

Does Index Insurance Crowd In or Crowd Out Informal Risk Sharing? Evidence from Rural Ethiopia

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Evidence from Rural Ethiopia

Abstract: We study how the introduction of a formal index insurance product affects informal risk sharing among pastoralists in southern Ethiopia. Using detailed social networks data and randomized incentives to purchase the insurance product, we find that a randomly matched peer's insurance uptake positively influences respondents' willingness to make informal transfers to that match. By contrast, respondents' own formal insurance uptake has no significant effect on risk sharing through customary institutions. Overall, our results suggest that in this context index insurance does not crowd out, and may even crowd in informal risk sharing mediated by social networks.

Keywords: drought, livestock, pastoralism, social networks

JEL Classification: C93, D81, D85, G22, O17, Q14

Weather risks threaten the welfare of rural populations in poor agrarian economies. Interventions to address those threats therefore attract significant attention. Uninsured weather risk arises in part because most rural households in low-income economies lack access to conventional agricultural insurance due to market failures associated with asymmetric information, such as moral hazard and adverse selection, as well as high transaction costs for monitoring and state verification (Barnett et al., 2008). Informal risk sharing arrangements based on risk pooling within social networks commonly fill part of the void left by formal financial markets failures (Townsend, 1994; Besley, 1995). But informal arrangements are typically best suited to managing idiosyncratic (i.e., household-specific) rather than covariate risk due to weather shocks.

A recent innovation in weather risk management, index insurance, aims to fill that gap. Index insurance indemnifies the losses predicted by objective measures strongly correlated with covariate shocks rather than the actual (and potentially idiosyncratic) losses experienced by policyholders. Because the insured's type and actions do not matter to payouts and individual loss verification is unnecessary, index-based products obviate the problems inherent to conventional agricultural insurance. As a result, index insurance has become popular over the past decade or so (Miranda and Farrin, 2012; Smith, 2016). Yet index insurance uptake rates remain low across many contexts in which it has been introduced (Giné, Townsend, and Vicker, 2008; Cole et al., 2013), in part because of basis risk, i.e., the difference between the losses actually incurred and the losses insured based on index values (Miranda and Farrin, 2012; Mobarak and Rosenzweig, 2012; Elabed et al. 2013; Dercon et al., 2014; Karlan et al., 2014; Jensen, Mude, and Barrett, 2014; Clarke, 2016).

Basis risk can, however, potentially help reinforce the relationships between the

demand for index insurance and participation in informal risk sharing, although theory yields ambiguous predictions. Dercon et al. (2014), Mobarak and Rosenzweig (2012, 2013), and Berg, Blake, and Morsink (2017) highlight the technological complementarity between index insurance and informal risk sharing. Covariate weather risk that affects all networks members can be insured by index insurance, while the residual basis risk can be insured by informal transfers. All else held constant, such complementarity should increase an informally insured individual's willingness to pay for index insurance while index insurance uptake should likewise reinforce informal risk pooling arrangements.

On the other hand, like other conventional indemnity insurance (Arnott and Stiglitz, 1991; Attansio and Ríos-Rull, 2000; Lin, Liu and Meng, 2014; Lenel and Steiner, 2016), index insurance could dampen demand for informal insurance and *vice versa*. For example, if an individual's utility depends in part on the aggregate wealth of one's network, then individual insurance uptake generates positive externalities and potentially a free-riding problem (de Janvry, Dequiedt, and Sadoulet, 2014). Similar effects arise if social norms compel socially connected individuals to share any insurance indemnity payment with uninsured peers in the event of a covariate weather shock (Munro, 2015), or if index insurance encourages excessive risk-taking by reducing the marginal cost of risky assets or activities, thereby imposing external costs on network members (Boucher and Delpierre, 2014; Vasilaky et al., 2014). These mechanisms might cause index insurance uptake to fray the social fabric underpinning informal risk sharing arrangements.

So which effect dominates? This matters because index insurance products are not introduced into a risk management void; informal risk management arrangements are ubiquitous. Therefore the net additional insurance coverage generated from index

insurance uptake depends fundamentally on whether it crowds in or out or has no effect on pre-existing informal risk sharing arrangements. Studies of the relationship between index insurance and informal risk sharing arrangements to date have focused on the effects of social networks on index insurance uptake, via social learning, imitation or scale effects (Mobarak and Rosenzweig, 2012; Trærup, 2012; Cai, de Janvry, and Sadoulet, 2015). Little is known about effects in the opposite direction: how index insurance uptake affects customary risk pooling arrangements mediated by social networks.

This article helps fill that void, by studying empirically the relationship between index insurance demand and informal risk sharing arrangements using unique experimental data collected among pastoralist communities in southern Ethiopia. The study area has experienced recurrent droughts every six or seven years, on average, since the mid-1970s, each causing widespread livestock mortality (Desta and Coppock, 2004; Megeresa et al., 2014). Longstanding customary, informal arrangements exist in the study area, most notably *dabare*, a form of informal reciprocal exchange under which one household lends livestock to another on a temporary basis in the wake of an adverse shock, with the understanding that roles may reverse in the future. Many observers indicate that *dabare* and other informal risk management institutions have been eroding over time (Lybbert et al. 2004; Huysentruyt, Barrett, and McPeak, 2009; Santos and Barrett 2011; Hurst et al., 2012).

In an effort to help protect pastoralists' livelihoods against uninsured drought risk, a commercial index-based livestock insurance (IBLI) product was introduced in August 2012 by Oromia Insurance Company. A key concern in introducing IBLI was whether it would buttress or undermine informal risk sharing institutions such as *dabare*. The major objective of this study is to identify the impacts of one's and one's peers' IBLI uptake on

the informal risk sharing links that underpin *dabare* transfers.

There are at least four fundamental challenges in empirical research on this topic. First, index insurance uptake is subject to non-random selection, so one needs a credible identification strategy to establish a causal effect of formal insurance on informal risk sharing. Second, network formation is highly likely endogenous to unobservables that influence decisions to purchase IBLI and *vice versa*, which makes it difficult to establish causal relationships between the two. Third, even if endogeneity issues can be resolved, correctly identifying one's social network remains a tricky task. Finally, the state-dependent transfers that characterize informal insurance arrangements might not be triggered by events during the survey period, leading to attenuation bias arising from not observing transfers that would have occurred in unobserved states of nature (Dizon, Gon, and Jones, 2015).

To address these four concerns, we employ a novel empirical strategy that combines randomized encouragement designs that provide a solid instrument for formal index insurance uptake with a random-matching-within-sample method to identify social networks and questions about hypothetical inter-household transfers otherwise unobservable during the survey period. More precisely, we randomly distributed discount coupons to generate exogenous price variation for IBLI uptake. The randomized coupon discount rate may provide a strong instrument that lets us identify the causal impact of a respondent's insurance uptake on inter-household transfer behaviors. Then, using best current practices, we elicited each respondent's network structure by matching him or her with eight other survey respondents randomly drawn from the sample, thereby avoiding bias in elicitation of the respondent's social network structure (Santos and Barrett, 2008; Conley and Udry, 2010; Maertens and Barrett, 2013). For each match, respondents were

asked about his or her willingness to make an informal transfer (*dabare*) to the match. This method obviates the attenuation bias inherent to using only actual transfers.

Our main finding is that, in most specifications, when random matches purchase IBLI, respondents become more likely to provide *dabare* transfers to that individual. When we refine the analysis further, we find that these positive inter-personal spillover effects are observed only when the respondent personally knows the match and when the respondent correctly believes the match purchased IBLI. Errors in subjective belief and prospective measurement error in response appear to attenuate the estimated effects in the less refined specification. Such behavior is consistent with index insurance crowding in informal risk sharing arrangements. We find no evidence of a free-riding problem wherein a respondent is less likely to buy IBLI when peers buy IBLI nor of crowding out of existing informal risk sharing networks wherein those who purchase IBLI are less likely to provide *dabare* transfers to their network members. These results remain largely robust to a range of specifications and estimators; our main findings do not appear driven by measurement errors or omitted variable bias. Taken together, we conclude that, if anything, formal index insurance reinforces informal social arrangements in our setting.

This article contributes to the literature on the nexus between formal index insurance and informal risk sharing arrangements. While a handful of recent studies ask similar questions, they infer the relationships between the two only indirectly by examining whether the demand for index insurance is greater if it is sold to groups rather than to individuals (Vasilaky et al., 2014) or whether insurance uptake increases at the group level if the technological complementarity between index insurance and informal arrangements is explained to prospective purchasers (Dercon et al., 2014). Our study is closest to Mobarak and Rosenzweig (2012), Berg et al. (2017) and Munro (2015). Their results are,

however, mixed. Mobarak and Rosenzweig (2012) and Berg et al. (2017) show evidence supporting the existence of technological complementarity (i.e., increased insurance demand among those engaged in informal arrangements) in observational data from rural India and in a lab experiment in Ethiopia, respectively, whereas Munro's (2015) evidence supports the free-riding hypothesis (i.e., the reduced insurance demand when subjects are allowed informal transfer) in lab experimental settings in India. Both studies focus on the effect of informal risk sharing arrangements on index insurance uptake, rather than the causal effect of index insurance on informal insurance. Our study reinforces Mobarak and Rosenzweig's (2012) and Berg et al.'s (2017) findings by showing that index insurance uptake positively affects informal insurance provision. To the best of our knowledge, this study is the first to provide rigorous evidence that formal index insurance products do not break down pre-existing informal arrangements but might instead complement or even reinforce them.

Study Design and Summary Statistics

Study area, IBLI, and a quasi-experiment

The study took place on the Borana plateau in Oromia region in southern Ethiopia. Borana is an arid-to-semi-arid ecological zone characterized by a bimodal rainfall pattern broken into four seasons: a long rainy season (March to May), a long dry season (June to September), a short rainy season (October to November), and a short dry season (December to February). The vast majority of the population is pastoralists whose livelihoods depend primarily on extensive livestock grazing. They mainly herd cattle, and to a lesser extent goats, sheep and camels (Desta and Coppock, 2004). Mobile pastoralism from permanent settlements to neighboring communities is common in search of pasture

and water in the face of seasonal forage and water scarcity. These pastoralists are overwhelmingly poor and extremely vulnerable to weather shocks. Recurrent catastrophic droughts have occurred regularly since 1970s (i.e., 1973/74, 1983/84, 1991/92, 1999/00, 2005/06, 2011/12). Widespread drought-related livestock mortality has pushed pastoralists into poverty traps (Lybbert et al., 2004; Santos and Barrett, 2011, 2016; Megersa et al., 2014; Barrett and Santos, 2014).

IBLI was introduced by a consortium led by the International Livestock Research Institute (ILRI) in collaboration with the Oromia Insurance Company (OIC) in August 2012. The design of IBLI followed a successful pilot project in northern Kenya launched in 2010 (Chantararat et al., 2013). IBLI uses the standardized Normalized Differenced Vegetation Index (NDVI) – based on satellite imagery to measure rangeland conditions – as an index. Sales of IBLI occur twice a year directly preceding long and short rainy seasons (i.e., January-February and August-September). Contracts cover one full year, i.e., two rainy-dry season pairs. Pastoralists choose the number and species of animal to insure. Insurance premiums vary across animal species and geographic regions according to actuarial estimates of drought-related mortality risk. Indemnity payouts are triggered when the index falls below the 15th percentile of the historical (since 1981) index distribution. Once triggered, the amount of indemnity payouts depends on the realized NDVI and total herd values insured (Ikegami and Sheahan, 2015). Since the first sales in Ethiopia in 2012, IBLI had been sold six times by the time of the data we use were collected; indemnity payouts occurred once, in October 2014. Uptake rates ranged from 12% to 30% per year in sample.

To stimulate IBLI uptake and manufacture exogenous variation in the effective price faced by prospective IBLI purchasers, an experimental design was employed in each sales

period. Discount coupons were distributed to randomly selected sub-samples of households, allowing them to purchase IBLI at a premium discount for up to 15 Tropical Livestock Units (TLUs)¹ insured. Rate discounts (hereafter, encouragement rates) ranged from 10 to 80 percent. Since randomization was independently implemented in each sales period, coupon recipients and realized encouragement rates changed across the sample households over time, generating exogenous, intertemporal, within-respondent variation. In each period, a randomly selected twenty percent of sample households did not receive a coupon.² Takahashi et al. (2016) examined factors affecting IBLI uptake in our study area and found that the distribution of discount coupons significantly increases uptake of IBLI. Thus, randomized receipt of a discount coupon serves nicely as an instrument for IBLI uptake.

Appendix 1 shows the balance test of household characteristics prior to the coupon distribution in the latest two sales periods. While imbalance is found in several variables, such as the household head's age and educational attainment, these variables are not jointly statistically significantly different between discount coupon recipients and non-recipients, indicating that the randomization worked well.

Jensen, Mude, and Barrett (2014) demonstrate that basis risk substantially reduces demand for IBLI in neighboring northern Kenya. Basis risk might, however, be at least partially mitigated by informal risk sharing. In Borana, two main types of informal arrangements exist: *busa gonofa* and *dabare*. *Busa gonofa* is a gift of animals from the rich to the needy, a semi-compulsory restocking scheme with animals redistributed solely within the same lineage (sub-clan), acting more like a mandatory kinship tax than a

¹ 1 TLU is equivalent to 1 cow, 0.7 camel, or 10 goats or sheep.

² Ten households received a 100% discount for a specific purpose related to a parallel, but separate study.

voluntary risk pooling arrangement (Berhanu, 2011). By contrast, *dabare* is a loan of cattle transferred voluntarily through clan (lineage) networks in response to a negative shock.³ Since contract enforcement is relatively easy for intraclan members, *dabare* partners are not necessarily direct acquaintances as long as both belong to the same clan, although it generally operates within closer relationships, such as friends and relatives (Tadese, 2010). We therefore focus on whether the voluntary informal risk sharing arrangement *dabare* is affected by the introduction of IBLI.

Sampling strategy and survey methods

We surveyed 17 study sites (composed of one to three *reeras*, local administrative units, each containing 100-300 households) in eight *woredas* (local administrative units that encompass *reeras*) in Borana: Dilo, Teltele, Yabello, Dire, Arero, Dhas, Miyo, and Moyale. These study sites were selected to maximize geographic distribution and capture agro-ecological and livelihood variation. Sample households in each selected study site were randomly chosen from the population list, prepared by local government Development Agents (DAs) who supported the field work.

The first round of the household survey was implemented among 515 households in March 2012, prior to the announcement of IBLI and the first sales period in August 2012. Thereafter, the follow-up surveys were conducted every March until 2015, for a total of four annual surveys. To maintain the sample size of around 500, attrited households were replaced by other households from the same study site that have similar TLU holdings as the attrited households. The attrition rate is low, however, only around 2% each round.

³ *Dabare* is used exclusively for an adverse shock. It is not used to lend animals to increase the recipient's herd size or for milk sharing in the absence of an adverse shock. Other informal institutions play this (and other) role(s).

Each survey round asked detailed questions about household characteristics, composition, activities, livestock holdings, income-generating activities, durable and non-durable assets, knowledge and experience of IBLI, and risk preferences (Ikegami and Sheahan, 2015).

Social networks

The literature proposes several methods to capture informal social arrangements. Perhaps, the simplest, and most popular method is to ask about actual inter-household monetary transfers and other informal exchanges. A drawback of this method is that we typically do not know the attributes each household with which a respondent engages in transfers, as most inevitably fall outside the sample. It follows that the data collected from this method fail to control for correlated social effects, where neighbors behave similarly simply because they have similar characteristics (Manski, 1993). Moreover, actual sharing may be observed only if negative shocks occur during the period covered by the survey questions, leading to underestimation of the extent of the true network (Dizon, Gong, and Jones, 2015).

Another common strategy is to ask each respondent about his/her informal link to every other household in the sample. However, using Monte Carlo simulation, Santos and Barrett (2008) demonstrate that this “network within sample” method less reliably recovers the underlying social network structure than does the “random matching within sample” method pioneered by Conley and Udry (2010), in which the sample respondents are randomly matched with other selected individuals in a sample.⁴

⁴ Maertens and Barrett (2013) elaborate on the case for the random matching within sample approach.

This study employs the random-matching-within-sample method to elicit respondents' informal networks. More specifically, a new questionnaire module was added in the March 2015 survey round in which we assigned each respondent to eight households randomly drawn from the sample, and asked (1) whether the respondent knows the match, and (2) whether the respondent is willing to transfer one or more cattle to the match if requested after the match suffers an adverse shock (replicating the *dabare* institution). To reduce recall and reporting errors as much as possible, we provided respondents with the match's information, such as age, clan, and residential location. We note that the second question above is hypothetical, which can overcome attenuation bias inherent to actual transfers data, but may not necessarily reflect respondent's actual behaviors. We expect that reporting bias would not be a serious problem in our study, however, as Santos and Barrett (2008) show that inferred insurance network derived from this approach closely matches actual network behavior among a different sample of Borana pastoralists from the same region. That said, we do a range of robustness checks in empirical analysis.

The existing literature points out that the costs and benefits of informal risk sharing vary by geographic and social distance (Fafchamps and Gubert, 2007). Although the recent diffusion of mobile phones might lower transaction costs and has facilitated long-distance risk sharing in several settings (Jack and Suri, 2014; Blumenstock et al., 2016; Munyegera and Matsumoto, 2016), whether physical distance is positively associated with informal arrangements remains an empirical question. In order to examine the role geographical distance might play, we randomly selected five matches among respondents in the same community and the remaining three matches from relatively far away, outside the community but within a 40-50 km radius of the respondent's permanent residence. We used GPS coordinates to identify those non-neighbors. The 40-50 km distance was

chosen to be sufficiently far that most income risks are expected to be uncorrelated, but not so far that there is little chance to meet and form links. Since pastoralists are mobile and commonly trek dozens, if not hundreds, of kilometers (Liao et al., 2017), these geographical boundaries offer a coarse means of exploring how informal risk sharing is facilitated or constrained by geographic distance.

The literature also shows the importance of social distance to network links. For example, Attanasio et al. (2012) and Chandrasekhar, Kinnan, and Larreguy (2015) find that socially close pairs tend to cooperate even without explicit enforcement, while distant pairs do not. In contrast, Vasilaky et al. (2014) find that when individuals are socially closer, they are less likely to collectively buy index insurance because of negative externality as suggested by Boucher and Delpierre (2014). These contradicting findings suggest that social distance play a different role in each specific context. In our setting, a particularly important factor might be kinship as Santos and Barrett (2011) show that the propensity to lend cattle is strongly and positively influenced by belonging to the same clan.

Summary statistics

Table 1 presents summary statistics of sample households in the 2015 survey. The sample is 513 households, mainly ethnic Borana, with a few Guji and Gabra. On average, households are large (6.9 persons), headed by a male with minimal or no formal education, poor – mean monthly household consumption per capita is about 300 birr⁵ – and depend on livestock, including milk and meat production, for more than 80 percent of total household income. Livestock also comprise these households’ main non-human asset,

⁵ 1 USD is equivalent to 20.46 birr as of March 31, 2015.

with average holdings of 18.9 TLU, dominated by cattle and supplemented with goats, sheep, and camels.

The uptake rate of IBLI in the August-September 2014 sales period was about 20 percent, which fell to 12 percent in January-February sales period in 2015, following a recurring pattern of lower uptake in the January-February sales window (Takahashi et al., 2016). Social networks are active; respondents express a willingness to transfer cattle to 3.8 out of 8 randomly selected matches within the sample, 3.1 of whom come from inside their village.

We elicited household's risk preference via an ordered lottery selection following Binswanger (1980). Each respondent was offered a chance to choose one of the six lotteries with payouts in birr of (50, 50), (45, 95), (40, 120), (30, 150), (10, 190), and (0,200) implemented with coin flip and real cash payouts. We define a respondent as highly risk averse if he/she chose either of the first two options, moderately risk averse if he/she chose either of the middle two options, and less risk averse if he/she chose one of the last two. About 12, 46, and 42 percent of respondents belong to the first, second, and third categories, respectively.

Table 2 cross tabulates observations between key variables of interest. Panel A shows that knowing the match is strongly positively associated with willingness to make an informal transfer. In 349 cases, a respondent is willing to transfer cattle to someone they claimed not to know. This could be surprising, but recognition of lineage names may suffice for some respondents to be *dabare* partners as long as the informal contract is enforceable through broader clan networks. We notice, however, 50 cases where a respondent shows willingness to make *dabare* transfers to unknown non-clan members, which would raise a concern that we may need to interpret the results with some caution.

As expected, respondents are far more likely to know (Panel B) and be willing to make transfers to matches from their own instead of a geographically distant community (Panel C). There are only 92 cases where a respondent knows a match from far away, even in this highly geographically mobile society. Detailed data examination reveals that the least reliable answers above (i.e., willing to make a transfer to unknown non-clan members) relate to those from distant communities (44 cases) rather than neighbors within their own community (6 cases).

Econometric Analysis

Benchmark empirical model

We now describe how we study the relationship between IBLI uptake and informal transfers econometrically. Let us define L_{ij} as equal to one if respondent household i is willing to transfer one or more cattle to randomly matched household ('match' or 'peer') j in times of need, and zero if not.⁶ This link is not necessarily undirectional, meaning $L_{ij} = L_{ji}$ need not hold, although *dabare* is generally recognized as a reciprocal institution.⁷ That is, if a respondent i is willing to transfer cattle to the match j , we consider that the informal link from i to j is established, regardless of whether i thinks it would receive a similar transfer from j nor whether j indicates a willingness to transfer to i in times of need.

Let D_i and D_j equal one if i and j purchase IBLI, respectively, and zero otherwise.

We ultimately want to examine the causal effects of D_j and D_i on L_{ij} in order to

⁶ Conceptually, L_{ij} can be a continuous variable; however, because of the lack of such data, we exclusively focus on binary response in this study.

⁷ The undirectional restriction could not be imposed anyway for the practical reason that we do not observe all dyadic pairs, ij and ji , in our data.

identify the positive or negative effects of IBLI uptake on informal insurance, specifically *dabare*-type risk sharing arrangements in this setting. Since it takes time for information on a peer's IBLI uptake to spread, we use the lagged value of D_j (i.e., contract purchase six months earlier, in August-September 2014, and thus a contract still in force) to represent i 's information in the March 2015 survey on j 's IBLI uptake. The respondent's uptake, D_i , is captured by January-February 2015 actual purchase, so there is a clear temporal sequencing of the IBLI demand and informal insurance link variables.

Denoting superscript for D_j to specify the timing of purchase, the benchmark dyadic model we estimate is specified as:

$$L_{ij} = \alpha_1 + \rho_1 D_i + \delta_1 D_j^{AS14} + \beta_1 (X_i + X_j) + \tau_1 (X_i - X_j) + \pi_1 W_{ij} + \varphi_1 + \omega_1 + u_{1ij} \quad (1)$$

where X_i and X_j denote a vector of controls for household i and j characteristics, respectively; W_{ij} describes the attributes of the link between i and j (on which, more below), φ_1 and ω_1 are the study site fixed effects for household i and j , respectively, and u_{1ij} is the unobserved mean zero, normally distributed error term.⁸

The vector X includes basic household characteristics, such as household head's gender, age, and completed years of education, log household per capita expenditure, TLU owned, and risk preference dummies elicited in the survey. We use the baseline (March 2012) values of X to minimize potential endogeneity concerns, although we emphasize that these are merely control variables.^{9,10} W_{ij} includes a dummy variable equal to one if i personally knows j , a dummy variable equal to one if j is relative,¹¹ which

⁸ Since we observe D_i (and D_j^{AS14}) only once for each household, we could not include household fixed effects in this specification.

⁹ Using the contemporary (March 2015) values of X does not qualitatively alter the estimation results.

¹⁰ For a dummy variable, e.g., gender of household head, the sum and difference of x_i and x_j do not make sense. Thus, we instead use a dummy equal to one if household heads i and j are same gender.

¹¹ There is no case when j is a relative not known by a respondent i .

captures social proximity, and the physical distance (in kilometers and squared kilometers) between the permanent settlements of i and j .¹² Since L_{ij} can be directional, we do not impose a symmetric restriction of $\beta X_{ij} = \beta X_{ji}$, where $|X_i - X_j|$ and $|W_{ij}|$ should be used instead of $(X_i - X_j)$ and W_{ij} (Fafchamps and Gubert, 2007). Following Attanasio et al. (2012), standard errors are clustered at the study site level to allow for possible correlations not only within dyadic pairs, but also across all dyads in the same study site.

The key parameters of interest are ρ_1 and δ_1 . Rejecting the zero null hypothesis in favor of $\rho_1 > 0$ indicates that i 's IBLI purchase increases his/her willingness to transfer cattle to the match; $\delta_1 > 0$ indicates that match j 's insurance uptake induces more informal transfers from i to j . Statistically significant positive estimates for either or both parameters would be consistent with crowding-in effects of IBLI uptake on informal risk sharing arrangements. One important caveat is that $\delta_1 > 0$ could arise as well if i wishes to free-ride on j 's uptake of IBLI, as will be discussed in more detail below.

Identification

Equation (1) above can be estimated by OLS, but parameter estimates will be biased and inconsistent due to the endogeneity of IBLI uptake. We therefore employ an instrumental variable (IV) estimation strategy using the random discount coupon rate of i 's insurance premium for the January-February 2015 sales period as an instrument for D_i , along with the same set of control variables as in equation (1). The set of estimated equations can then be rewritten as:

¹² We use the permanent settlement of each household because some members of some households migrate seasonally trekking their herds (Liao et al., 2017).

$$D_{ij} = \alpha_2 + \gamma_2 Z_i + \delta_2 D_j^{AS14} + \beta_2 (X_i + X_j) + \tau_2 (X_i - X_j) + \pi_2 W_{ij} + \varphi_2 + \omega_2 + u_{2ij} \quad (2)$$

$$L_{ij} = \alpha_3 + \rho_3 \widehat{D}_{ij} + \delta_3 D_j^{AS14} + \beta_3 (X_i + X_j) + \tau_3 (X_i - X_j) + \pi_3 W_{ij} + \varphi_3 + \omega_3 + u_{3ij} \quad (3)$$

where Z_i represents i 's randomly assigned coupon encouragement rate, which is, by design, orthogonal to the unobserved error terms in equations (2) and (3) and should have no independent relationship to L_{ij} . \widehat{D}_{ij} is then the respondent's predicted IBLI uptake (instrumented with Z_i) based on the parameter estimates from equation (2). In equation (2) we allow j 's uptake of IBLI in the August-September 2014 sales period, D_j^{AS14} , to potentially influence i 's uptake in the subsequent, January-February 2015, sales period, D_{ij} , hence the subscripting. This could reflect social learning, imitation, or omitted relevant variables that are correlated within the network and over time.

While the IV strategy represented by equations (2) and (3) might allow us to properly identify a causal impact of i 's own IBLI purchase on L_{ij} , the endogenous variable D_{ij} undesirably varies at the ij level in this specification because of the inclusion of j 's characteristics in the first stage regression.

We therefore also use the conditional mixed process (CMP) estimator, proposed by Roodman (2011), suitable for a large family of multi-equation systems in which the dependent variable of each equation may have a different format (Asfaw, Battista, and Lipper, 2016). More specifically, we estimate the following set of recursive equations:

$$D_i = \alpha_4 + \gamma_4 Z_i + \beta_4 X_i + \varphi_4 + u_{4i} \quad (4)$$

$$L_{ij} = \alpha_5 + \rho_5 \widehat{D}_i + \delta_5 D_j^{AS14} + \beta_5 (X_i + X_j) + \tau_5 (X_i - X_j) + \pi_5 W_{ij} + \varphi_5 + \omega_5 + u_{5ij} \quad (5).$$

So far, we have assumed that D_j^{AS14} is exogenous because j is randomly assigned to i and pre-determined to i 's transfer decision. If j 's uptake decision is considered to be given and independent from i in the real world, then D_j^{AS14} should be an exogenous random variable in the main equation (5). Yet if the informal insurance network forms

endogenously, the lagged explanatory variable can be correlated with unobservables over time and bias may arise due to omitted variables.

To test whether the results are altered by different specifications and estimators, we also run regressions by treating both D_i and D_j^{AS14} as endogenous using both IV and CMP estimators. The encouragement rate of j 's insurance premium in the August-September 2014 sales period (Z_j^{AS14}) is used as an additional instrument. The set of equations for the two endogenous variables IV estimation is specified as:

$$D_{ji}^{AS14} = \alpha_6 + \gamma_6 Z_i + \vartheta_6 Z_j^{AS14} + \beta_6 (X_i + X_j) + \tau_6 (X_i - X_j) + \pi_6 W_{ij} + \varphi_6 + \omega_6 + u_{6ij} \quad (6)$$

$$D_{ji} = \alpha_7 + \gamma_7 Z_i + \vartheta_7 Z_j^{AS14} + \beta_7 (X_i + X_j) + \tau_7 (X_i - X_j) + \pi_7 W_{ij} + \varphi_7 + \omega_7 + u_{7j} \quad (7)$$

$$L_{ij} = \alpha_8 + \rho_8 \widehat{D}_{ij} + \delta_8 \widehat{D}_{ji}^{AS14} + \beta_8 (X_i + X_j) + \tau_8 (X_i - X_j) + \pi_8 W_{ij} + \varphi_8 + \omega_8 + u_{8ij} \quad (8)$$

Similar to the previous regressions, the endogenous variables D_i and D_j^{AS14} vary at the ij level. In order to suppress that variation, we also estimate a more parsimonious CMP with instrumental variables as:

$$D_i = \alpha_9 + \gamma_9 Z_i + \beta_9 X_i + \varphi_9 + u_{9i} \quad (9)$$

$$D_j^{AS14} = \alpha_{10} + \vartheta_{10} Z_j^{AS14} + \beta_{10} X_j + \omega_{10} + u_{10j} \quad (10)$$

$$L_{ij} = \alpha_{11} + \rho_{11} \widehat{D}_i + \delta_{11} \widehat{D}_j^{AS14} + \beta_{11} (X_i + X_j) + \tau_{11} (X_i - X_j) + \pi_{11} W_{ij} + \varphi_{11} + \omega_{11} + u_{11ij} \quad (11)$$

Note that equations (9) to (11) are estimated jointly, using the full set of observations. In total, we have 8 peers for each of the 513 households, yielding 4104 observations in the main equation (11).¹³ The predicted value of \widehat{D}_i is the same regardless of when we use 513 or 4104 observations for equation (9) because each respondent household i appears exactly eight times in the latter specification. However, the predicted value of

¹³ Because a few key variables are missing for several households, the final number of observations used in estimation is 4033.

D_j^{AS14} in equation (10) differs between the 513 and 4104 observations because random matching exogenously determines the number of times household j to be matched to a respondent i (from a minimum of 1 to a maximum of 19, with mean of 8). Thus, sample weighting adjustments are needed to correct for the random overweighting of certain households in equation (10).

Unfortunately, since only one likelihood is computed for each observation via CMP, it is infeasible to adjust weights only in the equation (10). Thus, we first estimate the CMP model with the full set of observations (i.e., ignoring weight adjustments) and then estimate equation (10) separately using each of the 513 households using predicted values in estimating equation (11). The results are qualitatively quite similar between these two methods. In what follows, therefore, we present only the unweighted CMP results, which involve standard error adjustments for generated regressors.

Empirical results

Table 3 shows the main linear probability model estimation results for the key variables of interest.¹⁴ Column (1) corresponds to the result of the OLS estimator in equation (1), Columns (2) and (3) report the results of the IV and CMP estimators in equations (3) and (5), respectively, with only D_i treated as endogenous, and Columns (4) and (5) are for the result of the IV and CMP estimators with both D_i and D_j^{AS14} treated as endogenous, per equations (8) and (11).

Column (1) shows that match j 's IBLI uptake is positively associated with respondent

¹⁴ The first-stage regression results with control variables are in Online Appendix 1, while more parsimonious estimation results with fewer control variables in the main regression results are in Online Appendix 2. Conditioning that a respondent knows a family j , the main regression results are effectively the same as the ones presented in the main text.

i 's willingness to transfer. Columns (2) and (3) show qualitatively similar results. As reflected in column (2), the excluded instrument, the respondent's randomized coupon encouragement rate, is strongly correlated with the respondent's IBLI uptake, with a first-stage Kleibergen-Paap F-statistics of 198.2 ($p=0.000$).

The positive impact of a peer's uptake on a respondent's willingness to provide an informal transfer is consistent with the existence of either crowding-in or free-riding effects. If free-riding were a concern, however, those who purchase IBLI should limit their commitment to the informal *dabare* arrangement or even opt out altogether. We find no statistically significant effect of own IBLI uptake, however, although the negative (and insignificant) point estimate is similar in magnitude to the positive and significant coefficient estimate on j 's IBLI uptake. This result is consistent with related findings from the actual transaction data in the same study sites that show no correlation between one's IBLI uptake and interhousehold transfers (Bageant and Barrett, 2017). Moreover, the dynamic interaction analysis that will be implemented below shows no negative impact of a peer's IBLI uptake on the respondent's subsequent uptake, further supporting the absence of free-riding. We suspect that respondents were willing to make transfer to the insured peers because the insured are more likely to help respondents at the time of catastrophic covariate risk than the non-insured, all else held constant.

Once we treat D_j as endogenous, however, then the instrumented match's IBLI uptake becomes statistically insignificant and changes sign (Columns 4 and 5). Columns (4) and (5) suffer from a weak instrument problem, however, as signaled by a first-stage Kleibergen-Paap F-statistic that is merely 3.47 for D_j , far below the Stock-Yogo weak ID test critical value of 5.53 at the 25% level.¹⁵ Somewhat unexpectedly, the first-stage

¹⁵ Using the additional instrument equal to one if a respondent receives a discount coupon worsens

estimation result in Online Appendix 1 reveals that match's randomized coupon encouragement rate does not induce significantly greater uptake in this particular sales period.¹⁶

Overall, these results suggest that formal insurance uptake, whether by the respondent or by a match within the respondents' network, does not crowd out customary risk sharing arrangements. Indeed, there is suggestive evidence that others' insurance uptake increases respondents' willingness to make informal transfers, i.e., some crowding in of informal insurance occurs as a result of formal index insurance uptake.¹⁷¹⁸

Before moving on to robustness checks in the next section, other important findings in Table 3 include the following. Informal transfers are considerably more likely among acquaintances, which is reasonable because cattle are such a valuable asset in the pastoralist community that a respondent would typically be unwilling to transfer to non-acquaintances. Informal transfers are also more likely among socially and geographically proximate households. While the coefficient estimate on distance is negative and significant, and that on its squared term is positive and significant, the relationship is merely declining at a diminishing rate, not U-shaped, as the minimum probability of the link formation falls outside of the sample coverage even for non-neighbor matched households. These results are consistent with the prior literature's findings that social and

the problem, as the Kleibergen-Paap F-statistic falls to 2.707.

¹⁶ The insignificant coefficient estimate is also found when we run OLS on the 513 household observations where the dependent variable is IBLI uptake in the August-September 2014 sales period and one of the regressors is the randomized encouragement rate for the corresponding period. Such a weak correlation is rather exceptional. We found statistically significant effects of encouragement rates on IBLI uptake in other sales periods.

¹⁷ Put differently, our results can be interpreted as in line with Lenel and Steiner (2016), that the amount of informal transfer is reduced when solidarity partners do not avoid individual losses by purchasing formal insurance.

¹⁸ These results remain the same when we include both current and lagged Ds for both respondent and recipient, instead of assuming temporal sequencing of the IBLI demand and informal insurance link variables. These supplementary regression results are shown in Online Appendix 3.

physical distance are important for informal risk sharing, presumably because they decrease communication and transaction costs (Fafchamps and Gubert, 2007; Chandrasekhar, Kinnan, and Larreguy, 2015).

Robustness Checks

While we found no evidence of crowding-out effects of IBLI uptake on informal insurance, we failed to establish robust, causal inference of crowding-in effects as the results vary depending on specifications and estimators. On the other hand, our preferred estimation that treats peers' uptake, D_j , as endogenous suffers from a weak IV problem. We now explore the robustness of our findings through a series of alternative approaches to test the validity of the existence of crowding-in effects, first assuming D_j as exogenous that is free from the weak IV issue, but would suffer from endogeneity bias, and then relaxing that assumption.

Falsification test

If the effect of network members' IBLI uptake on a respondent's willingness to make *dabare* transfers truly arises because formal insurance crowds in informal insurance, then this effect should hold only for IBLI contracts currently in force. Match j 's lapsed contracts should have no impact on i 's current willingness to transfer cattle. By contrast, if the lagged j 's uptake does not guarantee exogeneity and we observe the significant effect due to endogeneity bias, we may observe similar effects in the lapsed contracts through autocorrelation. So a useful falsification test involves replacing D_j purchased in the fifth (August-September 2014) sales period, which were still in force at the time of the L_{ij} elicitation, with D_j values from previous sales periods, i.e., contracts that had

lapsed. IBLI uptake by respondents varied over time in response to discount coupon receipt and other factors, generating within-household variation that makes such a falsification test feasible.

The results presented in Table 4 (treating only D_i as endogenous) consistently show that the match's lapsed IBLI uptake has no impact on the respondent's willingness to transfer. The point estimates on the lapsed D_j variables derived from any of the previous sales periods are an order of magnitude smaller than in our main results and statistically insignificant in all specifications. This reinforces the interpretation of our main findings as indeed reflecting a positive crowding in effect of formal insurance uptake (D_j) on informal insurance (L_{ij}).

Measurement error

Another potential issue is measurement error in L_{ij} or D_j .¹⁹ As shown in Table 2, in 349 cases a respondent expressed willingness to transfer cattle to matches they claimed not to know. This could reflect indirect acquaintance – e.g., the respondent recognizes the match's family name but does not know the match specifically. But it could also signal measurement error, perhaps because these respondents did not understand the hypothetical transfer question and wanted to signal their altruism or respect for the traditional cultural practice of *dabare*. In such cases, respondent i 's responses would be plagued by measurement error. As one robustness check against such a possibility, we re-estimate using only the sub-sample households whose answers to the hypothetical transfer question do not include “Yes” to any unknown person. We estimated this sub-sample model by first treating only D_i as endogenous, and then both D_i and D_j^{AS14} as

¹⁹ Since we use an instrument for D_i , the measurement error in D_i is, if any, not problematic.

endogenous. For the sake of brevity, we present only the CMP results with the clustered standard errors at the study site level in Panel A, Table 5. The results do not alter our main finding in Table 3 that others' insurance uptake has positive impacts, but only when it is treated as exogenous.

A different approach to this prospective source of measurement error is to run the regressions separately for acquaintances and non-acquaintances. From the evidence in Tables 2 and 3, we already established that knowing the match is positively associated with the respondent's willingness to transfer cattle to the match. If claimed willingness to transfer to non-acquaintances reflects just measurement error, then splitting the sample should lead to greater precision in estimating the parameter of interest within the sub-sample of acquaintances. The results in Panel B of Table 5 show that the positive and significant relationship is observed exclusively for acquaintances: if a respondent personally knows the match, that match's uptake decision is strongly, positively associated with the respondent's willingness to transfer, but if not, there is no interpersonal spillover effects. The point estimate is greater in magnitude and more precisely estimated than in Table 3 when we strip out the observations of non-acquaintances. This also reinforces confidence that measurement error in L_{ij} , if any, underestimates the true impact, rather than overestimates it.

Another possibility is measurement error in D_j^{AS14} in the sense that household i inaccurately perceives j 's IBLI uptake. Knowing the match does not imply knowing the match's actual behavior (Hogset and Barrett, 2010), especially if the behavior in question (IBLI uptake) is not easily visible and verified. Thus, actual D_j^{AS14} and household i 's perception of D_j^{AS14} may differ, which may impact i 's behavior. Appendix 2 confirms that most respondents did not know their match's IBLI uptake status and of those who

believed they did, many held incorrect beliefs. Out of 324 matches that respondents believed had bought IBLI, for example, only 109 (33.6%) actually bought it in the same reference period according to match j 's self-report (Panel B).

As an alternative robustness check, we exploit proxy-reported peer's IBLI uptake in the latest survey, i.e., whether respondent i thought that match j bought IBLI in the sales periods prior to the survey.²⁰ This question was asked only when the respondent personally knew the match in order to avoid groundless guesses.

To examine whether our inferences change due to the measurement error that might arise from the deviation of actual from perceived D_j^{AS14} , we re-run the regressions replacing actual (self-reported) D_j^{AS14} with three dummy variables that represent the combination of (*proxy-reported, self-reported*) match's IBLI uptake behavior: $D_{j1}^i = (buy, buy)$, $D_{j2}^i = (buy, not\ buy)$ and $D_{j3}^i = (not\ buy, not\ buy)$. That is, D_{j1}^i is correct perception with actual purchase, D_{j2}^i is false positive, and D_{j3}^i is correct perception with actual non-purchase.²¹ The CMP results reported in Panel C of Table 5 show that the match's IBLI uptake has positive impacts on the likelihood of informal transfer especially when the respondent accurately knows it. The estimated positive impact of D_j^{AS14} on *dabare* transfers thus does not appear driven by measurement error in D_j^{AS14} .

Dynamic interaction effect

²⁰ One may argue that respondent's subjective beliefs on match's IBLI uptake should be used as a main explanatory variable because beliefs may matter more than (incorrectly understood) actual uptake patterns. Yet, such subjective belief is more likely to be endogenous. It is far more difficult to find a plausible instrument as i 's subjective belief is less correlated with j 's recipient status of discount coupons, exaggerating the weak IV problem. So we favor using actual uptake.

²¹ Since the number of observations of false negative is small, we set a reference group as false negative plus those respondents who did not know the peer's uptake status.

A final robustness check we implement concerns the prospective dynamics of IBLI uptake.²² So far, we have implicitly assumed that D_i and D_j are determined independently from own and peer's previous experiences on IBLI. Yet, those who have purchased IBLI before may learn from the experience, or they might have different unobserved preferences or characteristics from those who have not bought IBLI, leading to autocorrelation in formal insurance uptake. Furthermore, a peer's uptake might have a significant impact on the respondent's own uptake through social learning, imitation or scale effects (Trærup, 2012; Karlan et al., 2014; Cai, de Janvry, and Sadoulet, 2015). Through any of these mechanisms, D_i could be affected by the lagged D_i and D_j .

To explore this possibility, we exploit the panel data and the dynamic roll-out of IBLI to recursively estimate D_i and D_j round-by-round via the CMP estimator by modifying equations (9)-(11). That is, we estimate D_i and D_j for the first sales period (August-September 2012) with Z_i and Z_j from that period as instruments, where lagged uptake rates were necessarily zero. Then we use those predicted values along with Z_i and Z_j in the subsequent (January-February 2013) sales period to predict D_i and D_j in the second sales period (IBLI 2), and so on until the August-September 2014 (IBLI 5) sales period for D_j and January-February 2015 (IBLI 6) for D_i . The recursive structure generates consistent parameter estimates because we know the true values of baseline uptake were zero, as the product was not yet available, indeed it had not yet even been announced publically.

Those who purchased IBLI policies in the third and fourth sales periods received indemnity payouts in October 2014. If the receipt of a payment positively affects

²² Given that we have just established that only response to acquaintances matters, we now limit our estimation sample to relevant observations, excluding non-acquaintances.

subsequent propensity to purchase insurance, we would expect the third and fourth round uptake variables to have positive and statistically significant coefficient estimates on sixth round uptake, perhaps differentially greater point estimates than those of the other sales periods, which did not generate indemnity payouts.

The estimation results, presented in Table 6, contain several important new findings. First, we do not see any persistent, significant effect of own or peers' IBLI uptake on own current purchase of IBLI. Also, there is no differential impact on subsequent IBLI uptake for those who received indemnity payouts; the coefficient estimates on the third and fourth sales period uptake variables are uniformly statistically insignificant. Second, consistent with previous interpretation, we do not see any sign of free-riding, as would be reflected by a negative and significant coefficient estimate on peer's lagged IBLI uptake, if i would free ride on j 's contract in force. Most coefficient estimates on lagged peer's uptake are statistically insignificant.²³ Third, although i 's and j 's lagged uptake are individually insignificant, they have jointly significant impacts on subsequent uptake decisions in most sales periods. Last but foremost, when we take this recursive approach to addressing the prospective endogeneity of the IBLI uptake variables, the effect of the match's IBLI uptake on the respondent's willingness to make a *dabare* transfer increases significantly in magnitude and becomes statistically significant (Panel B).

Overall, a range of robustness checks confirm our central findings: formal index insurance uptake does not appear to crowd out informal risk sharing arrangements and may even crowd in customary transfers. Moreover, our most preferred estimation that

²³ We also used the average IBLI uptake rate among eight randomly assigned peers in the previous round as a regressor, along with the control variables used in equation (4). Consistent with Table 6's results, the average peer's IBLI uptake rate has no significant impact on the respondent's subsequent uptake, indicating that the observed willingness to transfer to the insured peer is not due to the expectation of free-riding. The result is shown in Appendix 3.

incorporates dynamic interactions among peers supports the existence of a causal relationship from IBLI uptake to increased willingness to make *dabare* transfers, even if both the respondent and match's uptake are treated as endogenous. Given the existence of positive impacts and absence of crowding-out or free-riding effects, we conclude that formal insurance complements informal social arrangements that support drought risk sharing in this setting.

Conclusions

Index insurance is increasingly considered an important tool to promote rural populations' resilience to shocks such as drought. However, the net additional insurance afforded by these products depends fundamentally on the extent to which they crowd out or crowd in informal insurance through customary institutions mediated by social networks. This paper offers novel empirical evidence on the relationship between uptake of formal index insurance products and informal transfers for very similar purposes. We exploit a unique data set from southern Ethiopia where index-based livestock insurance (IBLI) was recently introduced in pastoralist communities with pre-existing informal risk sharing arrangements known as *dabare*. Using randomized incentives to purchase IBLI and random matching of survey respondents to identify social networks within the communities, we explore whether respondents' and their network peers' formal index insurance uptake affects respondents' willingness to make informal risk sharing transfers to that same peer.

Our empirical findings can be summarized as follows. First, we find that a household is more willing to make informal transfer to peers who take up IBLI. We confirm this result with various robustness checks. Second, respondents' IBLI uptake has no

significant effect on his/her willingness to transfer to peers. Together, these first two results provide suggestive evidence against the hypothesis that formal insurance crowds out informal insurance in this context; if anything, it appears to crowd in customary risk sharing arrangements. Third, we find no evidence of free-riding wherein one person's IBLI uptake negatively affects others' uptake. Fourth, informal transfers are more likely within socially and geographically proximate pairs, for whom communication and contract enforcement are presumably easier. Overall, our results suggest an important complementarity between formal index insurance and informal risk sharing arrangements in mitigating drought risk in this setting.

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Table 1. Selected Household Characteristics, 2015

| | |
|--|----------------------|
| Ethnicity: Borana (=1) | 0.914 (0.280) |
| Household size (person) | 6.926 (2.644) |
| <i>Household head characteristics</i> | |
| Male (=1) | 0.783 (0.412) |
| Age (years) | 52.471 (17.947) |
| Education attainment (years) | 0.520 (1.847) |
| % with no education | 89.669 (30.467) |
| <i>Household economy</i> | |
| Monthly consumption per capita (birr) | 299.706 (140.959) |
| % income from livestock | 83.766 (20.535) |
| Owned animals (TLU) | 18.910 (30.757) |
| <i>IBLI uptake</i> | |
| August-September 2014 (=1) | 0.203 (0.402) |
| January-February 2015 (=1) | 0.119 (0.323) |
| <i>Informal risk sharing</i> | |
| Number of matches willing to transfer cattle (max=8) | 3.834 (2.672) |
| <i>Risk preference</i> | |
| Highly risk averse (=1) | 0.115 (0.319) |
| Moderately risk averse (=1) | 0.460 (0.499) |
| Less risk averse (=1) | 0.425 (0.495) |
| Sample size | 513 |

Standard deviations are in parentheses.

Table 2. Bivariate Relationships between Key Variables

| Panel A | | |
|---------------------|-----------------------------------|------|
| | Willing to make informal transfer | |
| Knows match | No | Yes |
| No | 1352 | 349 |
| Yes | 785 | 1618 |
| Panel B | | |
| | Geographic Distance | |
| Knows match | Not far | Far |
| No | 254 | 1447 |
| Yes | 2311 | 92 |
| Panel C | | |
| | Willing to make informal transfer | |
| Geographic Distance | No | Yes |
| Not far | 948 | 1617 |
| Far | 1189 | 350 |

Table 3. Estimation Results of Respondent's Willingness to Transfer

| | Di as endogenous | | | Di and Dj as endogenous | |
|--|---------------------|---------------------|---------------------|-------------------------|---------------------|
| | OLS (1) | IV (2) | CMP (3) | IV (4) | CMP (5) |
| Own IBLI uptake: Di (=1) | -0.005 (0.040) | -0.029 (0.124) | -0.022 (0.124) | -0.030 (0.129) | -0.019 (0.124) |
| Match's IBLI uptake: Dj (=1) | 0.033** (0.015) | 0.033** (0.015) | 0.033** (0.015) | -0.189 (0.261) | -0.212 (0.172) |
| Know family (=1) | 0.395*** (0.031) | 0.395*** (0.030) | 0.395*** (0.031) | 0.397*** (0.030) | 0.395*** (0.031) |
| Relative (=1) | 0.214*** (0.023) | 0.214*** (0.022) | 0.214*** (0.023) | 0.220*** (0.022) | 0.215*** (0.023) |
| Distance | -0.003** (0.001) | -0.003** (0.001) | -0.003** (0.001) | -0.003** (0.001) | -0.003** (0.001) |
| Distance squared/1000 | 0.029* (0.015) | 0.030** (0.015) | 0.029* (0.015) | 0.027* (0.015) | 0.029* (0.015) |
| Other control variables | YES | YES | YES | YES | YES |
| Study site dummies | YES | YES | YES | YES | YES |
| First stage Kleibergen-Paap rk Wald F statistic | | 198.241 | | 3.468 | |
| First stage Shea's F test for excluded instruments (p-value) | | | | | |
| D_i | | 11.44(0.04) | | 5.90 (0.012) | |
| D_j | | | | 1.43 (0.269) | |
| Observations | 4033 | 4033 | 4033 | 4033 | 4033 |

Clustered standard errors at the study site level in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Control variables include: A dummy equal to 1 if household heads i and j are same gender, and the sum and differences of household size, heads' age and its squared, head's years of education, log per capita expenditure, TLU, and risk preference.

Table 4. Robustness Checks: Falsification test

| | Willingness to transfer | | | |
|---|-------------------------|-------------------|-------------------|-------------------|
| | Di as endogenous CMP | | | |
| | (1) | (2) | (3) | (4) |
| Instrumented own IBLI uptake: Di (=1) | -0.023 (0.125) | -0.023 (0.125) | -0.024 (0.120) | -0.024 (0.120) |
| Match's IBLI uptake : Dj at the 4th sales period (=1) | -0.008 (0.014) | | | |
| Match's IBLI uptake : Dj at the 3rd sales period (=1) | | 0.005 (0.017) | | |
| Match's IBLI uptake : Dj at the 2nd sales period (=1) | | | 0.004 (0.026) | |
| Match's IBLI uptake : Dj at the 1st sales period (=1) | | | | -0.003 (0.016) |

Clustered standard errors at the study site level in parentheses: *** p<0.01, ** p<0.05, * p<0.1. N=4,033

Control variables included but not reported include: A dummy equal to 1 if household heads i and j are same gender, and the sum and differences of household size, heads' age and its squared, head's years of education, log per capita expenditure, TLU, risk preference, and study site dummies.

Table 5. Robustness Checks: Measurement Errors

| | Panel A | | Panel B | | Panel C |
|--|-----------------------------|-------------------------|--------------------|-------------------|---|
| | Only consistent respondents | | Acquaintances | Non-acquaintances | Subjective perception and actual behavior |
| | Di as endogenous | Di and Dj as endogenous | Di as endogenous | Di as endogenous | Di as endogenous |
| | CMP | CMP | CMP | CMP | CMP |
| | (1) | (2) | (3) | (4) | (5) |
| Instrumented own IBLI uptake (=1) | -0.039 (0.120) | -0.038 (0.119) | -0.064 (0.159) | 0.021 (0.195) | -0.023 (0.125) |
| Match's IBLI uptake (=1) | 0.036*** (0.012) | -0.109 (0.187) | 0.045** (0.018) | 0.007 (0.020) | |
| Correct perception with actual uptake (D1) | | | | | 0.080* (0.049) |
| False positive (D2) | | | | | 0.030 (0.034) |
| Correct perception with actual non-uptake (D3) | | | | | 0.077 (0.048) |
| Observations | 3042 | 3042 | 2358 | 1675 | 4033 |

Clustered standard errors at the study site level in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Control variables included but not reported here: A dummy equal to 1 if household heads i and j are same gender, and the sum and differences of household size, heads' age and its squared, head's years of education, log per capita expenditure, TLU, and risk preference, and study site dummies.

Table 6. Recursive Estimation of IBLI Uptake and IV Estimation of Transfer Likelihood

| | Panel A: 1st stage | | | | | | | | | | Panel B: Main equation | | |
|---|-------------------------|---------------------|--------------------|---------------------|--------------------|---------------------|-------------------------|---------------------|-------------------|---------------------|------------------------|--|----------|
| | <i>i</i> 's IBLI uptake | | | | | | <i>j</i> 's IBLI uptake | | | | | Willingness to lend a cow to <i>j</i> | |
| | IBLI 1 | IBLI2 | IBLI 3 | IBLI 4 | IBLI 5 | IBLI 6 | IBLI 1 | IBLI2 | IBLI 3 | IBLI 4 | IBLI 5 | | |
| Respondent (i) | | | | | | | | | | | | Instrumented own IBLI uptake (January-February, 2015) | -0.024 |
| IBLI uptake at the 1st period | | 0.401*** (0.139) | 0.114 (0.398) | 0.739 (0.621) | -0.173 (0.559) | -0.237 (0.372) | | 0.024 (0.046) | 0.106 (0.111) | 0.090 (0.136) | 0.074 (0.133) | Instrumented match's IBLI uptake (September/October, 2014) | 0.137* |
| IBLI uptake at the 2nd period | | | 0.978 (0.867) | -1.092 (1.430) | 0.552 (1.307) | 0.978 (1.053) | | | -0.217 (0.172) | -0.009 (0.206) | -0.217 (0.179) | Relative (=1) | 0.206*** |
| IBLI uptake at the 3rd period | | | | 0.218 (0.413) | 0.001 (0.368) | -0.341 (0.500) | | | | -0.045 (0.096) | -0.094 (0.190) | Distance | -0.003 |
| IBLI uptake at the 4th period | | | | | 0.157 (0.260) | 0.046 (0.286) | | | | | 0.038 (0.161) | Distance squared | 0.036 |
| IBLI uptake at the 5th period | | | | | | -0.036 (0.496) | | | | | | Other control variables | YES |
| Match (j) | | | | | | | | | | | | Study site dummies | YES |
| IBLI uptake at the 1st period | | -0.035 (0.049) | 0.081 (0.119) | -0.100 (0.129) | -0.156 (0.101) | -0.011 (0.077) | | 0.362*** (0.136) | 0.168 (0.195) | 0.505 (0.345) | -0.078 (0.281) | Observations | 2358 |
| IBLI uptake at the 2nd period | | | 0.094 (0.135) | 0.273* (0.149) | 0.152 (0.146) | 0.133 (0.155) | | | 0.765* (0.433) | -0.744 (0.939) | 0.893 (0.743) | | |
| IBLI uptake at the 3rd period | | | | -0.165 (0.121) | 0.042 (0.151) | 0.015 (0.107) | | | | 0.177 (0.565) | -0.500 (0.505) | | |
| IBLI uptake at the 4th period | | | | | 0.053 (0.086) | 0.116** (0.057) | | | | | 0.118 (0.305) | | |
| IBLI uptake at the 5th period | | | | | | -0.063 (0.110) | | | | | | | |
| Encouragement rate | 0.403*** (0.059) | 0.069* (0.040) | 0.136** (0.062) | 0.197*** (0.063) | 0.116** (0.058) | 0.348*** (0.090) | 0.420*** (0.065) | 0.123** (0.053) | 0.098 (0.066) | 0.185*** (0.060) | 0.134*** (0.043) | | |
| Other control variables | | | | | | YES | | | | | | | |
| Study site fixed effects | | | | | | YES | | | | | | | |
| Joint significance test for lagged uptake (chi-squared) | | | | | | | | | | | | | |
| Respondent (i) | | 8.29*** | 13.75*** | 2.66 | 0.92 | 1.24 | | 0.27 | 1.69 | 0.61 | 3.03 | | |
| Match (j) | | 0.50 | 3.67 | 3.42 | 5.63 | 8.14 | | 7.07*** | 10.00*** | 2.79 | 1.83 | | |
| Both respondent (i) and match (j) | | 10.36*** | 13.91*** | 8.95 | 14.93* | 26.46*** | | 8.39** | 11.34** | 3.69 | 6.44 | | |
| Observations | | | | | | 2358 | | | | | | | |

Clustered standard errors at the study site level in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Other control variables in the 1st stage variables include: Discount premium rate at each corresponding sales period for respondent and match, household size, head's characteristics (gender, age, age squared and completed years of education), log per capita expenditure, TLU and its square, a dummy equal to one if moderate risk averse, and a dummy equal to one if less risk averse. *i*'s (*j*'s) household characteristics are used for *i*'s (*j*'s) uptake equations as controls.

Other control variables in the 2nd stage variables include: A dummy equal to 1 if household heads *i* and *j* are same gender, and the sum and differences of household size, heads' age and its squared, head's years of education, log per capita expenditure, TLU, and risk preference.

Appendix 1. Balancing Test for Key Variables

| Sales period Coupon | Aug-Sep 2014 | | | Jan-Feb 2015 | | |
|---------------------------------------|----------------------|----------------------|---------|----------------------|----------------------|---------|
| | Non-recipient | Recipient | p-value | Non-recipient | Recipient | p-value |
| Ethnicity: Borana (=1) | 0.931 (0.255) | 0.913 (0.283) | 0.558 | 0.912 (0.285) | 0.917 (0.276) | 0.858 |
| Household size (person) | 6.941 (2.626) | 6.808 (2.637) | 0.651 | 6.863 (2.718) | 6.827 (2.615) | 0.903 |
| Head's Male (=1) | 0.812 (0.393) | 0.789 (0.409) | 0.609 | 0.814 (0.391) | 0.788 (0.409) | 0.571 |
| Head's Age (years) | 48.396 (16.964) | 52.274 (18.339) | 0.054* | 50.480 (18.634) | 51.766 (18.012) | 0.522 |
| Head's Education Attainment (years) | 0.356 (1.197) | 0.561 (1.972) | 0.319 | 0.657 (1.922) | 0.487 (1.827) | 0.405 |
| Head % with no education | 90.099 (30.016) | 89.320 (30.923) | 0.820 | 84.314 (36.547) | 90.754 (29.002) | 0.058* |
| Monthly consumption per capita (birr) | 332.083 (163.678) | 328.538 (194.208) | 0.866 | 346.199 (194.388) | 325.026 (186.943) | 0.310 |
| % income from livestock | 79.839 (25.409) | 77.004 (26.956) | 0.339 | 79.946 (22.688) | 76.970 (27.548) | 0.313 |
| Owned animals (TLU) | 22.418 (39.912) | 17.735 (24.129) | 0.132 | 19.637 (25.103) | 18.414 (28.652) | 0.693 |
| Highly risk averse (=1) | 0.089 (0.286) | 0.121 (0.327) | 0.364 | 0.157 (0.365) | 0.105 (0.306) | 0.139 |
| Moderately risk averse (=1) | 0.475 (0.502) | 0.459 (0.499) | 0.766 | 0.451 (0.500) | 0.465 (0.499) | 0.804 |
| Less risk averse (=1) | 0.436 (0.498) | 0.420 (0.494) | 0.775 | 0.392 (0.491) | 0.431 (0.496) | 0.482 |
| Joint F-test: <i>p</i> -value | 0.539 | | | 0.482 | | |

Standard deviations are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

The presented variables are drawn from the 2014 survey, prior to the distribution of discount coupons in August-September 2014.

Appendix 2. The Relationships among Proxy-reporting and Actual IBLI uptake, and Informal Transfer

| Panel A | | |
|--------------------------------|-------------------|------|
| | Informal transfer | |
| Proxy reporting of IBLI uptake | No | Yes |
| Yes, uptake | 81 | 243 |
| No uptake | 30 | 109 |
| Don't know | 661 | 1234 |

| Panel B | | |
|--------------------------------|-----------------------------|-----|
| | Actual IBLI uptake by match | |
| Proxy reporting of IBLI uptake | No | Yes |
| Yes, uptake | 215 | 109 |
| No uptake | 123 | 16 |
| Don't know | 1509 | 386 |

Appendix 3. The Impact of Others' Insurance Uptake on Own IBLI Purchase
(Linear Probability Model)

| | =1 if <i>i</i> uptake IBLI |
|--|----------------------------|
| Average of peers' (<i>j</i>) uptake rate at September-October 2014 | -0.131 (0.100) |
| Encouragement premium rate for <i>i</i> at January-February 2015 | 0.323*** (0.051) |
| Household size (# persons) | 0.002 (0.006) |
| Head is male (=1 if yes, =0 otherwise) | 0.013 (0.032) |
| Head's age | -0.002 (0.004) |
| Head's age ² | 0.000 (0.000) |
| Head's years of education | -0.007 (0.008) |
| ln per capita expenditure | 0.070*** (0.027) |
| TLU | -0.000 (0.001) |
| TLU ² | 0.000 (0.000) |
| Moderate risk averse (=1) | 0.039 (0.039) |
| Less risk averse (=1) | 0.034 (0.039) |
| Constant | -0.616** (0.250) |
| Study site dummies | YES |
| Observations | 513 |
| R ² | 0.308 |

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Online Appendix 1. First-stage Regression Results for Table 3.

| | Panel A: IV | | | Panel B: CMP | | |
|---|-----------------------------|-----------------------------|---------------------------------|---|-----------------------------|---------------------------------|
| | Di as endogenous | Di and Dj as endogenous | | Di as endogenous | Di and Dj as endogenous | |
| | Own IBLI uptake: Di (=1) | Own IBLI uptake: Di (=1) | Match's IBLI uptake: Dj (=1) | Own IBLI uptake: Di (=1) | Own IBLI uptake: Di (=1) | Match's IBLI uptake: Dj (=1) |
| Own encouragement rate (Jan-Feb 2015) | 0.325*** (0.093) | 0.325*** (0.096) | -0.005 (0.017) | <i>Respondent i's characteristics</i> | | |
| Match's encouragement rate (Aug-Sep 2014) | | -0.010 (0.016) | 0.092 (0.055) | Own encouragement rate (Jan-Feb 2015) | 0.326*** (0.096) | 0.325*** (0.096) |
| Know family | 0.018 (0.013) | 0.018 (0.014) | 0.007 (0.020) | Household size | 0.001 (0.004) | 0.001 (0.004) |
| Relative | 0.004 (0.021) | 0.004 (0.022) | 0.024 (0.029) | Head's male | 0.012 (0.027) | 0.012 (0.027) |
| Distance | 0.001 (0.001) | 0.001 (0.001) | 0.001 (0.001) | Head's age | -0.002 (0.003) | -0.002 (0.003) |
| Distance squared | 0.003 (0.005) | 0.003 (0.006) | -0.009 (0.008) | Head's age squared | 0.000 (0.000) | 0.000 (0.000) |
| Head's same gender | 0.006 (0.013) | 0.006 (0.013) | 0.030* (0.017) | Head's years of education | -0.007 (0.008) | -0.007 (0.008) |
| <i>Summation</i> | | | | ln per capita expenditure | 0.072*** (0.025) | 0.072*** (0.025) |
| Household size | 0.000 (0.002) | 0.000 (0.002) | -0.007** (0.002) | TLU | -0.000 (0.001) | -0.000 (0.001) |
| Head's age | 0.000 (0.000) | 0.000 (0.000) | -0.000 (0.000) | TLU squared | 0.000 (0.000) | 0.000 (0.000) |
| Head's years of education | -0.003 (0.004) | -0.003 (0.004) | 0.009* (0.004) | Moderately risk averse (=1) | 0.042 (0.032) | 0.042 (0.032) |
| ln per capita expenditure | 0.042** (0.015) | 0.042** (0.015) | -0.003 (0.016) | Less risk averse (=1) | 0.037 (0.035) | 0.037 (0.035) |
| TLU | -0.000 (0.001) | -0.000 (0.001) | 0.000 (0.000) | <i>Peer j's characteristics</i> | | |
| Risk preference | 0.000 (0.003) | 0.000 (0.003) | 0.001 (0.003) | Match's encouragement rate (Aug-Sep 2014) | | 0.087 (0.054) |
| <i>Difference</i> | | | | Household size | | -0.018*** (0.005) |
| Household size | -0.000 (0.002) | -0.000 (0.002) | 0.007** (0.003) | Head's male | | 0.035 (0.051) |
| Head's age | -0.000 (0.000) | -0.000 (0.000) | 0.000 (0.000) | Head's age | | 0.005** (0.002) |
| Head's years of education | -0.004 (0.004) | -0.004 (0.005) | -0.006 (0.005) | Head's age squared | | -0.000** (0.000) |
| ln per capita expenditure | 0.025** (0.010) | 0.026** (0.010) | -0.005 (0.016) | Head's years of education | | 0.015 (0.010) |
| TLU | 0.000 (0.000) | 0.000 (0.000) | 0.001 (0.000) | ln per capita expenditure | | 0.000 (0.033) |
| Risk preference | 0.002 (0.003) | 0.002 (0.003) | -0.005 (0.004) | TLU | | 0.001 (0.001) |
| Study site dummies | Yes | Yes | Yes | TLU squared | | -0.000 (0.000) |
| Constant | -0.781*** (0.286) | -0.779** (0.296) | 0.092 (0.055) | Moderately risk averse (=1) | | 0.002 (0.046) |
| Observations | 4,033 | 4,033 | 4,033 | Less risk averse (=1) | | 0.020 (0.032) |
| R-squared | 0.309 | 0.309 | 0.157 | Study site dummies | Yes | Yes |
| | | | | Constant | -0.658*** (0.221) | -0.657*** (0.221) |
| | | | | Observations | 4,033 | 4,033 |
| | | | | | | 0.085 (0.333) |

Clustered standard errors at the study site level in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Online Appendix 2: Second-stage Estimation Results with Fewer Controls with Respect to Table 3.

| | OLS (1) | Di as endogenous | | Di and Dj as endogenous | |
|---|---------------------|---------------------|---------------------|-------------------------|---------------------|
| | | IV (2) | CMP (3) | IV (4) | CMP (5) |
| Panel A: No control | | | | | |
| Own IBLI uptake: Di (=1) | 0.009 (0.055) | -0.067 (0.138) | -0.067 (0.142) | -0.063 (0.146) | -0.066 (0.141) |
| Match's IBLI uptake: Dj (=1) | 0.053 (0.040) | 0.057 (0.044) | 0.053 (0.040) | -0.318 (0.488) | -0.278 (0.457) |
| Observations | 4033 | 4033 | 4033 | 4033 | 4033 |
| Panel B: Only control "Know family dummy" | | | | | |
| Own IBLI uptake: Di (=1) | 0.014 (0.052) | -0.038 (0.129) | -0.038 (0.133) | -0.035 (0.136) | -0.037 (0.133) |
| Match's IBLI uptake: Dj (=1) | 0.045*** (0.014) | 0.047*** (0.016) | 0.045*** (0.014) | -0.247 (0.439) | -0.219 (0.431) |
| Know family (=1) | 0.472*** (0.020) | 0.472*** (0.019) | 0.472*** (0.020) | 0.475*** (0.022) | 0.472*** (0.020) |
| Observations | 4033 | 4033 | 4033 | 4033 | 4033 |

Clustered standard errors at the study site level in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Online Appendix 3. Estimation Results via CMP with More Lagged Uptake Variables

| | Di as endogenous CMP (1) | Di and Dj as endogenous CMP (2) |
|---|-----------------------------------|--|
| Instrumented own IBLI uptake at 5th sales period (=1) | 0.029 (0.106) | 0.029 (0.106) |
| Instrumented own IBLI uptake at 6th sales period (=1) | -0.025 (0.122) | -0.026 (0.122) |
| Match's IBLI uptake at the 5th sales period (=1) | 0.031** (0.015) | -0.223 (0.168) |
| Match's IBLI uptake at the 6th sales period (=1) | 0.021 (0.017) | -0.102 (0.068) |
| Observations | 4033 | 4033 |

Clustered standard errors at the study site level in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Control variables included but not reported here: A dummy equal to 1 if household heads i and j are same gender, and the sum and differences of household size, heads' age and its squared, head's years of education, log per capita expenditure, TLU, and risk preference, and study site dummies. Instruments for own IBLI uptake at 5th and 6th sales period includes the value of discount voucher corresponding period the respondent received, while instruments for match's IBLI uptake at 5th and 6th sales period includes the value of discount voucher corresponding period the match received.