejected by our data. When we then look at the way in which information quality interacts with risk sharing, by and large, we find that the better the quality of information in a family network (whether measured at the network or at the individual household level), the closer the allocations in that network are to those that would occur under perfect risk sharing. The results are more precise and more convincing when we consider the quality of information at the household rather than family network level and, in particular, when we consider the quality of the information that the network has about a household's wealth. We find that households whose wealth seems to be better known to the other members of households in the network are less sensitive to idiosyncratic shocks.

To the best of our knowledge, this is the first result relating so directly risk sharing to the quality of information.<sup>2</sup> We do not directly map the association we find between the sensitivity of individual consumption changes to idiosyncratic shocks and information asymmetries to a theoretical model of constrained efficient allocations. This evidence, however, represents an important step in that direction.

The rest of the paper is organised as follows. In Section 2, we present a conceptual framework to analyse risk sharing and relate it to information frictions. In Section 3, we present our data set and in Section 4, we describe our measures of information quality and report some descriptive statistics on them. We report the results of our empirical analysis in Section 5. Section 6 concludes the paper.

## 2. Risk Sharing with Imperfect Information: A Conceptual Framework

In this section, we provide a conceptual framework to inform the empirical analysis that we perform. We take the risk sharing group as a given and characterise risk sharing within that group. Our definition of risk sharing within a pre-defined group does not preclude the existence of other risk sharing arrangements or alternative mechanisms to absorb individual (or group level) shocks. However, the focus is on risk sharing within the pre-defined group.

The groups we consider in the empirical exercise are family networks. The members of an original family in 1991 were followed until 2010 as they move out of the initial nucleus. The survey team was able to achieve a remarkably high response rate: as discussed in Section 3, attrition was below 10%. It is, therefore, plausible to assume that membership of a 'risk sharing group' as we define it, can be considered as a given for the period we consider.

We study the ability of a pre-defined risk sharing group members to absorb idiosyncratic shocks, given the group level shocks. That is, we consider the ability to share risk within a given group and relate that ability to the quality of information within that group and, additionally, to some of the properties of the network. Although it is likely (as we show) that the quality of information within a group is partly a function of choices made by individual members, this consideration does not affect the nature of our exercise. We take the quality of information (or the nature of the network) within a risk sharing group as a given at a point in time and document the extent to which such a variable affects the ability of individuals to smooth out income shocks. Our exercise is silent, in the a first instance, about the mechanisms that lead to a specific relationship between information quality and risk sharing.

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2. De Weerd, Genicot, and Mesnard (2019) use these same data on information within family networks, but apply a different methodology for constructing a measure of misperceptions in order to study a different set of questions. They quantify misperceptions by constructing a weighted sum of differences between believed and actual asset holdings, setting weights according to the correlation of each of the assets with household consumption. Their focus is on testing alternative motives for transfers within family networks, which do not include risk-sharing. Indeed as their measure of information imperfections is constructed using consumption data, it cannot be related to risk sharing.

### 2.1. Perfect Risk Sharing

We start by considering risk sharing within a group of agents. Group membership is given exogenously and therefore risk sharing groups are defined exogenously. They could be villages, family networks or other groups.

The approach we take to characterise full risk sharing within a group goes back to Wilson (1968) and Townsend (1994). We assume that individual  $j$  belonging to group  $g$  receives a stochastic endowment  $y_t^{j,g}$ .

$$y_t^{j,g} = \bar{y}_t^g + \varepsilon_t^j.$$

We assume that  $y$  is perishable. For expositional simplicity we do not consider saving here, but it would be straightforward to add that or any other mechanism to absorb shocks, including risk sharing arrangements with different groups and/or institutions.

Individual  $j$  in group  $g$  receives utility from consumption  $c_t^{j,g}$ , which is given by their endowment plus a transfer  $\tau_t^{j,g}$ . The implications for allocations of perfect risk sharing can be derived considering a social planner problem, as in Townsend (1994), where the planner maximises a weighted sum of the expected utility of the risk sharing group.

$$\max_{\{\tau_t^{j,g}\}_{j=1 \dots K_g}} \sum_{j=1}^{K_g} \lambda_{j,g} \sum_{t=0}^{\infty} \beta^t \int_Y u(y_t^{j,g} + \tau_t^{j,g}) d\mu^t(y_t^{j,g}) \tag{1}$$

$$\text{subj. to: } \sum_{j=1}^{K_g} y_t^{j,g} = \sum_{j=1}^{K_g} c_t^{j,g} \quad \forall t \tag{2}$$

$$c_t^{j,g} = y_t^{j,g} + \tau_t^{j,g} \quad \forall t, j \tag{3}$$

where  $\mu^t()$  is a probability measure of the stochastic endowment  $y_t^{j,g}$ , which reflects the available (and public) information.  $y_t^{j,g}$  is completely observable (*ex-post*) and can be contracted upon.  $\lambda_{j,g}$  is the Pareto weight given to individual  $j$  in group  $g$ , which allows for inequality and asymmetries within the group and is assumed to be constant. Different  $\lambda$ 's might reflect different status within the risk sharing group, or access to different amount of resources by different individuals. Again, by modifying the aggregate resource constraints (2) and/or the individual budget constraint (3), it is possible to take into account additional insurance mechanisms either through saving or through risk sharing arrangements *outside the group*.

Considering the Lagrangian for this problem, in the absence of frictions (information, enforceability), the first order condition w.r.t.  $c_t^j$  is given by

$$\lambda_{i,g} \beta^t u'(c_t^{i,g}) \mu_t^g = v_t^g \quad \forall i, t. \tag{4}$$

where  $\mu_t^g$  is the probability of the state of the world at time  $t$  and  $v_t^g$  is the multiplier associated with group  $g$  aggregate resource constraint. From equation (4) we note

that the right hand side,  $v_t^g$ , does not depend on the individual household index  $i$ . Second, the Pareto weight  $\lambda_{i,g}$  is a constant that does not depend on  $t$ . Finally, the f.o.c. is not averaged across different states of the world, but holds, appropriately weighted by  $\mu_t^g()$ , the probability distribution of the income shocks, for every possible state. This last fact is key to the perfect risk sharing structure. As income shocks are fully observable and contractable upon, insurance contracts can diversity idiosyncratic income shocks, regardless of the properties of the stochastic process that generates them. Considering the ratio of these conditions for agents  $i$  and 1 we get:

$$\frac{u'(c_t^{i,g})}{u'(c_t^{1,g})} = \frac{\lambda_{1,g}}{\lambda_{i,g}}; \quad \forall i, t \tag{5}$$

Taking logs of equation (4) one gets:

$$\ln(\lambda_{i,g}) + \ln(u'(c_t^{i,g})) + t \ln(\beta) = \ln(v_t^g) \tag{6}$$

This equation can be taken to data in several ways. One can introduce and estimate individual fixed effects to capture the unobservable Pareto weights, or one can take time differences to difference them out. Having many risk sharing groups, one has to consider timeXgroup fixed effects.

Taking differences across time periods:

$$\Delta_s \ln(u'(c_t^{i,g})) + s \ln(\beta) = \Delta_s \ln(v_t^g) \tag{7}$$

Equations (6) and (7) capture the essence of perfect risk sharing. We notice the absence from the right hand side of any time varying idiosyncratic variable, once one controls for a group aggregate. In equation (6), which is expressed in levels, one has to control for individual fixed effects that capture the Pareto weights of the planner problem. These effects drop out once one considers the expression in different time periods and takes the difference between them. We notice that expression in equation (7) is not necessarily in first differences, that is the changes in (log) consumption considered are not over a specific period. One consider changes to difference out the Pareto weights fixed effects.

The restrictions in equations (6) and (7) are the key implications of perfect risk sharing. To test them, Townsend (1994) and others have augmented it with idiosyncratic variables, such as levels or changes of individual income.

$$\ln(u'(c_t^{i,g})) = \tilde{\kappa}^{i,g} + \ln(v_t^g) + \tilde{\gamma} \ln(y_t^{i,g}) + \tilde{\varepsilon}_t^{i,g} \tag{8}$$

$$\Delta_s \ln(u'(c_t^{i,g})) = \kappa^g + \Delta_s \ln(v_t^g) + \gamma \Delta_s \ln(y_t^{i,g}) + \varepsilon_t^{i,g} \tag{9}$$

where  $\tilde{\varepsilon}_t^{i,g}$  and  $\varepsilon_t^{i,g}$  reflect measurement error and other unobservables. The coefficients  $\tilde{\gamma}$  and  $\gamma$ , which measure the *vulnerability* of a single individual to idiosyncratic shocks, should be 0 under perfect risk sharing.

An attractive feature of this approach is that it is based exclusively on consumption and idiosyncratic resource information. It does not require information about the decentralization mechanisms (such as transfers) that a given realisation of income shocks would require to achieve first best.

## 2.2. Deviations from Perfect Risk Sharing: Imperfect Information

Empirically, perfect risk sharing is often rejected. Researchers have found that, although some smoothing of idiosyncratic shocks is observed, observed allocations are different from first best ones, in that consumption is affected by idiosyncratic shocks. Although individuals in a variety of contexts can achieve some insurance, the empirical evidence seems to reject perfect risk sharing (see Rosenzweig (1988), Udry (1994) and Kinnan (2020)). De Weerd and Hirvonen (2016) find similar evidence in the same data we use in what follows, which were collected in Tanzania.

As discussed in the introduction, in light of the rejection of perfect risk sharing, a profitable approach is to look at the relevance of specific frictions. In this paper, we analyse a very simple and specific information problem. In particular, we relate the level of risk sharing (or deviations from perfect risk sharing) to the quality of information in a given network. We start by assuming that individual household  $i$  in risk sharing group  $g$  (a family network), receives an exogenous income  $y_t^{i,g}$ . Each member of the risk sharing group receives some signals about the income received by everybody else.

$$x_t^{ij,g} = y_t^{i,g} + e^{ij,g} \tag{10}$$

where  $x_t^{ij,g}$  is the signal received by household  $j$  about household  $i$ 's income, where both households belong to group  $g$ .  $e^{ij,g}$  is a zero-mean random variable, which represents the noise that somewhat masks household  $i$ 's income from household  $j$ . The variance of this noise represents the quality of information that household  $j$  has about household  $i$ . We will allow the precision of the signal to be different across different members of the network and, as we discuss in what follows, construct estimates of the quality of the information each individual household in any given pair in a network has about the other. The quality of the information that different network members have about the economic status of any given individual household effectively defines the position of that household in the network.

In our empirical application, we follow two different approaches, which we discuss in the next sub-section. First, we assume that the extent of risk sharing within a pre-defined group (in our case a family network) is determined by the quality of information available in a network. Family networks where the information is of high quality, will be closer to the first best allocations that would be observed under perfect risk sharing. Individuals living in households that are part of family networks where information flows are of inferior quality, on the other hand, will be more vulnerable to idiosyncratic shocks that could be diversified.

Second, we relate household vulnerability to the position of the household in a family network, which in turn is determined by the quality of information in the network. This approach can be interpreted in the light of a model of bilateral transfers among all the households in the networks. In such a model, discussed by Attanasio et al. (2020, in progress), the net transfers between households  $i$  and  $j$  are determined by contracts based on the information common to these households, which is  $x_t^{ij,g}$  and  $x_t^{ji,g}$ . An attractive feature of this approach is that one can avoid consideration of



explicit incentive compatibility constraints induced by truth telling constraints or moral hazard problems. Instead, it uses a static framework where transfers between pairs of households can only be conditional on the information available to both members. We now turn to the discussion of these two approaches.

### 2.3. Empirical Strategy to Measure the Effect of Asymmetric Information

One of the advantages of the perfect risk-sharing model is that one can be agnostic about the specific decentralization of the efficient allocation. One, therefore, does not need to keep track of all bilateral transfers and can consider only net transfers, and therefore consumption allocations, of each individual. This is not necessarily the case in the asymmetric information case with several sources of asymmetries. It is possible, however, to implement tests that identify violation of perfect risk sharing by looking at the vulnerability of individual consumption to idiosyncratic shocks and relating such vulnerability to the quality of information in a given risk-sharing group.

To capture deviations from perfect risk sharing due to imperfect information empirically we extend equation (9) in several ways. First, we estimate the following equation:<sup>3</sup>

$$\Delta_s \ln(u'(c_t^{j,g})) = \kappa + \mu_t^g + \varphi_1 Iq^g + (\gamma_0 + \gamma_1 Iq^g) \Delta_s \ln(y_t^{j,g}) + \varepsilon_t^{j,g} \quad (11)$$

where  $Iq^g$  is a measure of the quality of information in family network  $g$  and  $\mu_t^g = \Delta_s \ln(v_t^g)$ . Because  $Iq^g$  varies only across networks, the parameter  $\varphi_1$  cannot be identified as the variation in  $Iq^g$  would be absorbed by the group dummies  $\mu_t^g$ .

The coefficient  $\gamma$  in equation (9) should equal to zero under perfect risk sharing, as idiosyncratic shocks and changes to household income should not be related to changes in household consumption, after controlling for group level shocks, which is what the group-time dummies  $\mu_t^g$  do.<sup>4</sup> Such a coefficient can therefore be interpreted as the “excess” sensitivity of individual consumption changes to idiosyncratic shocks. In equation (11), we let this coefficient be a function of the quality of information in a risk sharing group. If  $\gamma_1$  has the opposite sign of  $\gamma_0$ , vulnerability in high quality information networks is lower. Allocations in such networks are closer to those that would prevail under perfect risk sharing. Although such evidence would stress the importance of information frictions in shaping risk sharing arrangements, it does not follow directly from a theoretical model that maps these friction on onto consumption allocations.

3. We also estimate similar versions of equation (8), which is in levels. These equations have a very large number of parameters, as we need individual fixed effect and we have a small number of periods. The results are similar and are available upon request.

4. In our data, where we have two periods, and therefore, one period over which changes in consumption are observed, we only have group dummies. It is important, however, to remember that if additional time periods were available, we would have fully interacted time and group dummies, to reflect the resource constraints multipliers of each group.



The estimation of equation (11) requires a measure of the quality of information within a network. We discuss such a measure in Section 4 in what follows. The main idea here is that, family networks where information is very good are close to achieving perfect risk sharing, although family networks where information is very imperfect, deviate considerably from perfect risk sharing, so that individual households are vulnerable to idiosyncratic shocks.

In equation (11), the quality of information varies across family networks but it is constant for the households *within a family network*. In the model presented by Ambrus, Gao, and Milan (2020) and developed by Attanasio et al. (2020, in progress), under a certain set of assumptions, vulnerability of an individual does not depend exclusively on the average quality of the information flows in that network, but could depend on the position of a given individual in the network and an appropriate weighted average of the shocks received in the network. To bring this intuition to the data, in addition to equation (11), we also estimate the following equation:

$$\Delta_s \ln(u'(c_t^{j,g})) = \kappa^g + \mu_t^g + \varphi_2 NP^{i,g} + (\gamma_0 + \gamma_2 NP^{i,g}) \Delta_s \ln(y_t^{j,g}) + \varepsilon_t^{j,g} \quad (12)$$

where  $NP^{i,g}$  is a measure of household centrality within the family network, reflecting either average quality of the information about household  $i$ 's income held by the other members of the family network, or quality of information that household  $i$  has about incomes of the other households in the network. We discuss the definition and interpretation of these alternative variables in Section 4, where we discuss the construction of information quality measures. As before, in addition to interacting  $NP^{i,g}$  with individual shocks, we also enter that variable on its own.

Implementing the estimation of equations (11) and (12) requires the availability of variables that can capture the quality of information and the position in the risk sharing network of an individual. We discuss these issues in what follows. Before moving to the description of the data and to the methods we use to obtain these measures, it is worth mentioning a few additional issues. First, we notice that both the  $Iq^g$  and  $NP^{i,g}$  variables do not have a time subscript as we assume they are constant over time. This assumption is forced on us in part by the fact that we have measurements on the quality of information only in the last wave of the survey. We can justify this assumption, however, by pointing to the fact that we only consider two time periods. We can therefore argue that our measure of information quality captures the household vulnerability to idiosyncratic shocks that occur between those two periods.

A more worrying possible criticism is that the quality of information and the structure of the networks does not change randomly, but might be linked to individual incentives and economic opportunities. As we will see in what follows, much of the variation in household information quality is driven by distance between geographic locations, which is in turn driven by migration decisions. Although migration decisions are very likely to be driven by economic opportunities, we stress that our characterization of risk sharing, based on measuring how household vulnerability is affected by the quality of information (or the position in the network) takes these variables as predetermined.

Considering, for instance, equation (11), we notice that the left-hand side represents changes in the log of the marginal utility for household  $i$  belonging to group  $g$ . The residual term of that equation,  $\varepsilon_t^{i,g}$  represents measurement error and other unobservable shifts to the marginal utility of consumption. One possible source of bias in the results we obtain would be a correlation between the unobserved determinants of log marginal utility across networks and differences in the quality of information. Reassuringly, however, our results do not change when we add variables, such as changes in family composition, that might capture part of the variability of  $\varepsilon_t^{i,g}$ , suggesting that they are unlikely to be affected by this type of omitted variable bias. Of course, it could be that idiosyncratic changes in the marginal utility of consumption could induce migration of some network members and, as a consequence, be correlated with the quality of information. We take the information structure in an extended family network (and its drivers) as given and predetermined at the start of the period over which we consider consumption changes.

### 3. The Data from Tanzania

The Kagera Health and Development Survey (KHDS) in Tanzania is one of the longest running African panel surveys designed to study long-run and inter-generational trends in and mechanisms of poverty persistence and economic growth in rural households. Kagera region lies at the shores of Lake Victoria and shares a border with Uganda, Rwanda, and Burundi. The 2012 census estimated a population of just under 2.5 million. More than 80% of the households rely on agricultural production as their main source of income (NBS 2013). The first round of KHDS interviews was held in 1991–1994 with 915 households originating from 51 villages and urban areas across Kagera interviewed up to four times. The first follow-up survey was organized in 2004 with the aim of re-interviewing all individuals ever interviewed at the baseline (1991–1994). This involved tracking individuals who had migrated away from the village to other parts of the region, elsewhere in Tanzania or to neighboring Uganda. More than 93% of the baseline households were re-contacted after a 10-year period (see Beegle et al. 2006).<sup>5</sup> The second follow-up survey was organized in 2010. This time the tracking success rate was 92%; that is at least one original household member was interviewed for 92% of baseline households (see DeWeerd et al. 2012). Relative to comparable panel surveys, these household level attrition rates are exceptionally low (Alderman et al. 2001).

At the individual level, the re-interview rates among survivors were 82% in 2004 and 85% in 2010. The aim in the 2004 and 2010 survey rounds was to re-interview all of the surviving individuals who were on at least one of the 1991–1994 household rosters. In total, there were 6,353 individuals on these; by 2010, 1,275 of these had died whereas 85% of the surviving 4,996 individuals were re-interviewed.

5. This excludes 17 households in which all previous household members were deceased.

TABLE 1. Sample characteristics.

	Mean	SD
<b>Location of household</b>		
Regional capital/city	0.19	0.39
District capital/peri-urban town	0.12	0.33
Well-connected village	0.54	0.50
Remote village	0.15	0.36
<b>Main source of household income</b>		
Non-agricultural wage employment	0.16	0.37
Non-agricultural self-employment	0.10	0.30
Agriculture	0.53	0.50
Other	0.21	0.41
<b>Household consumption expenditure</b>		
2004 consumption per capita (in 2010 TZS)	444,680.83	390770.05
2010 consumption per capita (in 2010 TZS)	702,459.58	745049.09
<b>Household composition</b>		
Head is male	0.79	0.41
Head age	41.56	15.48
Head education	6.18	3.22
Highest level of education in hh	7.42	2.72
Household size	4.64	2.39
Male age 0 to 15	0.45	0.50
Female age 0 to 15	0.48	0.50
Male age 6 to 60	1.06	0.74
Female age 6 to 60	1.12	0.75
Male age 61+	0.08	0.27
Female age 61+	0.12	0.34
Observations	2,780	

At each round of the survey a complete multi-topic household questionnaire was administered to all split-off households containing individuals who had resided in the original baseline sample of households. Topics covered ranged from education, health, employment and migration of individual household members, to household asset ownership, consumption expenditure, formal and informal networks, remittances, history of economic shocks, and more (see DeWeerd et al. 2012 for a detailed description).

We now present some basic sample descriptive statistics and discuss the key features which make these data uniquely suitable for our analysis.

### 3.1. Sample Characteristics

Table 1 shows some descriptive statistics for the sample. We focus here on the sample we will use in the main analysis which excludes some households (we discuss which ones in what follows). In total we focus on 2,780 households formed from 709 original baseline households. By 2010 these were still predominantly located in rural areas with

nearly 70% in well connected or remote villages. About half relied on agriculture as the main source of household income. The great majority of households (79%) have a male head who, on average has around 6 years of schooling (equivalent to completing primary school). Even focusing on individuals with the highest level of education in the household, we see that this is equivalent to incomplete lower secondary schooling.

The main outcome in our analysis is consumption growth between 2004 and 2010; which seems quite substantial over that period. On average, in 2010, per-capita consumption is measured to be nearly 60% higher than that in 2004. Growth in non-food consumption has significantly exceeded that in food consumption, at 97% and 39% respectively. This increase is likely to be driven by several factors, including ageing and family changes, as well as aggregate growth. It is clear from the data that migration plays an important role; although per-capita consumption grew at half of the average rate (by 32%) among those who stayed in the original baseline villages, it more than doubled among those who moved outside the region. This difference is highlighted in other studies using these data (see Beegle et al. 2006 and De Weerd and Hirvonen 2016).

### 3.2. *Household Consumption Expenditure and Shocks*

We now turn to the key variables in the analysis set out in Section 2.3, including consumption expenditure and household income. Detailed consumption expenditure data were collected in each round of the survey. We utilise consumption expenditure data collected in the 2004 and 2010 rounds. The questionnaires included modules capturing food and non-food consumption, with differing recall periods to reflect seasonality of consumption of certain items and several checks built in to accurately capture consumption from home-production. The surveys also included price questionnaires which were used to generate temporal and spatial deflators for the consumption expenditure aggregates (DeWeerd et al. 2012).

Unfortunately, our data do not include detailed information on household income for the last (2010) survey wave. It is, therefore, not possible to run equations (11)–(12) as specified. Instead of income, however, we have information about the shocks, positive and negative, these households recall experiencing in each year between 2004 and 2010, collected in 2010. Specifically, for each year between 2004 and 2010 all individuals who had been members of the original households in 1991–1994 were asked to report whether it was a very good, good, average, bad, or very bad year. For very good and very bad years they were further asked to give reasons and for very bad years ways in which they coped.

The top panel of Table 2 shows that only a fifth of households did not report experiencing a bad or very bad shock in any of the years between 2004 and 2010. Households reported experiencing a bad shock in an average of 2.5 years over this period. Good shocks and very good shocks are less prevalent, though still nearly two-thirds of the households report experiencing at least one during the recall period.

To give some idea of what the key risks for families in this context are, the middle panel shows the reasons given by the 1,627 individuals in the sample who report having

TABLE 2. Shocks, their causes and consequences.

	Mean	SD
<b>Shock prevalence</b>		
Any bad or very bad shock between 2004 and 2010	0.80	0.40
Any good or very good shock between 2004 and 2010	0.65	0.48
Years with bad/very bad shocks between 2004 and 2010	2.57	2.11
Years with good/very good shocks between 2004 and 2010	2.27	2.30
Any bad or very bad shock in 2010	0.35	0.48
Any good or very good shock in 2010	0.33	0.47
N	3,313	
<b>Shock cause (2004–2010)</b>		
Failed harvest	0.32	0.47
Loss of employment	0.12	0.32
Family illness/death	0.38	0.49
Loss of assets	0.08	0.27
Other	0.11	0.31
N	1,627	
<b>Coping strategies (2004–2010)</b>		
Reduced consumption	0.29	0.46
Sold Assets	0.18	0.39
Took on more work	0.25	0.43
Diversified (business/crops)	0.11	0.31
Support from formal/informal orgs	0.03	0.16
Relied on family and friends	0.39	0.49
Migrated for work	0.03	0.17
Other	0.16	0.36
N	1,627	

had a very bad year at least once during the recall period. Most commonly cited reasons include family illness and death, as well as poor harvest. The bottom panel of the table suggests that family and friends are an important source of support during these hard times; two out of five individuals who report experiencing a very bad shock during the recall period said that they relied on family and friends as the main coping strategy. Other most commonly cited strategies include reducing consumption and taking on more work. In this paper we focus on shocks reported for 2010, the year immediately preceding the survey. The table shows that 35% of households reported experiencing a bad or very bad shock in that period, and nearly the same proportion (33%) a good or very good one.

In the third panel of Table 2, we report information on the main coping strategies individual households use to deal with the negative shocks they received. We notice that the most common coping mechanisms, used by nearly 40% of the households, is support from family and friends. The second most common coping mechanism

TABLE 3. KHDS 2010 sample location.

	Location of original household members in 2010	Family networks in 2010 with at least one individual in:
Same village as in baseline	0.52	0.86
Nearby village	0.09	0.31
Same region as in baseline	0.23	0.60
Another region in Tanzania	0.14	0.36
Another country	0.01	0.04
Observations	4,287	816

is a reduction in consumption, which is relevant for nearly 30% of the households, followed by an increase in labor supply (25%) and dis-saving (18%).

### 3.3. Family Networks

A key feature of the data that makes our analysis possible is availability of information on a relatively large number of “family networks.” We define a family network as the group of households formed by individuals who were living in a single household at the beginning of the data collection and that have subsequently split-off into different households, for a variety of reasons, including marriage and migration. Some of these split-off households are located in the same village as the original nucleus, others are in near-by villages, and others still live in relatively far away places. Our data include a large sample of such networks; although the original 1991–1994 sample consisted of 915 households, the 2010 sample contains members from 816 of these residing across 3,313 households. That is, on average each of the original households had split into just over four households. Consistently with this Table 3 shows that by 2010 only about half of the original members of the 1991–1994 households were still living in the original village; about a third moved out of the villages but remained in the region and 15% had left the region either relocating to another part of Tanzania or leaving the country.

Column 2 in Table 3 shows proportions of original households (or family networks) that had at least one member residing in each of the listed locations. This presents a somewhat different picture. Although about half of the original 4,287 *household members* who were re-surveyed in 2010 had moved to a different location, the great majority (86%) of the networks still had at least one member residing in the original village in 2010. Similarly, although only 15% of the individuals had moved out of the region by 2010, they came from 40% of the family networks. Maps in Appendix A show changes in the spatial distribution of the households between 1991–1994 and 2010.

## 4. Information Quality

In the 2010 (last) data-collection round of the KHDS, a big effort was made to capture interactions within the family networks and quality of information that members

possess about each other's standard of living. This is the information that makes this data-set uniquely suited for our purposes.

#### 4.1. Measuring Information Quality

Specifically, in the 2010 round each household within a family network was asked a series of questions about each of the other households in the family network. The information collected includes how often each pair interact and in what way, history of recent monetary and in-kind transfers and, critically for us, their beliefs about asset ownership among the other households in the network. The asset list includes house, land, livestock, phone, television, and motorized vehicle. Each household was asked about whether they themselves owned these assets and whether they believed that each of the other households did. For each dyad within the network, then, these data provide information on the "truth" (self-reported asset ownership for each household in the network) and the "beliefs" regarding all other households in the network. In this set-up, the quality of information that household  $i$  has about household  $j$  can differ from the information that household  $j$  has about household  $i$ . A limitation of the data is that original household members who were still living in the original baseline village in 2010 were not asked about each other even if they were living in different households so we have to assume that they have perfect information about each other.

In the exercise we perform, we need to construct statistics that represent the quality of information between the *nodes* of the family network. In total once we exclude households with no split offs and households for which we have no 2004 data, or are missing data for key variables we have a sample of 709 family networks, 2,780 households and 12,693 dyads (descriptive statistics for these households are presented in Table 1).

In order to use these data to construct a measure of information quality within a family network (and the quality of the information about a generic individual wealth), we assume that there is a latent variable  $\theta_{i,g}^j$ , which represents the wealth or well being of household  $i$  as perceived by household  $j$ ; where both households  $i$  and  $j$  belong to family  $g$ . Note that  $\theta_{i,g}^i$  represents the "true" latent variable for household  $i$ . Although we do not have direct information about either the "true" wealth of household  $i$  or how this wealth is perceived by household  $j$ , we have answers to questions about households  $i$  owning a number of assets given by all the households in the family to which  $i$  belongs, including  $i$  herself. We denote with  $A_{i,g}^{k,j}$  a variable that indicates whether household  $j$  thinks that household  $i$  of family  $g$  owns asset  $k$ .  $A_{i,g}^{k,i}$  indicates whether household  $i$  actually owns asset  $k$ .

Before delving into the description of the methodology we use to synthesize the information different households have of the wealth held by other member of the family network, we present some evidence about the correctness of the information about individual assets. In Table 4, we notice that a relative high proportion of answers about individual assets are "correct," in the sense that they coincide with the answer given by the individual owner. For all individual assets, the proportion of correct



TABLE 4. Quality of information: descriptives.

	Mean	SD
<b>Proportion of assets reported correctly by other households</b>		
House	0.80	0.40
Land	0.79	0.41
Animals	0.79	0.40
Phone	0.77	0.42
TV	0.79	0.41
Car	0.74	0.44
Proportion of all assets reported correctly	0.78	0.29
All assets reported correctly	0.46	0.50
N	12,693	

answers is close to 80%. However, less than half the dyads report correct answer for *all* assets. Therefore, we conclude that the information in the family networks in our sample is far from perfect.

To summarize the answers that individual dyads of households give about each other asset ownerships into a single index reflecting the quality of information about that dyad, we assume that, although the latent index  $\theta_{i,g}^j$  is unobservable by the researcher, the information about asset ownership is related to such a latent variable by an Item Response Theory (IRT) model. In particular, we assume that the standard of living latent variable  $\theta_{i,g}^j$  determines the probability that household  $i$  owns asset  $k$  according to a 1-parameter Rasch model:<sup>6</sup>

$$\text{Prob}\{A_{i,g}^{k,i} = 1\} = \frac{e^{\beta^k + \theta_{i,g}^i}}{1 + e^{\beta^k + \theta_{i,g}^i}} \quad \theta_{i,g}^i \sim \mathcal{N}(0, \sigma^2) \quad (13)$$

When information is available about at least two assets, it is possible to estimate the parameters of the measurement system in equation (13). Given the estimates of the relevant parameters, it is possible to obtain, from a set of measures  $A_{i,g}^{k,i}$ , an estimate of the unobservable household wealth  $\theta_{i,g}^i$ , which we denote by  $\hat{\theta}_{i,g}^i$ . The parameters of this model and the answers provided by household  $j$  about household  $i$ 's assets can be also used to get an estimate of  $\theta_{i,g}^j$ ,  $\hat{\theta}_{i,g}^j$ . The model in equation (13) effectively summarizes the information about asset ownership in a single index. Analogously, the same model can be used to summarize the answers provided by household  $j$  on household  $i$  so to obtain  $\hat{\theta}_{i,g}^j$ . The implicit assumption is that the latent factor representing  $j$ 's perception about  $i$ 's wealth can be represented by a model like the one in equation (13). Or, in other words, that household  $j$ 's answers to questions about various items owned by household  $i$  are driven by the sample factor that drives the answers by their own wealth.

6. We tried to estimate a two-parameter Rasch model but encountered some convergence issues.

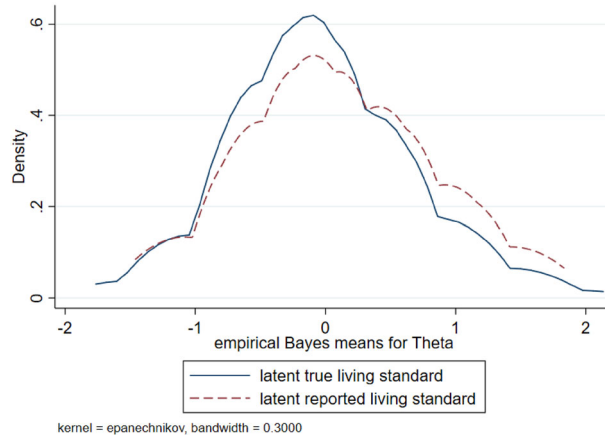


FIGURE 1. Kdensity of “true” & “perceived” living standard  $\theta$ .

Figure 1 shows the distribution of the true and the perceived living standard estimates from the IRT model. The fact that the two are not perfectly overlapping suggests that households in the network are not perfectly informed about each-other’s living standards.

#### 4.2. Constructing Measures of Information Quality

We then take assume the difference between  $\hat{\theta}_{i,g}^j$  and  $\hat{\theta}_{i,g}^i$  as reflecting the quality of information about income flows and shocks of the network members. We note that the model in equation (13) assumes that the latent factor  $\theta_{i,g}^i$  is normally distributed. This might not be the best representation of the variability of economic well-being within a network. We therefore consider three alternative measures that capture the different between  $i$ ’s “true well-being” and the perception of the same factor as held by household  $j$ . In particular, we define three different measures to capture such difference, which we label  $q_{i,j}^{g,\ell}$ ,  $\ell = 1, 2, 3$ .

$$\begin{aligned}
 q_{i,j}^{g,1} &= |\hat{\theta}_{i,g}^i - \hat{\theta}_{i,g}^j| \\
 q_{i,j}^{g,2} &= |e^{\hat{\theta}_{i,g}^i} - e^{\hat{\theta}_{i,g}^j}| \\
 q_{i,j}^{g,3} &= e^{|\hat{\theta}_{i,g}^i - \hat{\theta}_{i,g}^j|}
 \end{aligned}
 \tag{14}$$

The first measure takes the estimates of the latent factor  $\theta_{i,g}$  straight from the Rasch model in equation (13). The second measure considers the exponents of the latent factor estimated with the Rasch model, implicitly assuming that the factor being modeled in equation (13) is the log of the factor of interest. In this case, therefore, we express the distance between the actual and perceived status in term of the levels of this variable, as specified in the second line of equation (14). The third measure is somewhat in

TABLE 5. Quality of information and observables.

	Mean	SD
<b>Quality of information by distance between households</b>		
Q1 (0.4 km)	0.97	0.11
Q2 (4.2 km)	0.81	0.23
Q3 (17.2 km)	0.75	0.24
Q4 (81.6 km)	0.70	0.25
Q5 (613.5 km)	0.67	0.24
<b>Quality of information by last time households spoke</b>		
Less Than A Month Ago	0.86	0.21
Less Than A Year Ago	0.74	0.23
Less Than 2 Years Ago	0.71	0.25
Less Than 5 Years Ago	0.66	0.25
More Than 5 Years Ago	0.64	0.26
Don't Remember	0.59	0.26
N	12,693	

the middle of the first two. Given these definitions of the distance between the true and perceived well-being status, we construct an index that varies between 0 and 1. In particular, for each of the measures in equation (14) we define:<sup>7</sup>

$$\alpha_{ij}^{g,\ell} = \frac{1}{1 + q_{i,j}^{g,\ell}}, \quad \ell = 1, 2; \quad \alpha_{ij}^{g,3} = \frac{2}{1 + q_{i,j}^{g,3}}. \quad (15)$$

When  $q_{i,j}^{g,\ell}$  is zero, that is the information  $j$  has about  $i$  is perfectly accurate,  $\alpha_{i,j}^{g,\ell} = 1$ . Vice-versa, when the same information is very inaccurate,  $\alpha_{i,j}^{g,\ell}$  tends to zero.

Taking the simplest of these measures ( $\alpha_{ij}^{g,1}$ ), we now analyse how our measure of the quality of information between two households are related to a series of characteristics that we would expect it to be related to. Most obviously, households that are located closer together and those that interact more should have better information about each other. Table 5 shows that this is indeed the case—the degree of misperception is highly positively correlated with physical distance as well as with frequency of contact. For households living close to each other (bottom quintile of geodesic distance from each other in which households are on average 400 meters apart), our measure is closed to perfect at 0.97.<sup>8</sup> However, already for households at the median distance from each other (17.2 kms), the average index is 0.75. The same index declines to 0.67 for the households living in top quintile of distance from each other.

7. We multiply the third measure by two so that it varies between zero and one.

8. This is mostly mechanical as we assume perfect information for all households within a family network still located in the baseline village, because data on how much they know about each other were not collected for these.

A similar pattern is observed if we consider how our index varies with the frequency of contact. For households that have spoken to each other less than a month before the interview, the average index is 0.86. This declines with frequency: for households that have not spoken for more than 5 years the index is 0.64.

Having constructed the indexes  $\{\alpha_{i,j}^{g,\ell}, \ell = 1, 2, 3\}$  for each dyad in the network, we can organise them into a matrix  $A^{g,\ell} = [\alpha_{i,j}^{g,\ell}]$ , for each family network in our data, where we set  $\alpha_{i,i}^{g,\ell} = 0, \forall i$ . The matrices  $A^{g,\ell}$  so constructed are weighted adjacency matrices. We note that, unlike many of these matrices used in the literature, their elements are not binary, as they can take continuous values between 0 and 1. Furthermore, these matrices can be asymmetric, as the quality of information that household  $i$  has about household  $j$  might be different from the quality of information that  $j$  has about  $i$ .

Given an adjacency matrix  $A^{g,\ell}$ , for each household in family  $g$ , we can now construct measures of their position in the network. In our empirical application, we will use measures of degree centrality, which can be obtained summing or averaging, for each household, the elements of the row or the columns of the adjacency matrix corresponding to that household. As the matrices we are considering is not symmetric, the measures obtained averaging the rows or the columns are different. Averaging over the rows of the adjacency matrices we get:

$$InQ_i^{g,\ell} = \frac{1}{K_g - 1} \sum_{k \neq i} \alpha_{ik}^{g,\ell} \tag{16}$$

where  $K_g$  is the number of households in family  $g$ . The expression in equation (16) is the in-degree centrality derived from the adjacency matrix  $A^{g,\ell}$  and represents the average quality of the information the network has about the wealth of household  $i$ . Analogously, we can construct the out-degree centrality measure for household  $i$  averaging the elements of the matrix  $A^{g,\ell}$  corresponding to column  $i$ . This measure represents the average quality of the information household  $i$  has about the other network members.

$$OutQ_i^{g,\ell} = \frac{1}{K_g - 1} \sum_{k \neq i} \alpha_{ki}^{g,\ell} \tag{17}$$

Finally, we can also define the quality of information in family  $g$  averaging the individual measures as:

$$IQ^{g,\ell} = \frac{1}{K_g} \sum_j^{K_g} InQ_j^{g,\ell} \tag{18}$$

We notice that the expression in equation (18) can be constructed either from equation (16) or equation (17).

In Figures 2, for each of our information quality measures, we plot the density distribution of the in-degree and out-degree centrality in our sample of individual households. The three measures, with the possible exception of the third one, are

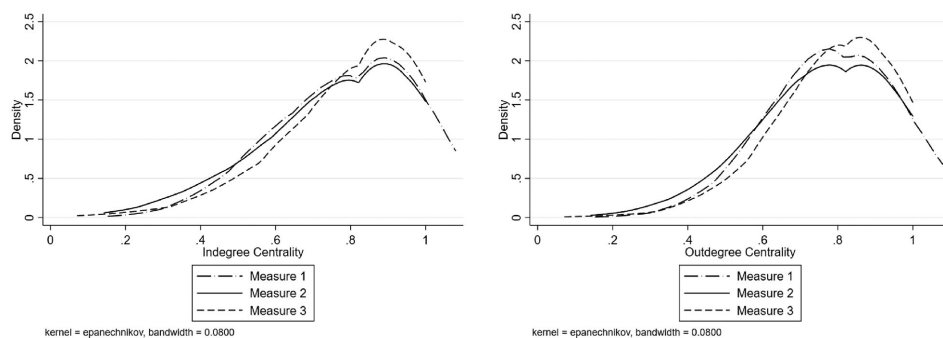
(a) Indegree Centrality ( $InQ_i^{h,\ell}$ )(b) Outdegree Centrality ( $OutQ_i^{h,\ell}$ )FIGURE 2. Kdensity of  $InQ_i^{h,\ell}$  and  $OutQ_i^{h,\ell}$ .

TABLE 6. Summary statistics and correlation matrix: network centrality measures.

	Mean	SD	$InQ_i^{h,1}$	$InQ_i^{h,2}$	$InQ_i^{h,3}$	$OutQ_i^{h,1}$	$OutQ_i^{h,2}$	$OutQ_i^{h,3}$
<b>Household level</b>								
$InQ_i^{h,1}$	0.79	0.17	1.000					
$InQ_i^{h,2}$	0.77	0.20	0.944	1.000				
$InQ_i^{h,3}$	0.81	0.18	0.983	0.929	1.000			
$OutQ_i^{h,1}$	0.78	0.16	0.318	0.313	0.303	1.000		
$OutQ_i^{h,2}$	0.77	0.18	0.316	0.322	0.303	0.956	1.000	
$OutQ_i^{h,3}$	0.80	0.16	0.305	0.301	0.294	0.983	0.943	1.000
N	2,780							
<b>Family network</b>								
$IQ^{h,1}$	0.79	0.13						
$IQ^{h,2}$	0.77	0.15						
$IQ^{h,3}$	0.80	0.13						
N	709							

distributed in a reasonably similar fashion, which spans a large set of values. The mode of the three distributions is above 0.80. The three distributions seem to be left-skewed.

Table 6 shows the means and standard deviations of the various degree centrality measures considered, both at the family network and the household levels; for the household level measures we also include the matrix of correlation coefficients. At the family network level, mean degree centrality across the three measures is around 0.8; it is lowest for the second measure at 0.7. A similar picture emerges, not surprisingly, from the household level measures of degree centrality. For each of the three measures,

in-degree and out-degree centrality vary similarly in our sample with a correlation coefficient which is above 0.9. We notice, however, that, for each of the three measures, the correlation between in- and out- degree centrality is much lower, at around 0.3. In our sample there seems to a considerable level of asymmetry in the adjacency matrices we construct with our measures of information quality.

### 5. Risk Sharing and the Quality of Information within Family Networks

Following the empirical strategy set out in Section 2.3, to measure the extent of risk sharing and deviations from first best allocations, similarly to Townsend (1994), we relate changes in individual consumption to idiosyncratic shocks; under perfect risk sharing, after controlling for risk-sharing group  $\times$  time effects, these shocks should be diversified. In particular, we estimate the following regression:

$$\Delta_s \ln(u'(c_t^{jg})) = v_t^g + \gamma_1 BS_t^{jg} + \gamma_2 GS_t^{jg} + \varepsilon_t^{jg} \tag{19}$$

where  $\Delta_s \ln(u'(c_t^{jg}))$  is the change in consumption for individual household  $j$  in family network  $g$ , and  $GS_t^{jg}$  and  $BS_t^{jg}$  are indicators for good and bad shocks received by that household and  $v_t^g$  reflect family network level resources and shocks at time  $t$ . These shocks might be in part attenuated by risk sharing mechanisms (such as saving or interactions with other groups) that we do not consider explicitly. The  $v_t^g$ 's are estimated as coefficients on group  $\times$  time dummy variables. As discussed previously, the definition of the group  $g$  is taken as given in our framework.  $g$  can represent villages or family networks or another predetermined group. In our exercise we consider risk sharing within family networks.

Unlike Townsend (1994), given the available information in our data, we do not use individual income to test for perfect risk sharing. Instead, we use the information on individual shocks of various nature, which we have discussed in Section 3.2. We also note that the changes in (log) consumption are not across adjacent time periods because data on these are not available: we use the difference across available time-periods in the analysis nevertheless to eliminate from the equation taken to the data the Pareto weights from the social planner problem. In the presence of perfect risk-sharing we would expect the coefficients  $\gamma_1$  and  $\gamma_2$  in equation (19), after controlling for group level shocks, represented by the group  $\times$  time  $v_t^h$  dummies, to be zero.

This is not what we find: The results in the first column of Table 7 show that the coefficients on the bad shock indicators ( $\gamma_1$ ) are statistically significant and negative, so that experiencing a bad or very bad shock in 2010 is related to a decrease in individual household consumption between 2004 and 2010. On the other hand, the coefficient on the ‘good shock’ is very small and, although positive, not significantly different from zero.

This evidence represents a rejection of perfect risk sharing in that idiosyncratic shocks are not fully diversified within the family network and is consistent with findings in other work (including work on this specific study context). The main purpose of this

TABLE 7. Sensitivity of risk-sharing to quality of information within family network.

<i>Inf. quality measure</i>	(1) <i>none</i>	(2) $IQ^{h,1}$	(3) $IQ^{h,2}$	(4) $IQ^{h,3}$
Bad shock in 2010	-0.134*** (0.035)	-0.420 (0.256)	-0.324 (0.223)	-0.324 (0.223)
Good shock in 2010	0.00289 (0.036)	0.679*** (0.262)	0.561** (0.227)	0.561** (0.227)
Good shock × mean degree cent $IQ^{h,\ell}$		-0.863*** (0.332)	-0.729** (0.293)	-0.729** (0.293)
Bad shock × mean degree cent $IQ^{h,\ell}$		0.365 (0.324)	0.248 (0.287)	0.248 (0.287)
Constant	0.434*** (0.0125)	0.434*** (0.0240)	0.434*** (0.0241)	0.434*** (0.0241)
Observations	2,780	2,780	2,780	2,780

Note: Standard errors in parentheses

Dep var = change in  $\ln$ pcconsumption between 2004 and 2010 (2010 prices); Family network FE

Shock = 1 if reported by anyone in household

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

paper is to relate these deviations from perfect risk sharing to imperfect information. As a first step in that direction, we interact the income shock variables with measures that reflect the quality of information in the network. Following the approach suggested in equation (11), we estimate the following regression:

$$\Delta_s \ln(u'(c_t^{j,g})) = v_t^g + (\gamma_{01} + \gamma_{11}IQ^{g,\ell})BS_t^{j,g} + (\gamma_{02} + \gamma_{12}IQ^{g,\ell})GS_t^{j,g} + \varepsilon_t^{j,g} \quad (20)$$

where we interact good and bad idiosyncratic shocks with the information quality in the family network  $g$ , using the three different versions of  $IQ^{g,\ell}$  derived in equation (18). As we discuss in Section 4,  $IQ^{g,\ell}$  is close to zero in family network with information of very poor quality and is 1 when information about asset ownership is perfect. We report the results in columns (2) to (4) of Table 7.

Given the specification in equation (20), the coefficients on the good and bad shocks now represent how household consumption is affected by those idiosyncratic shocks in networks with very low levels of information quality. On the other hand, the impact of bad and good shocks in networks with perfect information quality is obtained summing by summing the coefficients in rows (2) and (3) for the good shocks and in rows (1) and (4) for the bad shocks.

Starting with the coefficient on the good shocks, which in column (1) is effectively 0, we notice that it becomes positive and strongly significant in columns (3) and (4) for networks with very poor information quality. On the other hand, in networks with very good information quality, the coefficient is close to be zero. These results hold for all three definitions of information quality that we use.

Moving now to the negative shocks, for which the coefficient in column (1) is -0.13 and significant, we notice that for networks with very poor quality of information, the



TABLE 8. Sensitivity of risk-sharing to quality of information other households in a family network have about household.

	(1)	(2)	(3)	(4)
<i>In-degree cent. measure</i>	<i>none</i>	$\ln Q_i^{h,1}$	$\ln Q_i^{h,2}$	$\ln Q_i^{h,3}$
Bad shock in 2010	-0.134*** (0.0350)	-0.457*** (0.164)	-0.426*** (0.146)	-0.419** (0.164)
Good shock in 2010	0.00289 (0.0363)	0.428** (0.166)	0.279* (0.144)	0.417** (0.166)
HH indegree cent $\ln Q_i^{h,\ell}$		-0.337** (0.152)	-0.252* (0.139)	-0.327** (0.148)
Good shock × HH indegree cent $\ln Q_i^{h,\ell}$		-0.535*** (0.206)	-0.360** (0.182)	-0.511** (0.202)
Bad shock × HH indegree cent $\ln Q_i^{h,\ell}$		0.413** (0.203)	0.379** (0.184)	0.357* (0.199)
Constant	0.434*** (0.0241)	0.697*** (0.121)	0.627*** (0.109)	0.695*** (0.121)
Observations	2,780	2,780	2,780	2,780

Note: Standard errors in parentheses

Dep var = change in  $\ln p$  consumption between 2004 and 2010 (2010 prices); Family network FE

Shock = 1 if reported by anyone in the household

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

coefficient is larger in absolute value. Moreover, the coefficient on the interactions is of the opposite sign (row (4)) so that the sum of these coefficients and those in the first row is close to zero. These estimates, however, are not very precise, so that all these coefficients are not significantly different from zero. These results are also very similar across the three different measures of information quality.

We conclude that the evidence in Table 7 constitutes suggestive evidence that the quality of information affects the amount of risk sharing that we observe in family networks. The evidence is particularly convincing for positive shocks, although the point estimates for negative shocks offer a similar story, albeit with low precision.

Having considered the quality of information in a network we now move to considering how the sensitivity of household consumption to idiosyncratic shocks is affected by their position in the family network, as measured by the network centrality measures we have considered. In particular, we estimate the following equation:

$$\Delta_s \ln(u'(c_t^{j,g})) = v_t^g + (\gamma_{01} + \gamma_{21} IP_i^{g,\ell}) BS_t^{j,g} + (\gamma_{02} + \gamma_{22} IP_i^{g,\ell}) GS_t^{j,g} + \varepsilon_t^{j,g} \tag{21}$$

where  $IP_i^{g,\ell}$  is either the in-degree centrality  $\ln Q_i^{h,\ell}$  as computed in equation (16) or the out-degree centrality measure as constructed in equation (17). As previously, we compute these statistics for each of the adjacency matrices we derived. The first set of results, which we report in Table 8, measures how the quality of information about the situation of household  $i$  among other households in the family network affects

TABLE 9. Sensitivity of risk-sharing to quality of information household has about other households in the family network.

<i>Out-degree centr. measure</i>	(1) <i>none</i>	(2) <i>Out <math>Q_i^{h,1}</math></i>	(3) <i>Out <math>Q_i^{h,2}</math></i>	(4) <i>Out <math>Q_i^{h,3}</math></i>
Bad shock in 2010	-0.134*** (0.0350)	-0.139 (0.185)	-0.126 (0.160)	-0.0997 (0.186)
Good shock in 2010	0.00289 (0.0363)	0.116 (0.191)	0.0852 (0.165)	0.162 (0.195)
HH outdegree cent <i>Out <math>Q_i^{h,\ell}</math></i>		0.124 (0.183)	0.0523 (0.161)	0.195 (0.180)
Good shock × HH outdegree cent <i>Out <math>Q_i^{h,\ell}</math></i>		-0.144 (0.239)	-0.107 (0.209)	-0.200 (0.238)
Bad shock × HH outdegree cent <i>Out <math>Q_i^{h,\ell}</math></i>		0.00741 (0.233)	-0.0104 (0.204)	-0.0424 (0.230)
Constant	0.434*** (0.0241)	0.336** (0.146)	0.393*** (0.126)	0.278* (0.146)
Observations	2,780	2,780	2,780	2,780

Notes: Standard errors in parentheses

Dep var = change in lnpcconsumption between 2004 and 2010 (2010 prices); Family network FE

Shock = 1 if reported by anyone in the household

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

the sensitivity of its consumption to shocks, whereas the second, reported in Table 9, measures how the quality of information household  $i$  has about the situations of other households in the network affects its sensitivity to its own shocks.

The first column of Table 8 is reproduced from the same column in Table 7. When in columns (2)–(4) we add the measures of in-degree centrality, the results change substantially, especially for the second measure (column (3)). First, we notice that the in-degree centrality measures themselves are significant. Households that are more central experience, on average, lower levels of consumption growth. More importantly, the coefficients on both the negative and positive shocks increase in size and are both statistically significantly different from zero. These coefficients are relevant for households that have very low levels of in-degree centrality, that is households for which the information that other households in the network have is very poor. This result is particularly evident for the second and third measures that we use. Households about whom the network has better information experience consumption growth that is less volatile than average although, at the same time, experiencing lower growth. It is as if these household compensate for the reduced variability with lower consumption growth.

When we look at the interactions of the in-degree centrality with the shocks, we notice that both interactions are significantly different from zero and attract a coefficient which is opposite in sign to the coefficients on the shocks. For instance, in column (3), for a household which experiences a bad shock and whose economic

situation is well known to other households in the network so that it has an in-degree centrality of 1, the effect of a bad shock is given by  $-0.047 = 0.379 - 0.426$ , which is not statistically different from zero. Analogously, for the same households a positive shock attracts a coefficient of  $-0.081 = 0.279 - 0.36$ . Similar results hold for the third measure.

After the in-degree centrality, we also look at whether out-degree centrality play a role. That is we investigate whether the quality of information that each household  $i$  has about the economic status of the rest of the family network affects the relationship between consumption changes and idiosyncratic shocks. With this objective, we re-estimate equation (21) using as the  $IP_i^{g,\ell}$  variable the out-degree centrality measures constructed in equation (17). We report the results in Table 9.

In this case, the information quality variable does not seem to play any role. None of the terms involving such a variable are statically significant and, as the results become much noisier, no clear patterns emerge. We conclude that out-degree centrality does not play any role in the amount of risk sharing we observe in our sample.

Overall, these results suggest that the level of information within a network matters. It also matters, however, *what* information we consider. The results in Table 7 provide suggestive evidence that in family networks with better information consumption allocations are closer to what would be observed under perfect risk sharing.

The results based on the quality of information about household income is even stronger and more precise. It indicates that households with high in-degree centrality are less sensitive to idiosyncratic shocks. It also indicates that they experience, on average, slower consumption growth. On the other hand, the sensitivity of individual household to idiosyncratic shocks does not seem to be affected by out-degree centrality. The next step to this analysis is to consider models that can justify these patterns.

## 6. Conclusions

In this paper, we have studied the relationship between risk sharing within family networks and the quality of the information within these networks. To this end we have used a unique data set from Tanzania that has followed more than 700 family networks over a period of nearly 20 years, even when some of their members migrated outside of the original villages that they were living when the data collection was started.

A unique feature of these data is that they ask each individual household within a network information about their own wealth and assets held by the other members. We use this information to construct measures of the quality of the information flows between any two member households of the family network. We show that our method of constructing measures of information quality yields estimates that vary in a way that

is consistent with what one would expect: households that are geographically closer to each other or that talk to each other often have better information about each other. To the best of our knowledge, the construction of these measures is novel and has not been used before. Moreover, we use the information quality measures we estimate to construct weighted adjacency matrices for each of our network which are asymmetric and value each link between two individual households in terms of the quality of the information flows among them.

We then relate the quality of information we derive to the degree of risk sharing, as measured by some standard regressions of the type proposed by Townsend (1994) relating household consumption changes to household shocks, after controlling for family network level shocks. We show that in networks with better information quality, consumption allocations are closer to what one would observe under perfect risk sharing. More precisely, we show that households that more is known about in the network, are less sensitive to idiosyncratic shocks.

The quality of information between two households in a network is linked to specific choices individual make and in particular to migration. Individual households that are induced, by economic opportunities and other motives, to live far from other members of the network, effectively affect the quality of information. We argue, however, that as we consider the sensitivity of individual consumption to shocks experienced after the structure of the network and therefore the quality of information within it is established, this issue does not bias our results about the extent of risk sharing.

To the best of our knowledge, this is the first study that relates information quality to risk sharing. Although the results are very intuitive, the next step, that is being taken in Attanasio et al. (2020, [in progress](#)), is to consider risk sharing arrangements with information frictions and relate the consumption allocations that arise from such arrangements to the properties of the network that can be derived from the information data that we have.

Finally, we conclude with a note of caution. Our study does not characterise risk sharing fully. We only consider, partly because of the nature of the data we have, risk sharing within a specific network and ignore possible other mechanisms that could involve individuals outside the family network or other arrangements. Furthermore, our focus is on *ex-post* risk-coping strategies. Quality of information within the network may also affect *ex-ante* behaviour. We do not see evidence of systematic differences in frequency with which good and bad shocks occur in households belonging to networks with better and worse information. However, this question warrants further investigation. We also do not consider other frictions, such as the imperfect enforceability of contracts. Neither do we consider the process of network formation and specific processes (such as migration) that lead to better or worse information quality. These are important areas of future research.

**Appendix: A Location of the KHDS Sample in 1991 and 2010**

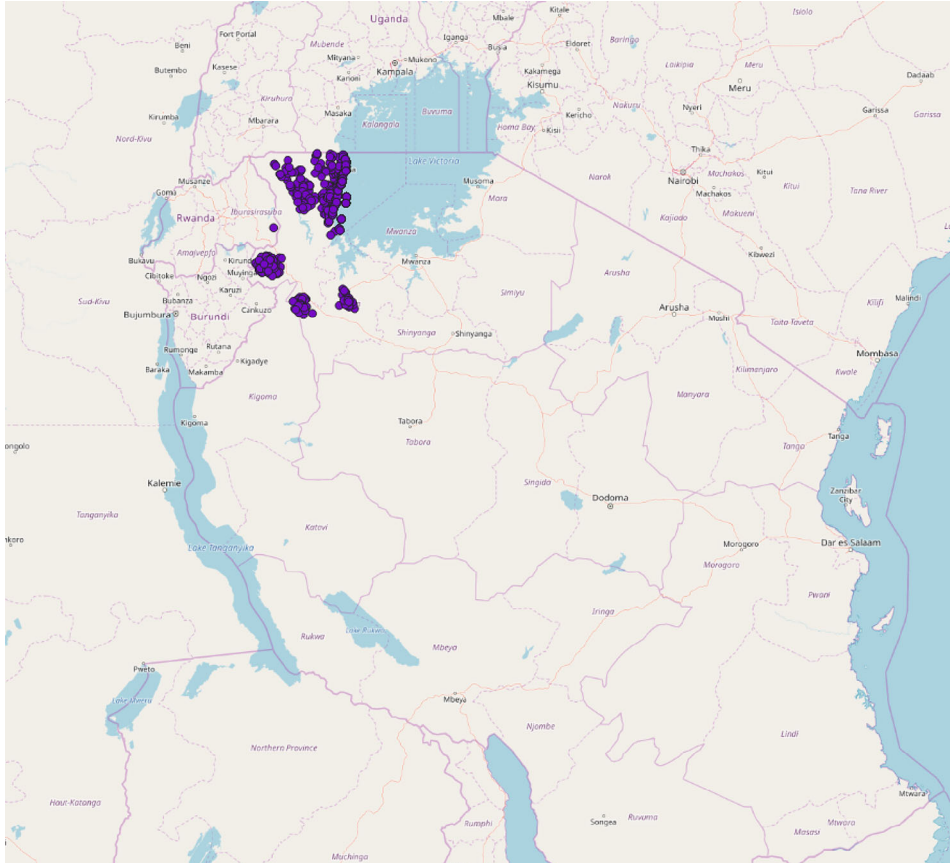


FIGURE A.1. 1991

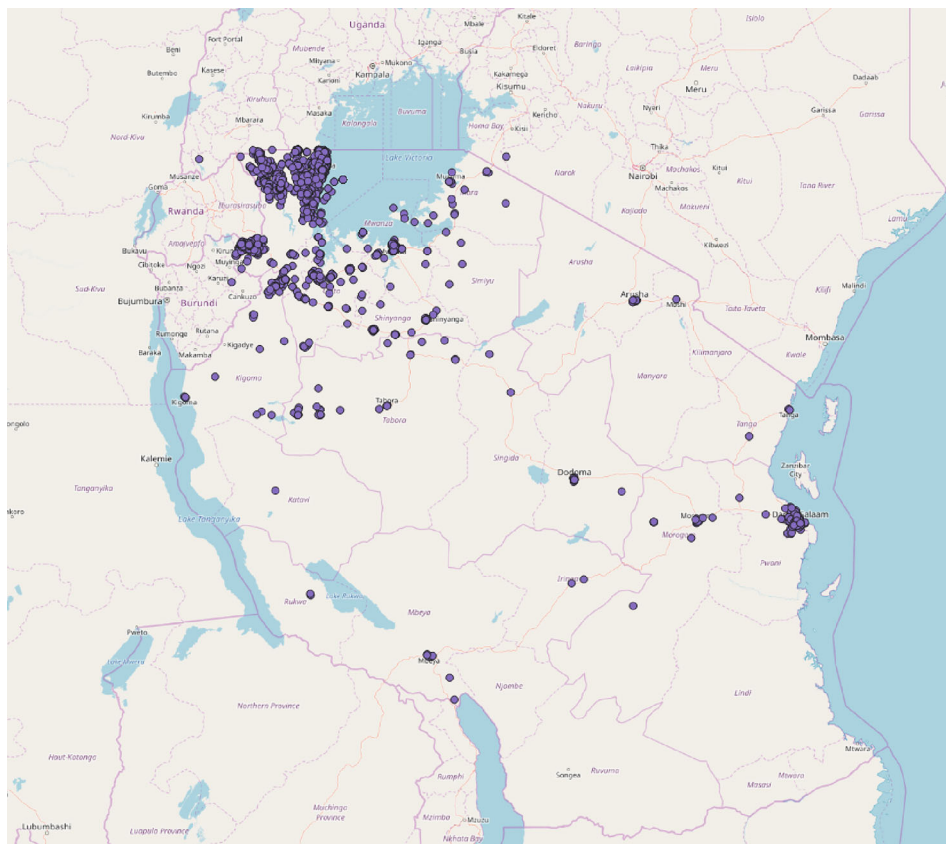


FIGURE A.2. 2010

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### Supplementary Data

Supplementary data are available at [JEEA](#) online.