Temporary Migration and Endogenous Risk-Sharing in Village India

Melanie Morten *
Yale University

October 21, 2012
Preliminary and incomplete, please do not cite
Please click here for most recent version

Abstract

I study a dynamic model of risk sharing with limited commitment frictions and endogenous temporary migration. First, I characterize the model and develop comprehensive comparative statics with respect to migration, risk sharing and welfare. I demonstrate the channels through which migration may decrease risk sharing. I show how to decompose the welfare effect of migration into the change in income and the change in the endogenous structure of the insurance market. I then show how risk sharing alters the returns to migration and therefore determines the migration decision. Second, I structurally estimate the model on the new (2001-2004) ICRISAT panel from rural India. Third, the quantitative results I find are as follows: (1) risk-sharing reduces migration by 50%; migration reduces risk-sharing by 41%; (2) the net welfare effect of migration is large, equivalent to a 15.5% increase in consumption; (3) contrasting endogenous to exogenous risk sharing, the consumption-equivalent gain of migration is 31% lower.

Keywords: Internal migration, Risk Sharing, Limited Commitment, Dynamic Contracts, India, Urban, Rural

JEL Classification: D12, D91, D52, O12, R23

*I am extremely grateful to my advisors, Mark Rosenzweig, Aleh Tsyvinksi, and Chris Udry, for their guidance and support. Thanks also to David Atkin, Dan Keniston, Costas Meghir, Mushfiq Mobarak, Andrew Newman, Michael Peters, Tony Smith, Melissa Tartari, Nancy Qian, Treb Allen, Muneeza Alam, Alex Cohen, Camilo Dominguez, Snaebjorn Gunnsteinsson, and Yaniv Stopnitzky, and participants at the Yale development lunch, Yale macro lunch, and NEUDC 2011 for many helpful comments and suggestions. I am appreciative of the hospitality and assistance from Cynthia Bantilan and staff at the ICRISAT headquarters in Patancheru, India. Any remaining errors are my own.

1 Introduction

Rural households in developing countries face extremely high year-to-year volatility in incomes; for example, income is more than three times more volatile in rural India than the United States[1]. Economists have long studied the complex systems of informal transfers that allow households to smooth income shocks in the absence of formal markets. However, informal risk-sharing is not the only option available to rural Indians who wish to smooth their consumption and minimize the welfare effects of income fluctuations. Households can also migrate temporarily, leaving to work in the city before returning home to the village. The option to migrate, by providing a self-insurance mechanism, may fundamentally change incentives for households to participate in informal risk-sharing. For this reason, it is necessary to consider the migration decision of the household jointly with the decision to participate in informal risk sharing networks. Understanding the joint determination of risk-sharing and migration is especially important in the context of rural India, where 20% of households have a temporary migrant, and for these households, migration income is 50% of household income.

In order to understand the interaction between migration and informal insurance, I construct a dynamic model of risk-sharing with limited commitment frictions and endogenous temporary migration. Households take risk-sharing into account when deciding to migrate, similarly the option to migrate will affect how willing a household is to participate in informal risk-sharing. The welfare effect of migration depends on a potential trade-off between increased income and the endogenous change in risk-sharing. The model shows that the effects of migration on risk-sharing and risk-sharing on migration are theoretically ambiguous. I structurally estimate the model using a household panel from rural India and use the estimates to quantify three comparative statics derived from the model. The quantitative results I find are as follows: (1) risk-sharing reduces migration by 50%; migration reduces risk-sharing by 41%; (2) the net welfare effect of migration is large, equivalent to a 15.5% increase in consumption; (3) contrasting endogenous to exogenous risk sharing, the consumption-equivalent gain of migration is 31% lower.

[1] The coefficient of variation is estimated to be 127 for rural India, relative to 39 for white males in the United States (Rosenzweig and Binswanger (1993)).

Economists usually think of migration as an income maximization problem. An individual chooses to migrate if their expected income is higher in the city than in the village. If households are part of a risk-sharing network then the logic is similar, but instead of comparing gross income, individuals compare expected post-transfer income differences. Why might migrants still want to participate in informal risk-sharing if they can use migration to self insure? Although migration may offer high average returns, it is also risky. Not all migrants find jobs or find well-paying jobs. The best empirical evidence, from a randomized trial where individuals were assigned incentives to migrate, estimates that the average return to migration is 30%. At the same time, the lowest 20% of migrants end up worse off when migrating than if they had stayed (Bryan et al. (2011)). Migration may be a way to access uncorrelated income sources and insure family members in the village, but potential migrants may need insurance themselves. This dual insurance can be provided through informal risk-sharing.

Beginning with Townsend (1994), economists have studied how households make and receive informal transfers to smooth income shocks. Empirical tests reject the benchmark of perfect insurance, but find evidence of substantial smoothing of income shocks. I model risk-sharing arising from limited commitment frictions, following Ligon et al. (2002). Limited commitment means that households can walk away from the agreement if their utility of doing so would be higher than staying. A positive correlation between income and consumption, as seen in the data, arises because households with high income shocks have a high outside option of walking away from the risk-sharing network and, so, keep more of their income. Introducing the option to migrate will directly affect a household's outside option. Because the key determinant of risk-sharing is the outside option, the limited commitment model is a natural model through which to examine the effect of migration.

To introduce temporary migration, I allow a household to make a decision about whether to migrate once they see what their income will be in the village for the year. If a household migrates, they remain part of the risk-sharing network. I solve for the migration and transfer decisions that maximize total utility of all households in the village, subject to a set of incentive compatibility constraints. The incentive compatibility constraints map to the two separate stages at which households can decide to drop out of any risk-sharing agreement: (1) after all migration decisions have been made and final income is revealed (for example, a rich migrant does not want to transfer too much back to others in the village), and, (2) at the time of migrating (for example, a household would rather not migrate even if it would be optimal for the network as a whole to migrate). Conditional on receiving at least the same utility as their outside option at the two points in time, neither household has an incentive to deviate either by changing the amount they transfer or from the prescribed migration decision.

I apply the model to the empirical setting of rural India. This is a setting where temporary migration is common and economically important; 20% of households have a temporary migrant, and for these households, migration income is half of household income.[2] I use the new wave of the ICRISAT household panel covering the years 2001-2004.[3] I verify four empirical facts in the data. First, migration responds to exogenous income shocks. When the monsoon rainfall is low, migration rates are higher. This matches the modeling assumption that migration decisions are made after income is realized. Second, households move in and out of migration status. 40% of households migrate at least once during the sample. However, on average, a migrant household only migrates half the time. This is consistent with households migrating when their returns are highest, for example if they receive a bad idiosyncratic shock, rather than migration being a permanent strategy. Third, risk-sharing is imperfect, and is worse in villages where temporary migration is more common. This is consistent with an interaction between informal risk-sharing and migration. Fourth, although a household increases their income by 30% during the years they send a migrant, total expenditure (consumption and change in asset position) only increases by 2/3 of this increase in income. This last fact is consistent with the migrant making transfers back to the network.

The model shows that the effects of migration on risk-sharing and risk-sharing on

[2]The numbers cited here are from the ICRISAT data used in this paper. Other household surveys in India find widespread temporary migration of up to 50% (Banerjee and Duflo (2007); Coffey et al. (2011)). For a detailed case study of patterns of labor migration in India see Breman (1996).

[3]The original data (VLS1) was collected over 1975-1984. I can merge together the VLS1 and VLS2 to have a 30 year panel on households. Migration in the VLS1 is very limited, with fewer than 1% of households having a temporary migrant and so I focus the migration analysis on the VLS2 data.

migration are theoretically ambiguous. Determining the direction of the effects is thus an empirical question. I structurally estimate the dynamic model of risk-sharing and migration on the household panel dataset using simulated method of moments. I use the model and structural results to quantify three comparative statics derived from the theoretical model:

1. *Effect of risk-sharing on transfers:* With risk-sharing, the migration decision depends on post-transfer income differentials between the village and the city. Theoretically, I show that risk-sharing can either increase or decrease migration. Empirically, I estimate the net effect of risk-sharing is to reduce migration by 50%. This is driven by an income effect in the village. It is the villagers with bad income shocks who migrate, but these households would be net recipients of transfers if they stayed. Transfers reduce the gains from migrating, lowering migration.

2. *Effect of migration on risk-sharing:* Theoretically, the effect of migration on risk-sharing is ambiguous. On one hand, the option to migrate increases the outside option of households, decreasing risk-sharing. On the other hand, migration allows the network to smooth aggregate shocks, increasing risk-sharing. Empirically, I estimate the net effect of introducing migration is to reduce risk-sharing by 41%. That is, the crowding out effect of migration dominates.

3. *Effect of migration on welfare:* Welfare depends on total resources available to the network and the allocation of the resources between members (the "size" and "slices" of the economic pie). I estimate that overall, migration results in a consumption-equivalent increase of 15.5%. Households with low endowments (low landholdings) particularly benefit from migration because of an increase in total income in the village.

The risk-sharing result highlights the important interaction between migration and risk-sharing. The option to migrate endogenously changes incentives for households to make transfers. Because households are connected through risk-sharing, this affects all members of the risk-sharing network, not just those who migrate. I re-estimate my model under two alternative environments - no risk-sharing, and no risk-sharing but borrowing and saving - and show that, under exogenously incomplete insurance markets where migration does not alter the structure of risk-sharing, the welfare gain is 31% higher. However, models of exogenous risk-sharing miss the crucial interaction between risk-sharing and migration that my model captures.

There is a clear policy prescription from these results. When households are connected through informal risk-sharing, there will be spillover affects from development policies that change households' income streams. I show the effect of a rural employment scheme, similar to the Indian Government's National Rural Employment Guarantee Act (NREGA) which guarantees rural households 100 days of employment, in my environment. This policy increases welfare, but reduces migration and decreases risk-sharing.

This paper contributes to an established literature examining rural-urban migration. Early models of migration set up the 'dual' economy: the choice between the subsistence, rural economy and the modern, urban economy where the wage was higher. Rural-urban migration was an integral part of the process of development, as the modern sector expanded and surplus labor moved to take advantage of higher wages (Lewis (1954), Harris and Todaro (1970)). However, the benefits of the traditional economy, for example providing access to loans, could discourage migration, potentially leading to a poverty trap (Banerjee and Newman (1998)). Such forces are still a key explanation for the extremely low rates of permanent migration seen in India today (Munshi and Rosenzweig (2009)). Rather than taking the decision between participating in rural institutions and migration as a binary decision, the key contribution of this paper is quantifying how rural institutions adjust to new technology. This is possible by analyzing temporary, rather than permanent, migration. If migration is temporary, then the migration decision is not as stark as having to sever ties with the risk-sharing network. Rather, the network stays intact, but the amount of insurance endogenously responds to the new income opportunities.

The second literature this paper contributes to is a literature studying incomplete markets, especially in developing countries. Developing countries lack access to formal credit and insurance markets, and do not fully provide this insurance informally (Altonji et al. (1992), Townsend (1994)). However, there is evidence of imperfect insurance. Limited commitment models appear to be a good empirical fit (Udry (1994); Cox and Eser (1998); Ligon et al. (2002)).[4] The limited commitment model has a key appeal in that the mechanism is very transparent. This has lead to several studies examining the interaction between changes to households' outside option and endogenous risk-sharing, including public insurance schemes (Attanasio and Rios-Rull (2000); Albarran and Attanasio (2002, 2003); Krueger and Perri (2010)), unemployment insurance (Thomas and Worrall (2007)) and options to save (Chandrasekhar et al. (2010)). This paper contributes to this literature by theoretically characterizing a dynamic model with endogenous risk-sharing and migration, and empirically estimating the key interaction between migration and risk-sharing when markets are endogenously incomplete.

In the following section I present the risk-sharing model with endogenous migration. Section 3 introduces the household panel used to estimate the model and verifies that the modeling assumptions hold in these data. Section 4 discusses how to take the model to the data, and Section 5 presents the structural estimation results and performs the two policy experiments. Section 6 concludes the findings.

2 Joint model of migration and risk sharing

This section presents the model of risk sharing with endogenous temporary migration. I build this model in three steps. Section 2.1 presents a model of migration with exogenous risk sharing transfers. Section 2.2 presents the limited commitment model of risk sharing without migration. Section 2.3 merges the first two components together to present the full model of limited commitment risk sharing with endogenous temporary migration.

I use the model to derive three theoretical results: (1) the effect of risk sharing on migration; (2) the effect of migration on risk sharing; (3) the effect of migration on welfare. The results are theoretically ambiguous and thus an empirical question, to which I turn later in the paper.

[4]Of course, there are many other explanations for imperfect risk-sharing, including moral hazard (Ligon (1998); Lim and Townsend (1998); Townsend and Karaivanov (2010)) and hidden income (Kinnan (2010)).

2.1 Migration with exogenous risk sharing

This section develops a model of temporary migration with exogenous risk sharing transfers. I use the reduced form model to derive comparative statics for the effect of risk sharing on migration. I show that an increase in risk sharing will have two offsetting effects on migration, and the net effect is theoretically ambiguous.

Temporary migration is short-term migration. I model agents migrating in respond to income differences between the village and a city. Agents also pay a utility cost if they migrate. This cost captures both the physical costs (for example, costs of transportation) and the psychic costs (for example, begin away from friends and family) of migration.[5] Temporary migration lasts one period: agents see the income in the village and make a decision about whether to migrate. If they migrate, they return back to the village at the end of the period. Assume the agent has income e in the village and expects to earn income m if they migrate. If an agent migrates they pay a utility cost d. The agent will migrate if the expected utility gain of doing so is positive: [6]

$$\mathrm{E}u(m) - d > u(e).$$

Now, consider that the agent also receives transfers (either positive or negative), denoted by τ, from a risk sharing network. Transfers are made ex post of the migration decision. Assume the transfers depend on the agent's income and a penalty p levied by the network if agents do not make transfers. The key attribute of risk sharing transfers is that they provide insurance against bad income shocks. Agents get transfers when they have low income and make transfers when they have high income. This is captured by assuming $\frac{\partial \tau(y,p)}{\partial y} < 0$. Assume also that the degree of risk sharing depends on the ex-

[5] Assuming a utility cost of migrating is common in the literature. A utility cost of migration can also easily explain why American Samoans, legal residents of the United States, choose to live in America Samoa where per capita income is \$8,000, instead of legally migrating to Hawa'ii where per capita income is \$21,000.

[6] Migration could also be a way for households to diversify risk. That is, there could still be welfare gains from migrating if income in the migration destination is less correlated with origin income, and not necessarily higher. Rosenzweig and Stark (1989) show, for example, that households which face a more risky income stream send their daughters further away to be married, and argue this is to diversify spatially correlated income shocks. I assume in this paper that migration decisions are made ex post of the income realization and so income diversification will not generate migration.

ogenous penalty. This is captured by assuming that the absolute value of transfers is a function of the penalty: $\frac{\partial|\tau(y,p)|}{\partial p} > 0$.

With risk sharing, the agent considers post-transfer income, instead of gross income. The agent migrates if the expected utility gain is positive:

$$\mathrm{E}u(m + \tau(m, p)) - d > u(e + \tau(e, p)).$$

We want to derive the effect of risk-sharing on migration. To do this, consider the effect of an exogenous increase in the penalty p. An increase in p will increase magnitude of the risk sharing transfer because it becomes more costly to not participate fully in risk-sharing. As a result, agents who receive a positive transfer receive a larger transfer, and agents who make a transfer make a larger transfer.

Consider an agent who is indifferent between migrating and staying:

$$\mathrm{E}u(m + \tau(m, p)) - d = u(e + \tau(e, p)).$$

An increase in the penalty will have two offsetting effects on migration. For a small increase in p, the agent will now migrate if:

$$\underbrace{\mathrm{E}\frac{\partial \tau(m,p)}{\partial p} u'(m + \tau(m,p))}_{\text{Insurance effect: change to expected migration income}} \quad > \quad \underbrace{\frac{\partial \tau(e,p)}{\partial p} u'(e + \tau(e,p))}_{\text{Income effect: change to village income}}$$

The overall effect of an improvement in risk sharing on migration depends on the relative magnitude of the offsetting income and insurance effects. The first effect is an income effect. The expected gain from migration is not the gross income difference between the village and the migration destination, but the post-transfer income difference between the village and migration destination. The agents with the highest expected utility gain from migrating are the agents with low income realizations. However, with risk sharing, these agents would be receiving a net transfer from the network. This reduces the gain from migrating.

The second effect is an insurance effect. Migration is risky. An agent may travel to the city and be unable to find work, or may find employment and earn a high income. Migrants who have a bad outcome may receive transfers from the network, and migrants who are lucky may transfer back to the network. The risk sharing network may therefore insure the migration outcome and increase the expected gain from migrating.

Next, I consider how the risk sharing transfers are determined.

2.2 Limited commitment risk sharing without migration

This section presents the limited commitment risk sharing without migration (Kocherlakota (1996), Ligon et al. (2002)). The following section will add temporary migration to this model of risk sharing.[7]

The risk sharing problem in to find transfers that maximize the joint utility of both households, subject to a 'walking away' constraint. This constraint is that utility from participating in the network is as high as utility from not participating. The first best allocation of resources is perfect risk sharing, where each agent receives a constant share of total resources, independent of their income. However, with limited commitment, a positive correlation between income and consumption can arise because households with high income shocks have a high outside option of walking away from the risk sharing network and, so, keep more of their income.

The economy is a two person endowment economy[8]. Agents receive a draw from an income distribution each period. There are no financial markets: agents cannot save or borrow. The state of the world in the village is indexed by s, which takes a finite number of values, $s = \{1, 2, ...S\}$. The realization of the state of the world determines the endowment income for each household. The endowments for the two households, A and B, in state s are given by the vector $e(s) = \{e^A(s), e^B(s)\}$. Let s_t be the realization of the state of the world in period t, and s^t denote the history of the realizations of the state of

[7]See also Coate and Ravallion (1993); Kehoe and Levine (1993); Attanasio and Rios-Rull (2000); Dubois et al. (2008) for other limited commitment models.

[8]The limited commitment model is solved for two households. Assuming Gorman Aggregable preferences it is possible to aggregate the model to allow for risk sharing between N households in the village. This is discussed in the estimation section.

the world up to time t, $s^t = \{s_0, s_1, ..., s_t\}$. The state of the world is governed by a Markov transition matrix Π, with $\pi_{s',s} = \pi(s_{t+1} = s'|s_t = s)$. With slight abuse of notation, I will refer to the vector e in place of s. The key component of the limited commitment problem is the value of the outside option. This is given by the present discounted value of consuming their endowment stream: $\Omega^i(e) = \mathrm{E}\sum_{t=0}^{\infty} \beta^t u(e_t)$.

I present the recursive formulation of the limited commitment problem, using the techniques of Marcet and Marimon (1998) and following Attanasio and Rios-Rull (2000)[9]. The limited commitment problem is recursive in two state variables: the current state of the world, e, and a summary measure, x, of the binding participation constraints up until that period. This summary measure x is equivalent to the ratio of marginal utilities, so is referred to as an endogenous pareto weight. The endogenous pareto weight is updated at time t to reflect the current period's binding participation constraints.

The value function for household A is expressed by $V^A(x, e)$ and similarly $V^B(x, e)$ for agent B. The social planner's value function is a weighted sum which takes into account the endogenous weight of household B: $V(x, e) = V^A(x, e) + xV^B(x, e)$.

The social planner solves for transfers to maximize joint utility:

$$V(x, e) = \max_{\tau, x'} u(e^A + \tau) + xu(e^B - \tau) + \beta \mathrm{E} \underbrace{V(x', e')}_{V^A(x',e')+x'V^B(x',e')}. \tag{1}$$

subject to:

$$u(c^i) + \beta \mathrm{E} V^i(x', e') \geq u(e^i) + \beta \mathrm{E}\Omega^i(e'), \tag{2}$$

and:

$$c^A + c^B \leq e^A + e^B. \tag{3}$$

where (2) is the participation constraint that requires the utility from participating in the agreement to be as high as the outside option, and (3) is the budget constraint for the economy.

[9]Refer to Appendix A for the equivalent date-zero problem.

Definition 1. A *constrained efficient equilibrium* is defined by two functions:

1. An updating rule for the endogenous pareto weight $x' = x'(x, e)$.

2. Transfer function $\tau(e, x') = \{\tau^A, \tau^B\}$.

such that (1) is maximized subject to the participation constraints (2) and resource constraint (3).

The solution to this problem is a simple updating rule for the endogenous pareto weight x, which maps directly to the share of resources for each household. Ligon et al. (2002) show that the constrained efficient contract is a state-specific range of pareto weights (and hence consumption shares) that simultaneously satisfy the participation constraints of both households. Specifically,

Proposition 2.1 (Proposition 1, Ligon et al. (2002))**.** *The constrained efficient contract can be characterized as follows. There exist S state-dependent intervals $[\underline{x}_r, \overline{x}_r], r = 1, 2, ...S$ such that $x(e_t)$ evolves according to the following rule. Let e_t be given and let r be the state which occurs at time $t+1$; then*

$$x(e_{t+1}) = \begin{cases} \underline{x}_r & \textit{if } x(e_t) < \underline{x}_r \\ x(s_t) & \textit{if } x(e_t) \in [\underline{x}_r, \overline{x}_r] \\ \overline{x}_r & \textit{if } x(e_t) > \overline{x}_r \end{cases}$$

The key mechanism in the limited commitment model is the value of walking away and consuming the endowment stream. It is therefore a natural model to study the effect of migration because migration opportunities will change a household's outside option: instead of consuming only the endowment in the village, the household will now have the opportunity to migrate.

2.3 Limited commitment with migration

I bring together the separate models of (1) limited commitment risk sharing, and (2) migration, and construct a model of limited commitment risk sharing with endogenous temporary migration.

Temporary migration is the option to work in the city for one period and return back to the village at the end of the period[10]. To introduce temporary migration, I allow a household to make a decision about whether to migrate once they see what their income will be in the village for the year. If a household migrates, they remain part of the risk sharing network. However, because migration affects the outside option of households, the amount of insurance may change.

I solve for the migration and transfer decisions that maximize total utility of all households in the village, subject to a set of incentive compatibility constraints. The incentive compatibility constraints map to the two separate stages at which households can decide to drop out of any risk-sharing agreement: (1) after all migration decisions have been made and final income is revealed (for example, a rich migrant does not want to transfer too much back to others in the village), and, (2) at the time of migrating (for example, a household would rather not migrate even if it would be optimal for the network as a whole to migrate). Conditional on receiving at least the same utility as their outside option at the two points in time, neither household has an incentive to deviate either by changing the amount they transfer or from the prescribed migration decision.

The timing in the model is as follows. (1) Households observed their endowment in the village. (2) Households decide whether to migrate (*ex-ante participation constraint*). (3) If households migrate, they realize their migration income. (4) Households make or receive risk-sharing transfers (*ex-post participation constraint*). (5) Agents consume. (6) Migrants return back to the village. (7) End of the period; the same problem is repeated the following period.

The economic environment is as above in Section 2.2, with the addition of an income process for migration income. Migration income for each agent is an i.i.d. draw from a discrete migration income distribution. The state of the world in the migration destination is indexed by q which takes a finite number of values. The migration state is not realized until after migration decisions have been made. The migration income for each household in state q is given by $m(q) = \{m^A(q), m^B(q)\}$, although this vector is only ob-

[10] I abstract from any learning about migration. For papers that consider learning and migration see Pessino (1991); Bryan et al. (2011).

served for agents who migrate. With slight abuse of notation I will refer to the vector m in place of q. Agents pay a direct utility cost d if they migrate.

The option to migrate changes the outside option for households. The new value of autarky, $\Omega^i_m(e_t)$, incorporates the option to migrate. Because migration is a choice, migration weakly increases the outside option for households:

$$\Omega^i_m(e_t) = \max \mathrm{E}\{u(e^i_t), u(m_t) - d\} + \mathrm{E}\sum_{t=0}^{\infty} \beta^t \max\{u(e^i_t), u(m_t) - d\}.$$

We are now ready to solve for constrained efficient transfers and migration. The problem is solved recursively in two stages. First, conditional on migration decisions ($\{\mathbb{I}^A, \mathbb{I}^B\}$) and the realization of migration outcome m, transfers are chosen to maximize joint utility such that the ex-post incentive compatibility constraints of both agents are satisfied. This yields the intermediate optimized value function $\tilde{V}(x, e, m, \mathbb{I}^A, \mathbb{I}^B)$. Second, given constrained efficient ex-post transfers, $\tilde{V}(x, e, m, \mathbb{I}^A, \mathbb{I}^B)$, migration is chosen to maximize expected joint utility such that the ex-ante incentive compatibility constraints of both agents are satisfied. The value function for the combined problem is given by $V(x, e)$.

The ex-post problem, conditional on the migration decisions and migration outcome, is to choose transfers to maximize total utility:

$$\tilde{V}(x, e, m, \mathbb{I}^A, \mathbb{I}^B) = \max_{\tau} u(y^A + \tau) - \mathbb{I}^A d + x(u(y^B - \tau) - \mathbb{I}^B d) + \underbrace{\beta \mathbb{E} V(x', e'),}_{\text{First stage function}} \tag{1'}$$

subject to

$$u(c^i) + \beta \mathrm{E} V^i(x', s') \geq \mathbb{I}^i u(m^i) + (1 - \mathbb{I})^i u(e^i) + \beta \mathrm{E}\Omega^i_m(e'), \tag{2'}$$

and

$$c^A + c^B = (1 - \mathbb{I}^A)e^A + \mathbb{I}^A m^A + (1 - \mathbb{I}^B)e^B + \mathbb{I}^B m^B, \tag{3'}$$

where ex-post income for agent i is given by $y^i = \mathbb{I}^i m^i + (1 - \mathbb{I}^i)e^i$, (2′) are the ex-post participation constraints and (3′) is the ex-post resource constraint for the economy.

The ex-ante problem takes the optimized ex-post value function, $\tilde{V}(x, e, m, \mathbb{I}^A, \mathbb{I}^B)$, and chooses migration to maximize expected joint utility such that the ex-ante incentive compatibility constraints of both agents are satisfied:

$$V(x, e) = \max_{\mathbb{I}^A, \mathbb{I}^B} \int \tilde{V}(x, e, m, \mathbb{I}^A, \mathbb{I}^B) \mathrm{d}F_m, \tag{4}$$

subject to an ex-ante participation constraint:

$$\mathrm{E}u(c^i) + \beta \mathrm{E}V^i(x', e') \geq \max(u(e^i), \mathrm{E}(u(m^i) - d)) + \beta \mathrm{E}\Omega^i_m(e'). \tag{5}$$

Definition 2. A *constrained efficient equilibrium with temporary migration* is defined by three policy functions:

1. Migration rule $i(e) = \{\mathbb{I}^A, \mathbb{I}^B\}$
2. Updating rule for pareto weight $x' = x'(e, m, i, x)$
3. Transfer function $\tau(e, m, i, x') = \{\tau^A, \tau^B\}$

such that the social planner's problem (4) is maximized, subject to the ex-ante incentive compatibility constraints (5), ex-post incentive compatibility constraints (2′), and ex-post resource constraints (3′).

A similiar updating rule for the relative pareto weight x holds in the model with temporary migration. There exist S states in the village and Q possible states in the migration destination. Denote the combined state of the world by the vector $\{e_t, m_t\}$. Then,

Proposition 2.2 (Adapted from Proposition 1, Ligon et al. (2002))**.** *The constrained efficient contract can be characterized as follows: There exist $S \times Q$ state dependent intervals $[\underline{x}_{r,n}, \overline{x}_{r,n}], r = 1, 2, ...S; n = 1, 2, ...M$ such that $x(\{e_t, m_t\})$ evolves according to the following rule. Let $x\{e_t, m_t\}$ be given and let r, n be the state which occurs at time $t + 1$; then*

$$x(\{s_{t+1}, m_{t+1}) = \begin{cases} \underline{x}_{r,n} & \textit{if } x(\{s_t, m_t\}) < \underline{x}_{r,n} \\ x(\{s_t, m_t\}) & \textit{if } x(\{s_t, m_t\}) \in [\underline{x}_{r,n}, \overline{x}_{r,n}] \\ \overline{x}_{r,n} & \textit{if } x(\{s_t, m_t\}) > \overline{x}_{r,n} \end{cases}$$

We now to derive comparative statics of migration on risk sharing and welfare.

2.3.1 Comparative statics on risk sharing, consumption, and welfare

This section derives two theoretical comparative statics: (1) the effect of migration on risk sharing, and (2) the effect of migration on welfare. I present a simple numerical example to illustrate the channels of the effects. I then present a simple numerical example to illustrate the two effects.

Throughout this section, I consider the cross-sectional income distribution in the village. Households receive an income draw from the village income distribution $F_{\text{no migration}}$. Migration will change the cross-sectional income distribution because agents who migrate will receive a different income than if they had stayed in the village. I refer to the resulting income distribution of agents after migration has occurred, and all migration income realized, as the ex-post income distribution, represented by $F_{\text{migration}}$.

To allow for correlation between agents, assume that at time t, the state of the world is either good (H) with probability π or bad (B) with probability $1-\pi$. Conditional on the aggregate state of the world z, each household receives an i.i.d. income draw from an ex-post distribution with mean $\mu(z)$ and variance $\sigma(z)$. Village income is a draw from the no-migration distribution: $e_t^i \sim F_{\text{no migration}}(\mu, \sigma)$, where the μ is the vector of the mean in bad and good years, $\mu = [\mu_B, \mu_G]$, and σ is the vector of the variance in bad and good years, $\sigma = [\sigma_B, \sigma_G]$.

Now consider introducing migration. Migration will change both total income and the distribution of income. First, migration may increase total income in the economy. This is captured by a change in μ. Migration offers a mechanism to smooth aggregate shocks. Therefore, migration may differentially affect the mean income in the economy in good years ($\mu(G)$) and bad years ($\mu(B)$). What about the variance of income? Migration may allow households with low income shocks a way to self-insure, which would reduce the ex-post cross-sectional variance. However, migration may also introduce income risk, increasing the cross-sectional variance of income. The overall effect of migration on the income process is captured by the ex-post distribution $e_t^i \sim \tilde{F}_{\text{migration}}(\tilde{\mu}, \tilde{\sigma})$.

2.3.2 The effect of migration on risk sharing

I show here that migration will have two offsetting effects on risk sharing. The first is an incentive effect arising from the endogenous change in consumption allocation through the changes in the outside option. The second is a self-insurance effect, from the direct change in income as a result of migration.

To understand how risk sharing changes we first need to define risk sharing. There are many measures in the literature. I follow Krueger and Perri (2010) and use a summary measure that captures the relative spread of income and consumption in the cross-section. This measure is used because it can easily be incorporated into the theoretical framework.[11]

Definition 3. *Risk sharing* is defined as $RS_t = 1 - \frac{\sigma(c_t)}{\sigma(e_t)}$ where $\sigma(c_t)$ is the standard deviation of consumption and $\sigma(e_t)$ is the standard deviation of income.

This measure of risk sharing is bounded between 0 and 1, and takes the value 1 if resources are perfectly shared between households ($\sigma(c_t) = 0$) and the value 0 if there is no transfer of resources ($\sigma(c_t) = \sigma(e_t)$). Risk sharing decreases when the ratio between consumption and income increases. That is, risk sharing decreases if rich agents transfer relatively fewer resources to poor agents after a change to the income distribution. A change to the distribution of income, through migration, will either increase or decrease risk sharing depending on how transfers respond.

Consider the effect on risk sharing of migration, captured by a change in the ex-post mean μ and standard deviation σ of the income distribution. There are two effects: (1) an incentive effect, through the endogenous change in the distribution of consumption arising from the change in the outside option of households, and (2) a self-insurance effect, through the exogenous change in the income distribution.

$$\Delta RS_t = \underbrace{\frac{\partial RS_t}{\partial \sigma(c_t)} \left(\frac{\partial \sigma(c_t)}{\partial \sigma} \Delta \sigma + \frac{\partial \sigma(c_t)}{\partial \mu} \Delta \mu \right)}_{\text{Incentive effect}} + \underbrace{\frac{\partial RS}{\partial \sigma(e_t)} \Delta \sigma}_{\text{Self-insurance effect}}$$

[11] In the empirical section I compute alternative measures of risk-sharing.

The net effect on risk sharing depends on the relative strength of the incentive effect and the self-insurance effect.

2.3.3 The effect of migration on welfare

Total welfare depends on the distribution of consumption and total income. Migration will have two effects on welfare. First, migration directly changes the total resources available to the network. Second, migration endogenously changes the distribution of consumption between network members.

Total welfare is maximized if all households have an equal share of consumption: that is, if $\sigma(c_t) = 0$. We can express the welfare for this economy as $W = W(\sigma(c_t), \mu)$. Consider the introduction of migration:

$$\Delta W = \underbrace{\frac{\partial W}{\partial \sigma(c_t)} \left(\frac{\partial \sigma(c_t)}{\partial \sigma} \Delta\sigma + \frac{\partial \sigma(c_t)}{\partial \mu} \Delta\mu \right)}_{\text{Risk sharing effect}} + \underbrace{\frac{\partial W}{\partial} \mu \Delta\mu}_{\text{Income effect}}$$

The sign of both effects is positive. Therefore, if migration reduces risk sharing, then welfare will be lower than if risk sharing was unchanged.

2.3.4 A simple numerical example

To illustrate these effects I work through a simple numerical example. Consider an economy with a deterministic income process and symmetric endowments. In even periods household A receives a good income shock; in odd periods B receives a good shock. The total resources in this economy are equal to 2, with the agent who has a good shock receiving 1.3 (65% of the total resources), and the other agent 0.7 (35% of the total resources). Assume logarithmic utility and a discount rate of 0.7.

I model migration as a risk-free migration opportunity where the guaranteed income is 0.8. I assume no utility cost to migrating. Under these parameters the current poor agent will always migrate but the current rich agent will not migrate. This changes the income process in two ways. First, total resources available to the network increase to 2.1 from 2.0. Second, the share of total resources that the rich agent receives decreases to 0.62

from 0.65.

Figure 1 shows the effect of migration on consumption and risk sharing in this economy. The incentive compatibility curve (net present value of endowment stream) for the agent with the binding participation constraint is drawn through each endowment point. Te intersection of the incentive compatibility curve and the budget set for the economy yields the risk-sharing equilibrium. Pre-migration, the risk sharing allocation is for the rich agent to consume 1.04 (52% of the total resources) and the poor agent to consume 0.96 (48% of total). After-migration, the incentive compatibility curve shifts, reflecting the increase in the net present value of income. As a result, the initial allocation rule is no longer incentive compatible. The new equilibrium is for the rich agent to consume 1.16 (56% of total resources), and the poor agent to consume 0.94 (44% of the total). Risk sharing is reduced.

Figure 2 decomposes the welfare effect of introducing migration. There are two offsetting effects. Migration increases the total resources available to the economy, increasing welfare. However, migration endogenously changes risk sharing. This causes a shift along the welfare curve, reducing welfare. These two effects are illustrated in the figure.

2.4 Summary of theoretical predictions

This section presented a model of limited commitment with endogenous temporary migration. Migration and risk sharing are jointly determined. I derived three comparative statics:

1. *Effect of risk sharing on transfers:* With risk sharing, the migration decision depends on post-transfer income differentials between the village and the city. There is an income effect and an insurance effect. The income effect reduces the gains from migration and reduces migration. The second effect is the insurance effect. Risk sharing occurs ex post of the realization of the migration outcome. Because migration is risky, risk sharing transfers may increase migration.

2. *Effect of migration on risk sharing:* Migration will change both the allocation of income (the self insurance effect) and the endogenous allocation of consumption (the

incentive effect). If the variance of consumption decreases relative to the variance of income, then risk sharing increases. Theoretically, the effect of migration on risk sharing is ambiguous. On one hand, the option to migrate increases the outside option of households, decreasing risk sharing. On the other hand, migration allows the network to smooth aggregate shocks, increasing risk sharing.

3. *Effect of migration on welfare:* Welfare depends on total resources available to the network and the allocation of the resources between members (the "size" and "slices" of the economic pie). The effect of migration on welfare can be decomposed into an income effect and a risk sharing effect. The income effect captures the effect on welfare of changing the income distribution holding allocation constant. It is positive, increasing welfare. At the same time, migration affects the outside option of households, which may make it more difficult to satisfy incentive compatibility constraints. This may reduce the amount of risk sharing, reducing welfare.

Because the theoretical results are ambiguous, the net effect is an empirical question. I now introduce the empirical setting of rural India, where I will estimate the model.

3 30-year panel of rural Indian households

I use the ICRISAT Village Level Studies (VLS) data from semi-arid India. The ICRISAT data are a very detailed panel household survey, with modules covering consumption, income, assets, and migration. This paper uses both the original data (VLS1), collected over 1975-1984, and the *new* ICRISAT data (VLS2), collected from the same villages starting in 2001. [12] Temporary migration is very scarce in VLS1: fewer than 1% of households report having a temporary migrant, so the migration analysis is performed using the VLS2 data only[13]. This section introduces the data and verifies the model assumptions hold in this empirical context.

[12] For more information of the initial ICRISAT panel refer to Walker and Ryan (1990)).

[13] The majority of migration in VLS1 is migration due to marriage, with the woman migrating to her husband's home (Rosenzweig and Stark (1989)).

3.1 Descriptive statistics of migration

Temporary migration is common in rural India today. Figure 3 plots the prevalence of temporary migration by village and year, in the VLS2 data. On average 20% of households participate in temporary migration each year. The prevalence of participation in the temporary migrant labor market varies over location, village and time. For example, migration is much higher in the two villages in Andhra Pradesh state due to their proximity to Hyderabad, a main migration destination.

3.2 Verifying the model assumptions in this empirical context

I verify 4 key facts in the data: (1) Migration responds to exogenous income shocks. (2) Households move in and out of migration status. (3) Risk-sharing is imperfect, and is worse in villages where temporary migration is more common. (4) Marginal propensity to consume from migration income is less than 1. Throughout the rest of the analysis I scale all household variables to per adult equivalents, to control for household composition. I define household composition using the first year in the survey to control for endogenous changes in household composition due to migration.

1. *Migration responds to exogenous income shocks*

   The summer monsoon rain at the start of the cropping season is a strong predictor of crop income (**?**). Figure 4 shows that migration responds to this income shock. When the monsoon rainfall is low, migration rates are higher. This matches the modeling assumption that migration decisions are made after income is realized.

2. *Households move in and out of migration status*

   40% of households migrate at least once during the sample. However, on average, a migrant household only migrates half the time. This is consistent with households migrating when their returns are highest, for example if they receive a bad idiosyncratic shock, rather than migration being a permanent strategy.

3. *Risk sharing is incomplete*

Risk sharing in the ICRISAT villages is incomplete, and risk-sharing is worse in villages with higher temporary migration. To show this, I estimate a test for full risk-sharing. I estimate the following regression for household i in village v at time t:

$$\log c_{ivt} = \alpha \log y_{ivt} + \beta_i + \gamma_{vt} + \epsilon_{ivt},$$

where γ_i is a household fixed effect and γ_{vt} is a village-year fixed effect that captures the total resources available to the village at time t. The intuition of tests of full risk sharing is that individual income should not predict consumption, conditional on total resources (Townsend (1994)).

Table 2 reports the results of tests of full risk sharing. The first 3 columns of the table report the results using the complete 30 year panel. I repeat the analysis using only the new VLS2 data in the last 3 columns. Results are consistent. Full risk sharing is rejected. The estimated income elasticity is 0.20 using the full sample, or 0.08 using the new VLS2 sample.

Columns 2 and 4 interact the mean level of migration in the village with income. The estimated coefficient is positive and statistically significant: an increase in 10% of the mean level of migration in the village increases the elasticity of consumption to income by 0.025: villages with higher rates of temporary migration have lower rates of risk sharing. This does not indicate causality, but is again consistent with the joint determination of risk sharing and migration.

4. *Marginal propensity to consume from migration income is less than 1:*

   Table 1 decomposes the change in household income and expenditure for migrant households. Although a household increases their income by 30% during the years they send a migrant, total expenditure (consumption and change in asset position) only increases by 2/3 of this increase in income. I do not observe transfer data in the dataset, but this shortfall between income and expenditure is consistent with an increase in transfers from the household to the network.

These four empirical facts provide some reduced form evidence for a relationship between migration and risk-sharing. In the model, migration and risk-sharing are jointly determined. It is therefore necessary to estimate the model structurally. The following section explains the structural estimation procedure.

4 Structural estimation

This section describes the structural estimation procedure. Section 4.1 discusses the simulated method of moments estimator; Section 4.2 the specific moments matched; Section 4.3 model identification and computational issues.

4.1 Simulated method of moments estimator

The aim of the structural estimation is to generate a 4-year series of simulated data to match the 4-year series of observed data as closely as possible. To do this, I estimate the model using simulated method of moments (McFadden (1989)).[14] I construct a vector of moments from the data, q_s, relating to migration, income, and risk sharing. I then solve the model for a specific value of the underlying parameters, θ, generate a simulated dataset, and construct the same moments from the simulated data. This yields a vector of simulated moments $Q(\theta)$. The simulated method of moments estimator $\hat{\theta}_{SMM}$ is given by:

$$\hat{\theta}_{SMM} = \underset{\theta}{\operatorname{argmin}}(Q(\theta) - q_s)' W^{-1} (Q(\theta) - q_s)$$

where W is a positive definite weighting matrix.[15]

I construct the simulated data by simulating a long time series of data. For a given value of the parameter vector, θ, the solution of the limited commitment model yields the migration rule, updating rule for the pareto weight, and transfer rule for each state of the

[14] An alternative estimation procedure would be to construct a pseudo-likelihood using indirect inference methods (see, for example, Guvenen and Smith (2010)). I choose method of simulated moments as my model produces moments which map directly to the data.

[15] I currently use the identify matrix for W. This will be updated to the optimal weighting matrix.

world. I use the following algorithm to generate the data. It is necessary to supply an initial pareto weight for the algorithm, so in order to minimize the effect of this initial weight I construct a long time series and discard the initial periods, computing the moments of the final 4 periods in the data.

The algorithm is as follows:

1. Construct the vector of data moments q_s.
2. For the given θ solve the model and find the migration rule, pareto intervals, and transfer rule.
3. Construct a history of $T - 4$ aggregate shocks for each village. Use the actual realization of the aggregate shocks in the data for the last 4-years of the series.
4. Draw a history of T idiosyncratic shocks for N individuals in each village
5. Together, the idiosyncratic shock and aggregate shock determine the state of the world s for each T
6. Set the $t = 0$ pareto weight to a random number $x \in [0, 1]$ for each household
7. Use the migration rule, pareto intervals, and transfer functions to simulate the N agents over T years.
8. Discard the first $T - 4$ years of data. Compute the simulated moments $Q(\theta)$ using N individuals over 4 years where the aggregate shocks in the simulated data match the aggregate shocks in the data.
9. Compute the criterion function $(Q(\theta) - q_s)'W^{-1}(Q(\theta) - q_s)$

The following section details the exact moments matched in the data during this algorithm.

4.2 Moments matched in data

There are four groups of model parameters that need to be estimated:

1. *Income distribution in village:* The income distribution in the village determines the income of households if they do not migrate. I allow for aggregate shocks at the village level, and for idiosyncratic income to depend on landholdings.

2. *Income distribution if migrate:* The income distribution at the destination determines the income of households if they migrate.

3. *Utility cost of migrating:* The utility cost is a key determinant of migration. I allow the utility cost vary by the number of males in the household, to capture differential migration rates between high-male and low-male households.

4. *Coefficient of relative risk aversion:* The coefficient of relative risk aversion determines both risk sharing and migration.

Table A shows the parameters that are estimated and how the parameters are matched to the data.

Table A: Parameter vector for structural model

Type of parameter	*Symbol*	*Main source of variation in data*
Income distribution in village	μ_v	Mean income of non migrants
	σ_v	Standard deviation of income of non-migrants
Scaling parameters for land owners	$\alpha^{\mu}_{\text{land},v}$	Mean of income of non-migrant land owners
Income distribution if migrate	$\mu_{\text{mig},v}$	Mean income of migrants
	$\sigma_{\text{mig},v}$	Standard deviation of income of migrants
Utility cost of migrating	d_v	Mean households migrating
Scaling parameter for male household	$\alpha_{\text{male},v}$	Mean male households migrating
Coefficient of relative risk aversion	γ_v	Share of non-migrants receiving a transfer
		Share of migrants receiving a transfer
		Mean consumption of non-migrants
		Mean consumption of migrants
Parameters set exogenously		
Discount rate	β	0.9
Scaling parameter good agg shock	μ	1.2
Income share from migration		0.6

Notes: The parameters with a v subscript are estimated at the village level. Parameters without a v subscript are estimated across the entire sample. The estimation sample is 5 villages. The total vector size is 29 (5 parameters estimated separately for each village and 4 parameters estimated across the entire sample).

The model is over-identified, meaning I match more moments than parameters. In addition to structurally estimating parameters, I set three parameters exogenously. First, I set the discount rate = 0.9. It is difficult to separately identify β and γ because they are highly negatively correlated (see Guvenen and Smith (2010)). I set $\beta = 0.9$ to match the values estimated for the ICRISAT villages by Ligon et al. (2002). Second, I set the scaling parameter for the good shock to 0.2. This matches the mean difference in the data between a good and bad aggregate shock. Third, I set the income share from migration to 0.6, matching the share of household income from migration for households with a temporary migrant observed in the data.

Because I allow for heterogeneity in land holdings and household composition when estimating the model, it is necessary to have a large enough sample size within each village. For this reason, I drop village 6 because its sample size is only 32 households. The final structural estimation sample is 5 villages. In total, I estimate 8 parameters for each village, and set 3 parameters exogenously. This yields a total of 40 parameters to be estimated. The parameter vector $\theta = \{\theta_{\text{estimated}}, \theta_{\text{exogenous}}\}$ is a vector of 43 parameters which fully characterizes the risk-sharing and migration model.

4.3 Identification of parameters

This section details the identification of each group of parameters, and how to extend the 2 agent model to the N household village.

4.3.1 Household income

Household income depends on the aggregate income shock, an idiosyncratic income shock, migration decision and migration income. Exogenous variation in income comes from monsoon rainfall, which determines the aggregate state of the world in the village.

Total household income depends on the migration decision. If the household does not migrate, their income comes only from their village income draw, y_{ivt}. If the household migrates, the migrant receives migration income draw, m_{ivt}, and total household income is a combination of income earned by the migrant and income earned by the non-migrants.

Each household i in village v receives an income at time t that has an idiosyncratic (ϵ) and an aggregate component (ν):

$$y_{ivt} = \nu_{vt}\epsilon_{ivt}.$$

The aggregate state is either high or low, each with equal probability. The idiosyncratic shock is an iid draw from a village-specific log-normal distribution with mean μ and variance $\sigma^2_{\text{idio,v}}$:

$$\log(\epsilon) \sim \mathcal{N}(\mu_v, \sigma^2_{\text{idio},v}).$$

I allow the village income distribution to be a function of land holdings. I scale the mean of the income distribution by $\alpha^{\mu}_{\text{land}}$, estimated structurally, if the household is in the top half of the land holding distribution within village.

If agent i migrates from village v they receive an income draw m from a log-normal distribution with mean $\mu_{\text{mig,v}}$ and variance $\sigma^2_{\text{mig,v}}$. I assume that all agents face the same ex-ante income distribution if they migrate:[16]

$$\log(m) \sim \mathcal{N}(\mu_{\text{mig,v}}, \sigma^2_{\text{mig,v}}).$$

To implement the estimation I discretize the income processes. To do this I follow Kennan (2006), and choose points of support in the distribution such that there is equal probability put on each support point. There is a trade-off between number of points of support and computational time of the algorithm. I allow 10 points of support for the idiosyncratic income process and 3 points of support for the migration income process.

[16] It would be possible to incorporate additional dimensions of heterogeneity into the estimation procedure, such as education. In the data I find no relationship between education and selection into temporary migration, but a small and marginally significant difference in the wage rate if agents migrate. This is because temporary migration is primarily low-skilled manual work.

4.3.2 Utility parameters

The discount rate β and the coefficient of relative risk aversion γ both affect risk sharing: households who are more patient can share idiosyncratic risk more easily, and agents who are more risk averse also prefer to share risk more. Risk aversion also affects migration decisions as agents who are more risk averse prefer certainty over uncertainty and require larger expected gains in order to migrate.

It is difficult to separately identify β and γ because they are highly negatively correlated (see Guvenen and Smith (2010)). I set $\beta = 0.9$ to match the values estimated for the ICRISAT villages by Ligon et al. (2002). I identify γ by matching consumption based moments that summarize the degree of risk sharing in the economy: the share of households receiving transfers, and mean consumption.

4.3.3 Utility cost of migrating

The direct utility cost, d is unobserved to the econometrician but is key to the household's decision to migrate. d is identified by matching mean migration rates. Intuitively, if the direct utility cost were zero there would be a threshold income level in the village below which agents would migrate. Increasing d increases this threshold and increases the share of the village who have income below this threshold.

In the data, the number of males in the household is a strong prediction of migration.[17] To match this fact, I allow for heterogeneity in the migration cost by the number of males in the household. I assign a dummy indicator $\mathbb{I}_{\text{male}}$ if the household has more males than the median household, and estimate a scaling parameter α_{male} for the utility cost for these households. The specific moments I match in the data are the mean migration rate, and the mean migration rate of many-male households.

[17] Overall, 28% of temporary migrants are women. However, these women are almost always accompanied by a male member of the household. If there is only one migrant from a household, 94% of the time this is a male migrant. This gender difference could reflect cultural norms about women traveling alone, or reflect differential returns from migration by gender.

4.3.4 Moving from 2 to N households

The model presented in Section 2 was a two household model. The model can be extended to N agents by including each agent's relative pareto weight as an additional state variable. However, this is computationally intensive. I follow Ligon et al. (2002) and other empirical applications of the limited commitment model (Laczo (2011)) and construct an aggregated "average rest of the village" household.

The average rest of the village depends on the particular household: a household who receives a relatively low idiosyncratic shock will have a lower income than the average member of the village. For each state of the world s I construct the average village member by assigning the income realization such that the sum of household H and household $-H$ is equal to the average level of resources in the economy.[18]

5 Structural Results

This section presents the structural estimation results and performs counterfactual policy analysis. I use the estimated results to examine the effect of migration and risk sharing separately, within the model. The key result in this section is that migration reduces risk sharing. I explore this result by contrasting endogenous limited commitment with exogenous limited commitment models of risk sharing.

Section 5.1 discusses the fit of the model to the data. Section 5.2 presents the key empirical results. Section 5.3 examines the effect of examines the effect of several development policies: a rural employment scheme; economic growth in the city; and a reduction in the utility cost of migrating.

5.1 Model fit and description

The parameter point estimates from the structural estimation are provided in Appendix Table 2.[19] Migration has a positive expected return: mean income if agents migrate is

[18]Please refer to the appendix for a discussion of some computational issues.

[19]Standard errors will be computed by first approximating the discrete migration choice with a continuous formula, following Keane and Smith (2004) and then following Hansen, L.P. (1982). This is in progress.

higher than staying in the village (mean of the lognormal distribution is 1.7, compared to 1.3). However, migration is considerably riskier (mean of the standard deviation across is villages is 1.00, compared to 0.7 for mean standard deviation of village income). The implied utility cost of migrating is substantial. The utility cost of 0.1 is equivalent to 30% of mean household consumption. The utility cost of migration is lower in Villages (1) and (2), which are the high-migration villages in Andhra Pradesh state, close to Hyderabad, and higher in Villages (3)-(5), which are villages in Maharastra, further away from main migration destinations. The model matches the higher rates of migration by households with many males by assigning a lower utility cost; for these households the utility cost is equivalent to approximately 15% of mean consumption.

The data fit the model well. Table 3 shows the moments targeted during the estimation procedure, averaged over the 5 village sample. The means of the income and consumption distributions are a close match. The mean correlation between income and consumption (removing the effect of permanent male/land endowments) is matched well, however, the model over-predicts the share of migrants receiving risk-sharing transfers from the network. This is most likely due to the small number of discrete states used to estimate the migration process (I allow for three possible migration outcomes); a finer grid would provide a better match on this. Finally, as a test of how well the model matches other characteristics in the data, I show the share of households that migrate this year if they migrated last year. The model predicts 50% of households are repeat migrants; the data is slightly higher at 65%. This is a reasonable match, considering I only allow for two sources of heterogeneity in the model (landholdings and household composition), and of course there are many other possible sources of heterogeneity in the data.

In the model it is the households with the lowest income realizations that choose to migrate. The selection of migrants by group is shown in Figure 5. Households with land have a higher income in the village, and so are less likely to migrate than landless households because the relative gain to migrating is lower. Households with males face a lower utility cost, and are much more likely to migrate. I separate out migration in good aggregate shocks and bad aggregate shocks: the mean migration rate in a good aggregate shock is 14%; in a bad aggregate shock 18%.[20]

Migration has a positive return. Table 4 shows the effect of migration for migrants. The mean income of migrant households is 5600 rupees per equivalent adult (approximately \$104 USD). However, these households would have been considerably worse off had they not migrated. The counterfactual income (what migrants would have received had they not migrated) is approximately half of actual income, at 2700 rupees (\$ 50 USD). 72% of migrant households have higher income from migrating than they would have if they had not migrated.[21] The second panel in Table 4 shows the effect of migration on village income. Households migrate when they receive a bad shock, causing non-migrants to be in the upper tail of the distribution. The estimated mean of village income, conditional on not migrating, is 5900 rupees per adult equivalent household member (approximately \$110 USD). The actual mean of the income distribution is only 5400 rupees per adult equivalent household member (approximately \$100 USD).

5.2 Effect of migration on risk sharing and welfare

I now consider the economy with and without migration. The relative thought experiment is the economy with an infinite utility cost of migration, but the same income processes. The structural estimates yield the income distribution agents face in the village and in the city. I recompute the limited commitment model assuming that households face the same income distribution in the village, but do not have the option to migrate. Risk sharing will endogenously respond to the altered incentive compatibility constraints arising from removing the option to migrate.

I find that risk sharing decreases with migration compared to without migration. Welfare for the network increases overall. I then recompute the welfare effects of migration under two alternative models of risk sharing and show that the magnitude of the benefit with migration is smaller than under exogenously incomplete markets (agents can

[20] The precise income values of when households migrate are not necessarily larger in bad shocks; this is due first to the discretization of the income process, introducing lumpiness; and second because the income distribution for bad aggregate shocks has more mass below a given income realization, corresponding to higher migration, that the distribution for the good aggregate shock.

[21] This number is consistent with the results in Bryan et al. (2011) who estimate a 10-20% risk of "failure" from migration.

borrow and save, but do not interact with each other). Migration increases welfare, but some of the potential welfare gain of migration is lost because risk-sharing endogenously changes.

5.2.1 Migration reduces risk-sharing

Migration causes risk-sharing to decrease: the average correlation between income and consumption increases. The change in the relationship between income and consumption after migration is plotted in Figure 6. There are two offsetting effects of allowing access to migration in the economy on risk sharing. The first effect is a 'self insurance' effect which captures the mechanical change in the allocation of endowments. The second is an incentive effect which captures the change in the allocation of consumption (refer to Section 2.3).

Table 5 shows the change in risk sharing between the economy with the option to migrate and the economy without the option to migrate. For ease of interpretation, I present the change in the correlation between income and consumption.[22] The statistic is computed over the sample and by subgroup. Migration causes risk-sharing to decrease: on average, the correlation between income and consumption is 14% before migration. With migration, this correlation is 20%. The decrease in risk-sharing results in agents with consumption that tracks their income more closely. The overall correlation masks substantial heterogeneity within group. The largest change in risk sharing is for the agents who can migrate easily and hence have the highest change in their outside option: households with many males. Columns (3) and (4) make the same comparison with and without migration over the sample of agents who do not migrate. The households who do not migrate have the same income in both states of the world, so the change is only through the change in the distribution of consumption for these households. The same pattern holds.

[22]Results are robust to defining risk sharing using $1 - \frac{\sigma(c)}{\sigma(y)}$; the correlation yields an easier comparison so is used here.

5.2.2 Migration increases welfare...

Table 6 considers the welfare implications of introducing migration, comparing average welfare in the economy without migration and average welfare with migration. For ease of comparison the mean migration rate for each group in included in the table.

Introducing the option to migrate increases village welfare by 4.4%, or 15.5% in terms of consumption-equivalent value. Without migration the richer agents (the agents with land) have the highest level of welfare. There is no difference in welfare by the number of males in the household as the number of males only affects the utility cost if households migrate. The largest relative benefits from migration are to the poor (landless) households: welfare for the landless households with few males increases by 5.7%, and for landless households with many males, 7.6%. With migration, households with males migrate more often than households without males. However, even households who do not migrate benefit from the fact that there neighbors are getting richer. For example, landless households with few males only migrate 14% of the time, but still receive a large increase in welfare.

5.2.3 ... but not by as much, due to the endogenous change in the insurance market

Although migration increases welfare, it also endogenously changes the structure of informal insurance. To explore the welfare effects of the change in risk-sharing, I consider two alternative mechanisms of risk sharing: autarky, where households cannot make or receive transfers, and exogenous incomplete markets, where households can borrow and save a risk free asset.[23]I find that the relative welfare gains from migration are higher under both autarky and exogenous incomplete markets. The key difference between the setup of limited commitment risk sharing and the two alternatives is under limited commitment households are linked through risk-sharing. However, under exogenous incomplete markets, households are independent. Hence, the structure of risk-sharing does not adjust due to changes in households' outside option.

The results are in Table 7. With limited commitment, the welfare gain of migration

[23]I solve a Huggett (1993) economy, setting the risk free interest rate to 0.04 and an exogenous borrowing constraint of approximately 50% of average annual income.

is 4.4%. Under autarky, the gain is 6.7%, and under borrowing-saving, 11.2%. The borrowing-saving regime generates a higher relative welfare because households can self-insure against bad migration outcomes. This explains why the migration rate is substantially higher under borrowing-saving (56%) compared to the baseline model (17%).

The second result from Table 7 is migration behavior under alternative risk sharing regimes. There are two potentially offsetting effects of transfers on migration: an income effect, that reduces migration, and an insurance effect, increasing migration (refer to Section 2.1). I find a substantial decrease in migration rate when households can share risk: migration is 50% lower with limited commitment than with autarky. The income effect in the village dominates the insurance effect.

5.3 Policy experiments

I use the model to compute the welfare effects of three policy experiments. First, I consider a village employment scheme, similar in flavor to the Indian Government's National Rural Employment Guarantee Act (NREGA). Second, I consider the effect of reducing the utility cost of migrating, through government policies that reduce the physical costs of migrating (for example, public infrastructure) or reduce the psychic costs of migrating (for example, assistance in providing housing services to temporary migrants). Third, I consider the effect of economic growth in the city.

[Section coming soon]

6 Conclusion

Economists have long studied the complex systems of informal insurance between households in developing countries. Informal insurance is important because formal markets are generally absent in developing countries, leaving households exposed to a high degree of income risk. However, studies of informal insurance have generally not considered that households have access to other risk-mitigating strategies. This paper studies temporary migration, a phenomenon that is both common (20% of rural Indian households have a migrant) and economically important (migration income is more than half total household income for these households). Temporary migration provides a way for households to self-insure, hence may fundamentally change incentives to participate in informal insurance. For this reason, this paper has argued that it is necessary to consider the migration decision of the household *jointly* with the decision to participate in informal risk sharing networks.

The analysis proceeds in three steps. First, I characterize a model of endogenous limited commitment risk sharing with endogenous temporary migration. Risk sharing and migration are jointly determined. In the limited commitment model, the key determinant of risk sharing is the household's outside option. Migration changes the outside option, hence changing the structure of endogenous risk sharing. I demonstrate how the welfare effect of migration can be decomposed into an income effect and a risk-sharing effect. I then show how risk sharing alters the returns to migration, and determines the migration decision. Second, I estimate the model structurally on the new wave of the ICRISAT panel dataset. Third, I quantify the theoretical comparative statics. The empirical results are: (1) risk-sharing reduces migration by 50%; migration reduces risk-sharing by 41%; (2) the net welfare effect of migration is large, equivalent to a 15.5% increase in consumption; (3) contrasting endogenous to exogenous risk sharing, the consumption-equivalent gain of migration is 31% lower.

The fact that households make both risk sharing and migration decisions jointly has several implications for development policy. The first is that in an environment where households are connected through informal risk-sharing, any development policy will affect not only targeted households, but other households. This point has been made for other contexts, such as public insurance in the PROGRESA villages (Attanasio and Rios-Rull (2000)), but the effect of migration on risk-sharing has not been studied. The second is that specific policies may be needed to replace informal risk sharing, particularly in high-migration areas. Future avenues of research could consider a richer economic environment to more fully consider the distributional impacts of migration.

References

Albarran, P and O Attanasio, "Do public transfers crowd out private transfers?," *UNU/WIDER Discussion Paper*, 2002.

_ and _ , "Limited commitment and crowding out of private transfers: Evidence from a randomised experiment," *Economic Journal*, 2003.

Altonji, J, F Hayashi, and L Kotlikoff, "Is the extended family altruistically linked? Direct tests using micro data," *The American Economic Review*, 1992.

Attanasio, O and Jose-Victor Rios-Rull, "Consumption smoothing in island economies: Can public insurance reduce welfare?," *European Economic Review*, 2000.

Banerjee, Abhijit and A Newman, "Information, the dual economy, and development," *Review of Economic Studies*, 1998.

_ and Esther Duflo, "The economic lives of the poor," *Journal of Economic Perspectives*, 2007.

Breman, Jan, *Footloose Labour: Working in India's Informal Economy*, Cambridge University Press, 1996.

Bryan, Gharad, Shyamal Chowdhury, and Ahmed Mushfiq Mobarak, "Seasonal Migration and Risk Aversion," 2011.

Chandrasekhar, Arun, Cynthia Kinnan, and Horacio Larreguy, "Does Savings Crowd Out Informal Insurance? Evidence from a lab experiment in the field," 2010.

Coate, Stephen and Martin Ravallion, "Reciprocity Without Commitment: Characterization and Performance of Informal Insurance Arrangements," *Journal of Development Economics*, 1993.

Coffey, Diane, John Papp, and Dean Spears, "Dual economies or dual livelihoods? Short term migration from rural India and non-agricultural employment," 2011.

Cox, D. and Z Eser, "Motives for private transfers over the life cycle: An analytical framework and evidence for Peru," *Journal of Development Economics*, 1998.

Dubois, Pierre, Bruno Jullien, and Thierry Magnac, "Formal and Informal Risk Sharing in LDCs: Theory and Empirical Evidence," 2008.

Guvenen, Fatih and Anthony Smith, "Inferring Labor Income Risk From Economic Choices: An Indirect Inference Approach," 2010.

Hansen, L.P., "Large sample properties of generalized method of moments estimators," *Econometrica: Journal of the Econometric Society*, 1982.

Harris, John and Michael Todaro, "Migration, Unemployment and Develpment: A Two-Sector Analysis," *The American Economic Review*, 1970.

Huggett, M, “The Risk-Free Rate in Heterogeneous-Agent Incomplete-Insurance Economies,” *Journal of Economic Dynamics and Control*, 1993.

Keane, Michael and Anthony Smith, “Generalized Indirect Inference for Discrete Choice Models,” 2004.

Kehoe, T and D Levine, “Debt-constrained asset markets,” *The Review of Economic Studies*, 1993.

Kennan, J, “A note on discrete approximations of continuous distributions,” 2006.

Kinnan, Cynthia, “Distinguishing Barriers to Insurance in Thai Villages,” 2010.

Kocherlakota, N, “Implications of Efficient Risk Sharing without Commitment,” *Review of Economic Studies*, 1996.

Krueger, D and F Perri, “Public versus private risk sharing,” *Journal of Economic Theory*, 2010.

Laczo, Sarolta, “On Risk Sharing in Village Economies: Structural Estimation and Testing,” 2011.

Lewis, W.A., “Economic Development with Unlimited Supplies of Labour,” *The Manchester School*, 1954.

Ligon, E, “Risk sharing and information in village economies,” *Review of Economic Studies*, 1998.

Ligon, Ethan, Jonathan Thomas, and Tim Worrall, “Informal Insurance Arrangements with Limited Commitment: Theory and Evidence from Village Economies,” *The Review of Economic Studies*, 2002.

Lim, Y and Robert M Townsend, “General equilibrium models of financial systems: theory and measurement in . . . ,” *Review of Economic Dynamics*, 1998.

Marcet, A and R Marimon, “Recursive Contracts,” *cadmus.iue.it*, 1998.

McFadden, D, “A method of simulated moments for estimation of discrete response models without numerical integration,” *Econometrica: Journal of the Econometric Society*, 1989.

Munshi, Kaivan and Mark Rosenzweig, “Why is Mobility in India so Low? Social Insurances, Inequality, and Growth,” 2009.

Pessino, C, “Sequential migration theory and evidence from Peru,” *Journal of Development Economics*, 1991.

Rosenzweig, Mark and H Binswanger, “Wealth, weather risk and the composition and profitability of agricultural investments,” *The Economic Journal*, 1993.

_ and Oded Stark, “Consumption smoothing, migration, and marriage: evidence from rural India,” *The Journal of Political Economy*, 1989.

Thomas, J and Tim Worrall, "Unemployment Insurance under Moral Hazard and Limited Commitment: Public versus Private Provision," *Journal of Public Economic Theory*, 2007.

Townsend, Robert M, "Risk and Insurance in Village India," *Econometrica*, 1994.

_ and Alexander Karaivanov, "Dynamic Financial Constraints: Distinguishing Mechanism Design from Exogenously Incomplete Regimes," *Manuscript*, 2010.

Udry, Christopher R, "Risk and Insurance in a Rural Credit Market: An Empirical Investigation in Northern Nigeria," *The Review of Economic Studies*, 1994.

Walker, Thomas and James Ryan, "Village and Household Economies in India's Semi-arid Tropics," 1990.

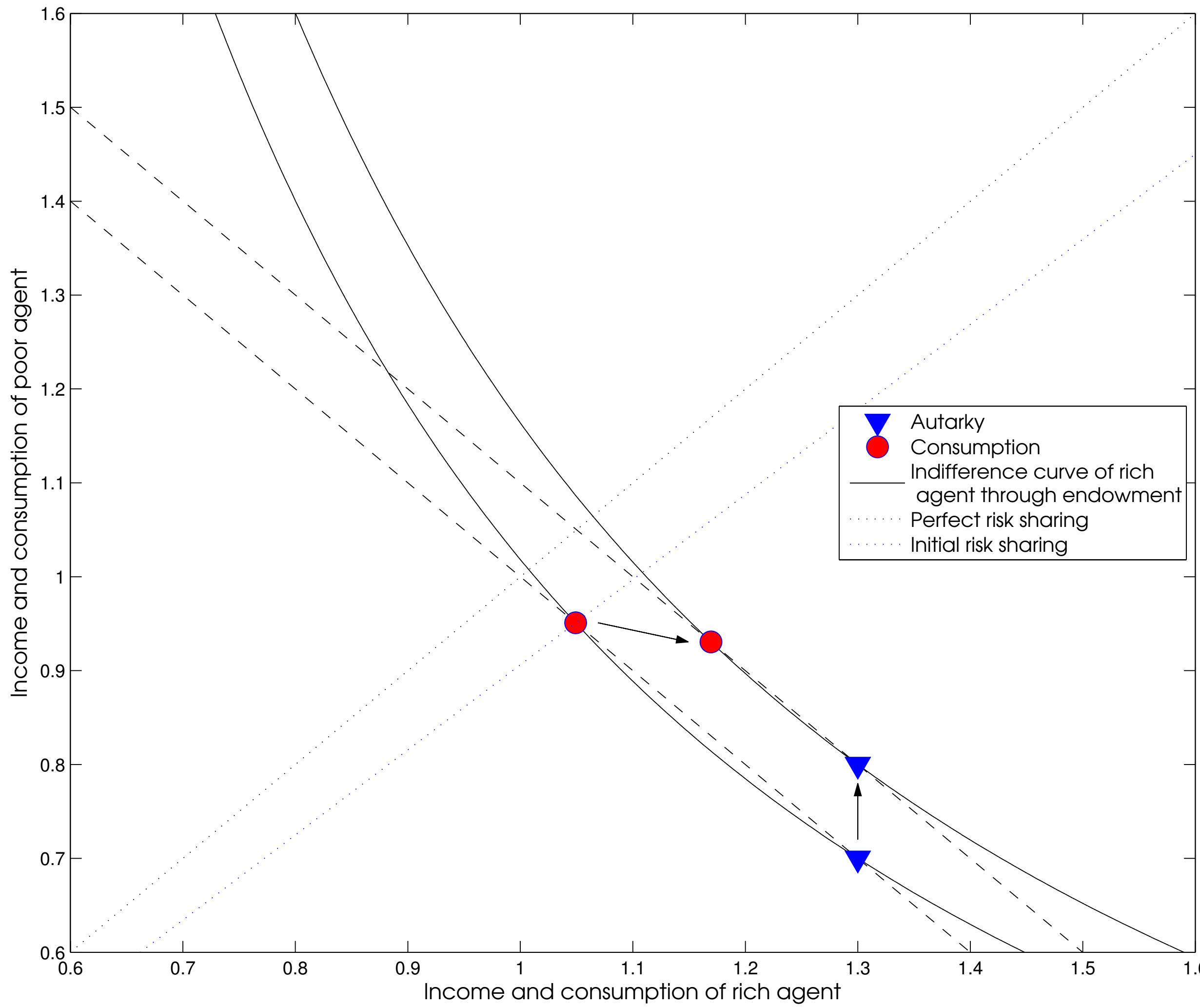

Figure 1: Effect on consumption from migration under limited commitment.

Notes: This figure plots autarky and consumption for a simple limited commitment economy with a deterministic income process with two states of the world and constant aggregate resources. The initial autarky point is $\{y_{\text{rich}} = 1.3, y_{\text{poor}} = 0.7\}$. Under limited commitment the amount of risk sharing is constrained by the outside option of the agent with the binding participation constraint (here: the current rich agent). The risk sharing equilibrium is a consumption allocation that yields the same utility to the rich agent as autarky. In the graph this is the point closest to equal allocation of resources where the indifference curve intersects the budget constraint for the economy: $\{c_{\text{rich}} = 1.05, c_{\text{poor}} = 0.95\}$. In this example there is imperfect risk sharing: the rich agent consumes more than half of total resources, but the allocation is more equitable than autarky. Consider the introduction of a migration opportunity that yields a guaranteed income of 0.8. The current poor agent will migrate but the current rich agent will not migrate. This changes the income process to $\{y_{\text{rich}} = 1.3, y_{\text{poor}} = 0.8\}$. The outside option for all agents has increased which shifts out the indifference curve for the current rich agent. The new limited commitment consumption equilibrium is the bundle $\{c_{\text{rich}} = 1.17, c_{\text{poor}} = 0.93\}$. The initial risk sharing is no longer incentive compatible. The share of total resources the rich agent consumes increases. Risk sharing is crowded out by the increase in the outside option due to migration.

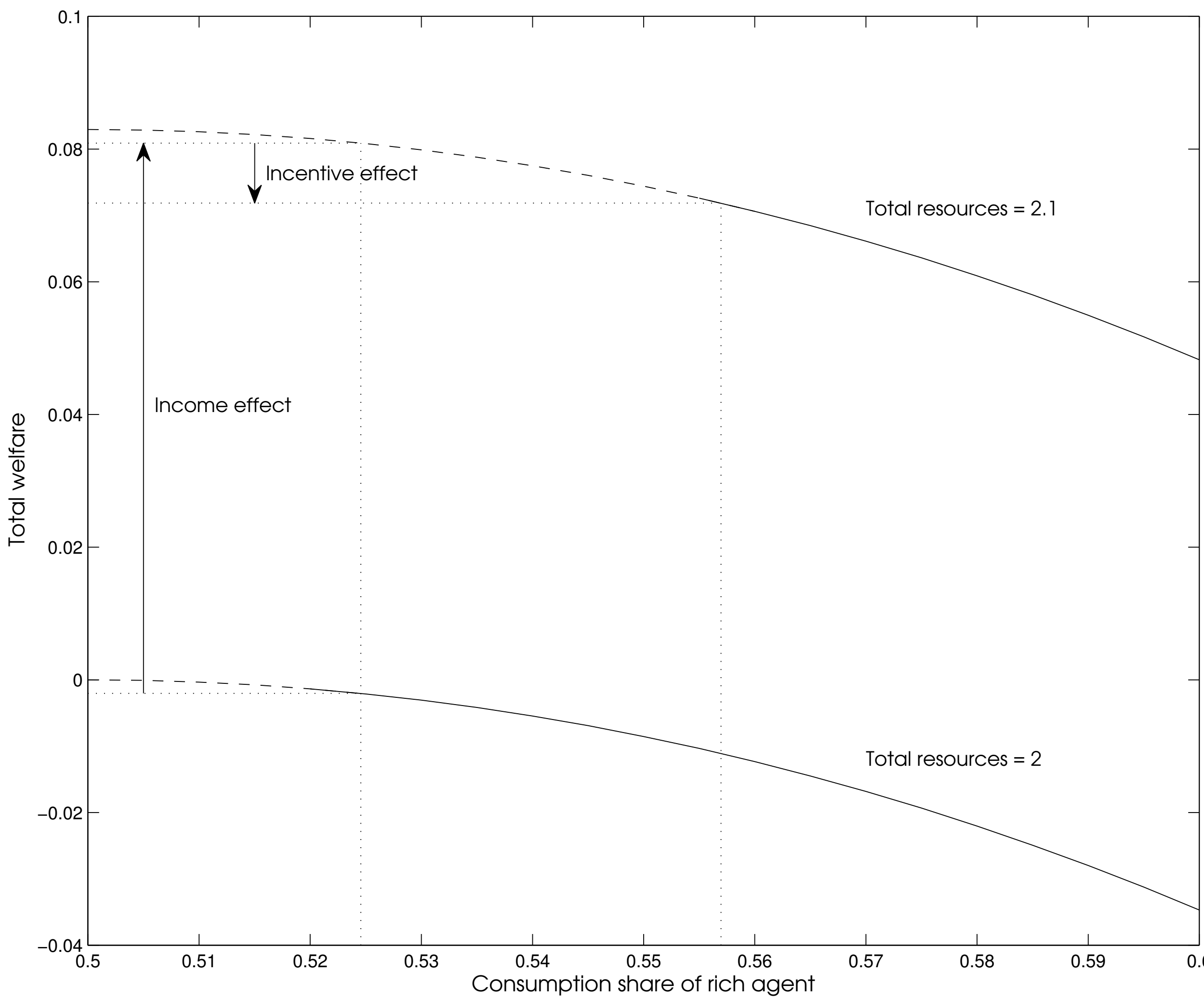

Figure 2: Effect on welfare from migration: income effect and incentive effect

Notes: This figure plots the two effects on welfare from migration: an income effect due to extra resources, and an incentive effect due to crowding out of risk sharing. The dashed portion of the graph shows the consumption allocations which are not incentive compatible. Total welfare is maximized when the consumption share is equal to 0.5. However this consumption allocation is not incentive compatible. The shift in autarky from $\{y_{\text{rich}} = 1.3, y_{\text{poor}} = 0.7\}$ to $\{y_{\text{rich}} = 1.3, y_{\text{poor}} = 0.8\}$ increases the total resources available to the network but decreases risk sharing. The income effect shows the welfare gain from higher income, holding the consumption share constant. The incentive effect shows the reduction in welfare due to decreased risk sharing.

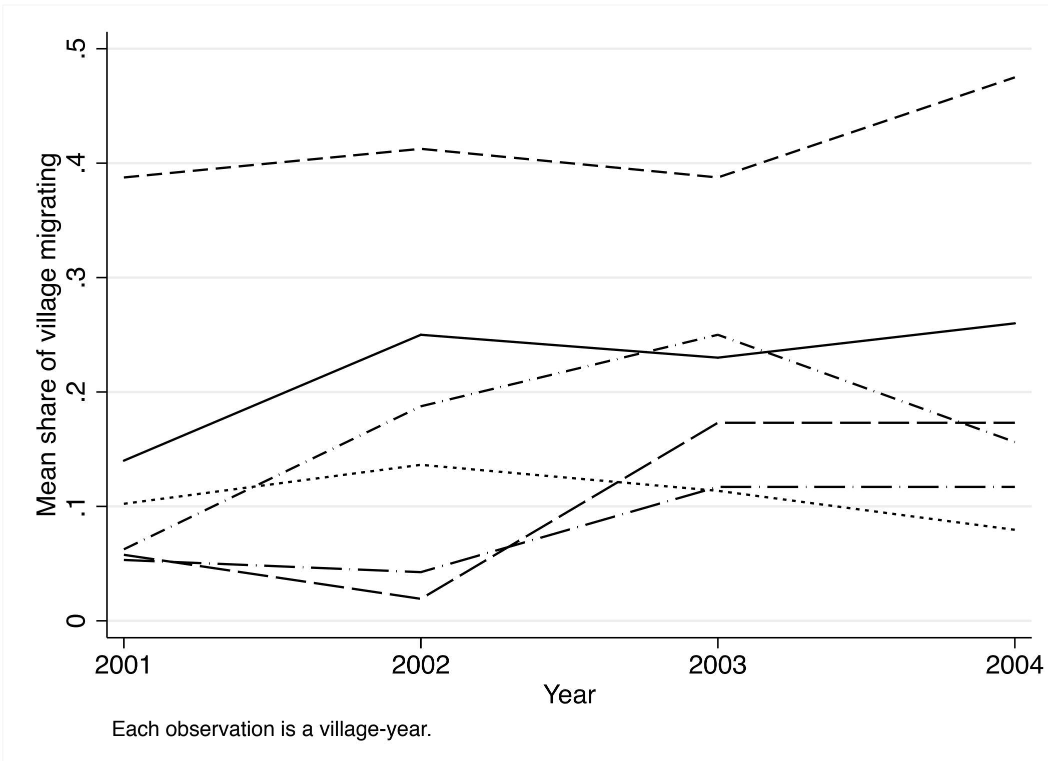

Figure 3: Migration varies over space and time: Temporary migration in the six ICRISAT villages over time.

Notes: The figure plots the share of households with a temporary migrant in each of the six ICRISAT villages by year.

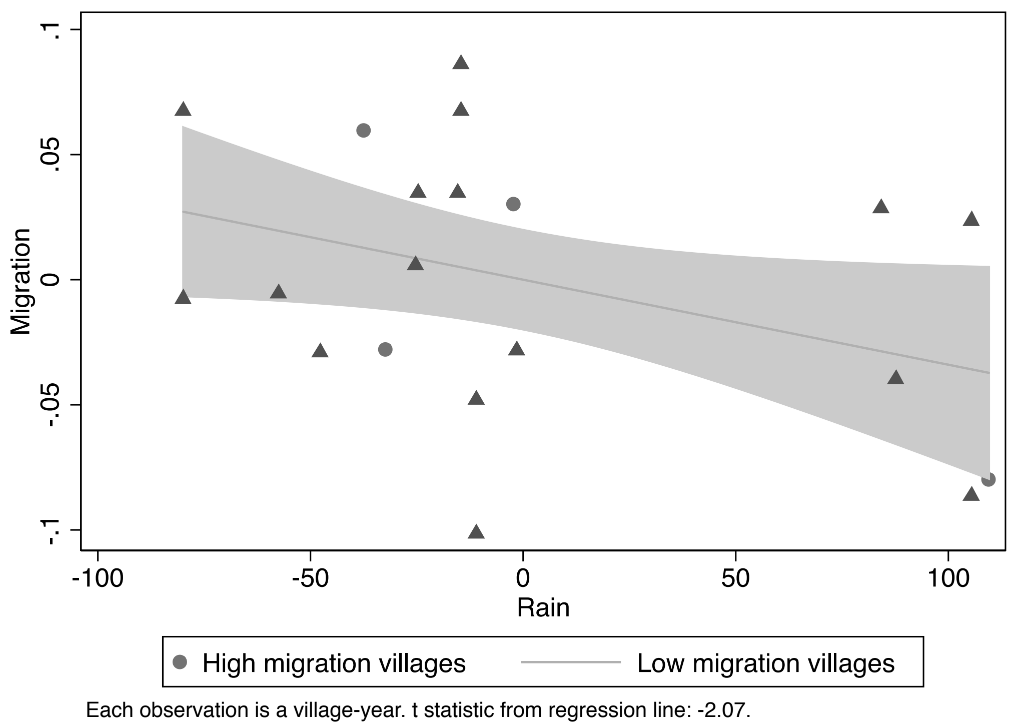

Figure 4: Verifying model assumptions: Temporary migration responds ex-post to income shocks.

Notes: The figure plots the relationship between demeaned migration rate and demeaned monsoon (June) rainfall in the six ICRISAT villages between 2001-2004. Monsoon rainfall is a strong predictor of crop income for the coming year. Migration decisions are made after the monsoon rainfall and respond to expected income shocks. The unit of observation is a village-year; there are 24 observations. A regression line with a 95% confidence interval is included in the figure.

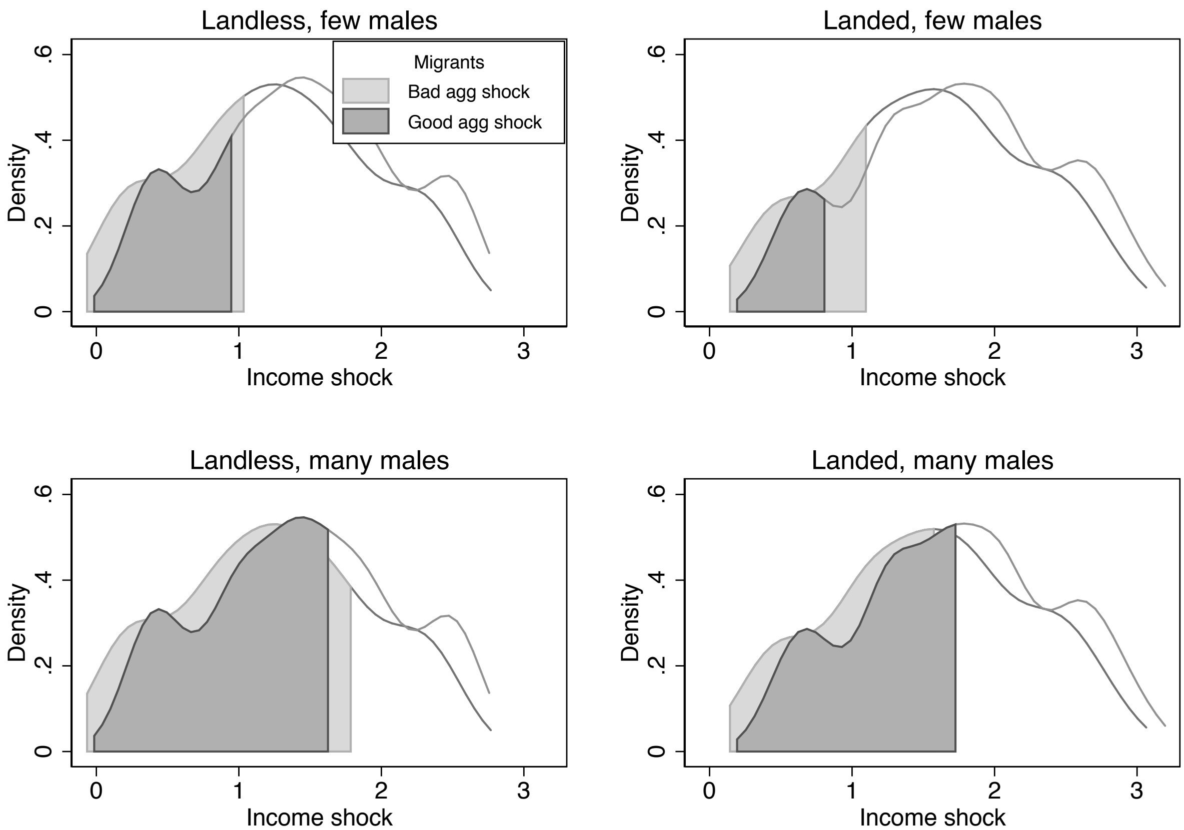

Figure 5: Structural estimation: Income distribution and selection into migration by population subgroup

Notes: The figure plots the migration and income distribution for each subgroup (males/land) for good and bad aggregate shocks. Computed from structural estimation results. The shaded area represents the agents who migrate in each period.

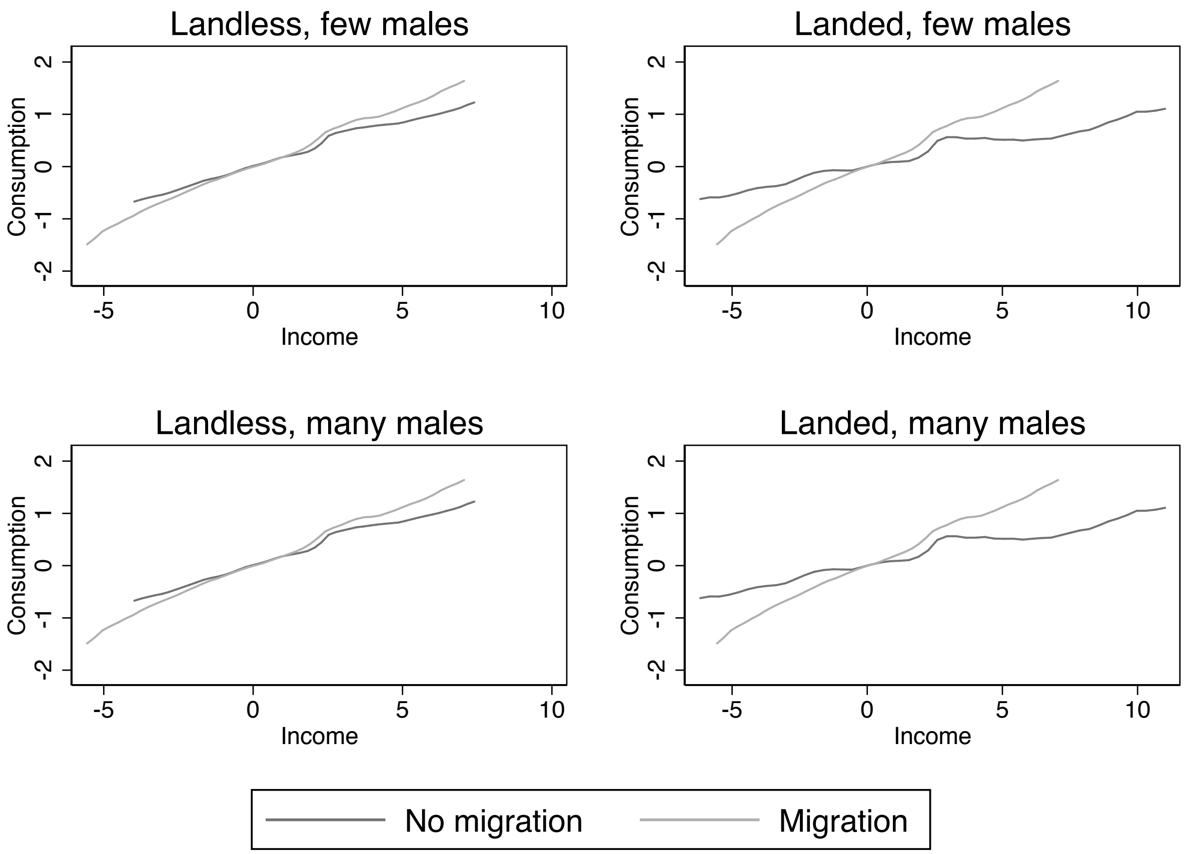

Figure 6: Structural estimation: Relationship between income and consumption (both demeaned)

Notes: The figure plots a kernel-weighted local regression line of demeaned consumption on demeaned income, comparing no-migration to migration. Computed from structural estimation results.

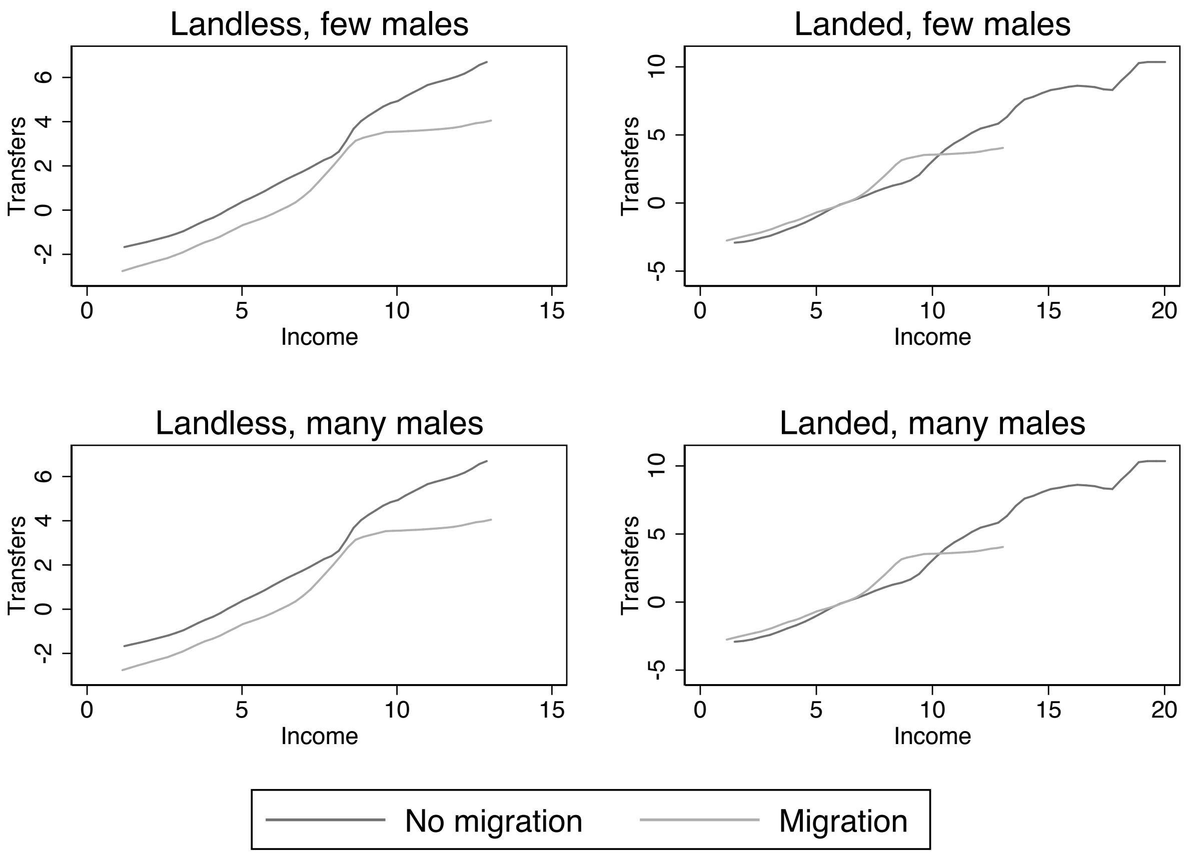

Figure 7: Structural estimation: Relationship between income and transfers

Notes: The figure plots a kernel-weighted local regression line of transfers on income (both in levels), comparing no-migration to migration. A negative value of transfers means the household receives transfers; a positive they make a transfer. Computed from structural estimation results.

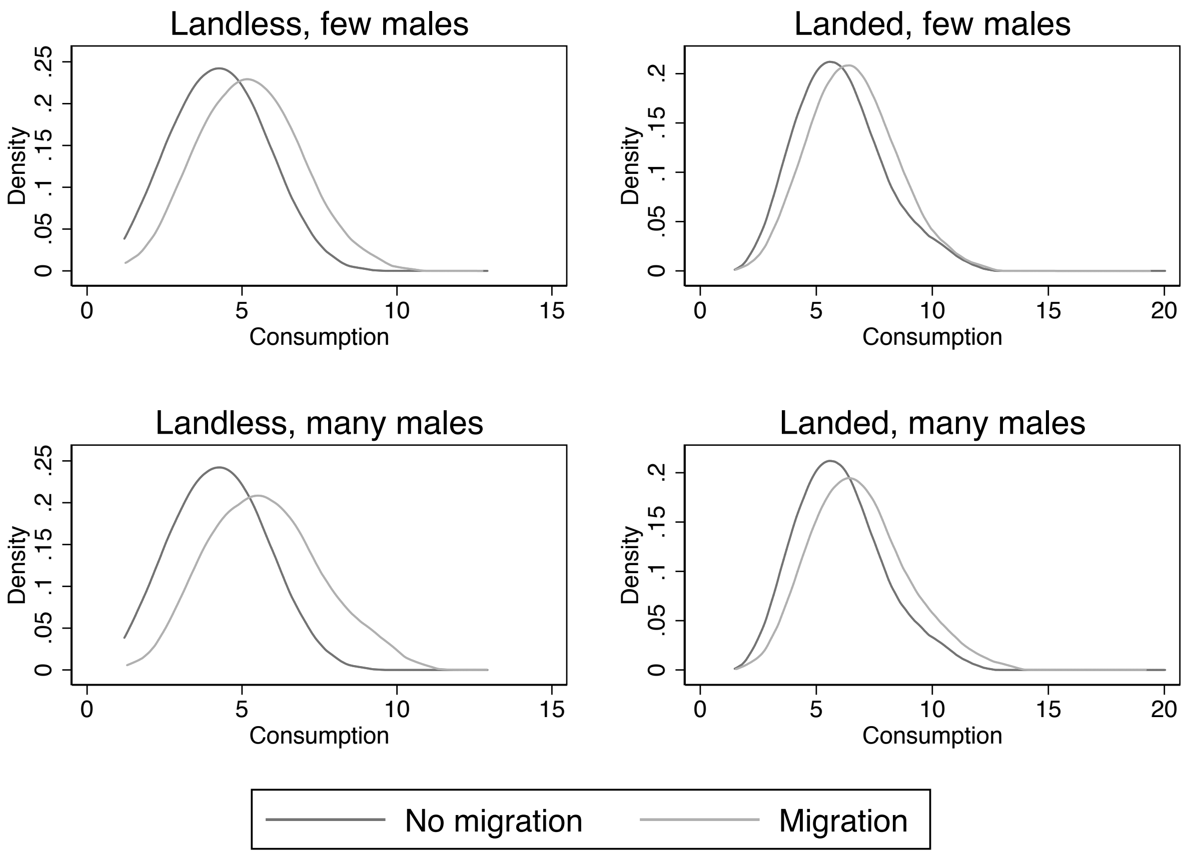

Figure 8: Structural estimation: Distribution of consumption

Notes: The figure plots the distribution of consumption, comparing no-migration to migration. Computed from structural estimation results.

Table 1: CHANGE IN HOUSEHOLD INCOME AND EXPENDITURE WHEN MIGRATE

Dep. variable:	(1) Income b/se	(2) Consumption b/se	(3) Δ Net Savings b/se	(4) Δ Assets b/se	(5) Expenditure b/se
Dummy if migrate	1492***	606	352	318	858
	(483)	(524)	(318)	(470)	(880)
Household FE	Yes	Yes	Yes	Yes	Yes
Mean dep. variable	5828	6856	-587	312	6158
R-squared	0.652	0.515	0.170	0.256	0.396
Number observations	1449	1449	1149	1149	1149
Number households	438	438	437	437	437

Notes: OLS regressions with standard errors clustered at village-year. Calculated from ICRISAT data 2001-2004. Change in net savings is change in savings less change in debt. Change in assets is change in value of durables, farm equipment, and livestock. Change variables defined over 2002-2004. Expenditure is sum of columns 1-3. Mean dependent variable calculated over non-migrants.

Table 2: TEST FOR PERFECT RISK SHARING

	Combined sample (VLS1 and VLS2)		VLS2 only	
	(1)	(2)	(3)	(4)
Dep. variable: Consumption	b/se	b/se	b/se	b/se
Income	0.198***	0.199***	0.071***	0.028
	(0.029)	(0.029)	(0.016)	(0.022)
VLS2 *X* Income	-0.090**	-0.133***		
	(0.034)	(0.036)		
Mean village migration *X* Income		0.239**		0.243*
		(0.116)		(0.121)
Village-Year FE	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes
R-squared	0.685	0.687	0.627	0.630
Number observations	2429	2429	1446	1446

Notes: OLS regressions of log income on log consumption. Standard errors clustered at village-year level for all columns. VLS1 is ICRISAT data 1975-1983. VLS2 is ICRISAT data 2001-2004. Mean village migration interacts the average village level of temporary migration with individual income.

Table 3: GOODNESS OF FIT OF MODEL TO DATA

	(1) Data b	(2) Model b
Moments targeted during estimation		
Mean of non-migrant income	5.837	5.946
Std dev non-migrant income	4.261	3.710
Mean of non-migrant income: own land	6.525	6.538
Mean of migrant income	5.802	5.589
Std dev migrant income	3.736	3.730
Mean migration rate	0.197	0.170
Mean migration rate: male hh	0.306	0.243
Correlation of consumption and income	0.223	0.207
Mean non-migrant consumption	5.962	5.944
Mean migrant consumption	5.289	5.421
Percent nonmigrants receiving transfer	0.548	0.559
Percent migrants receiving transfer	0.427	0.603
Moments not targeted during estimation		
Percent migrating this year if migrated last year	0.654	0.495

Notes: Table reports how well the model matches the data by moment. All monetary values are 000's of rupees per adult equivalent in household.

Table 4: EFFECT OF MIGRATION ON VILLAGE INCOME AND INCOME OF MIGRANTS

	(1) Data b	(2) Model b
Income of Migrants		
Observed mean income	5.802	5.589
Mean income if stayed in village		2.724
Share of migrants with income gain		0.723
Village Income		
Observed mean income of non-migrants	5.837	5.946
Mean of untruncated village income distribution		5.399

Notes: Model column calculated using structural estimates. All monetary values are 000's of rupees per adult equivalent in household. Migration is endogenous: the agents with the lowest income realizations migrate. This causes the income distribution in the village to be left-truncated.

Table 5: EFFECT ON RISK SHARING OF INTRODUCING MIGRATION

	Whole sample		Only non-migrants	
	(1)	(2)	(3)	(4)
Risk sharing: corr(y, c)	No migration mean	With migration mean	No migration mean	With migration mean
Overall	0.141	0.199	0.128	0.186
Landless, few males	0.184	0.219	0.173	0.218
Landed, few males	0.103	0.140	0.100	0.135
Landless, many males	0.184	0.255	0.160	0.226
Landed, many males	0.103	0.194	0.105	0.188

Notes: Table compares risk sharing in an economy with migration to the same economy without migration. The risk sharing measure is the correlation between consumption and income. Columns 1 and 2 compute the statistic for the whole sample. Columns 3 and 4 compute the statistic only for households who don't migrate when they have the option: this keeps income constant. Risk sharing is crowded out by the increase in households' outside option with migration.

Table 6: EFFECT ON WELFARE OF INTRODUCING MIGRATION

	(1)	(2)	(3)	(4)	(5)
Mean welfare	No migration mean	Migration mean	Welfare gain mean	Cons eq. gain mean	*Migration rate* mean
Overall	2.170	2.279	1.044	0.155	0.166
Landless, few males	2.050	2.191	1.057	0.173	0.140
Landed, few males	2.290	2.345	1.019	0.073	0.041
Landless, many males	2.050	2.223	1.076	0.265	0.323
Landed, many males	2.290	2.358	1.025	0.110	0.160

Notes: Table shows mean welfare for whole sample and by subgroup. Column 1 computes welfare with no migration. Column 2 computes welfare with migration. Column 3 is welfare gain (Col 2/Col 1). Column 4 computes the consumption equivalent welfare gain (computed as per Lucas(1987)). Column 5 is mean migration rate.

Table 7: EFFECT OF ALLOWING MIGRATION UNDER DIFFERENT RISK SHARING REGIMES

	(1) Endogenous incomplete mean	(2) No risk sharing mean	(3) Exogenous incomplete mean
Migration rate			
Overall	0.166	0.350	0.558
Landless, few males	0.140	0.359	0.639
Landed, few males	0.041	0.240	0.358
Landless, many males	0.323	0.479	0.756
Landed, many males	0.160	0.320	0.479
Welfare gain relative to no migration			
Overall	1.044	1.067	1.112
Landless, few males	1.057	1.090	1.147
Landed, few males	1.019	1.032	1.052
Landless, many males	1.076	1.096	1.178
Landed, many males	1.025	1.050	1.072
Consumption equivalent gain relative to no migration			
Overall	0.155	0.203	0.225
Landless, few males	0.173	0.223	0.283
Landed, few males	0.073	0.110	0.119
Landless, many males	0.265	0.281	0.335
Landed, many males	0.110	0.196	0.162

Notes: Table shows change in welfare with migration compared to no migration for whole sample and by subgroup. Endogenous incomplete markets is the limited commitment model. No risk sharing is autarky. Exogenous incomplete markets considers a Hugget (1993) economy where agents can buy and sell a risk-free asset.

Appendix Table 1: EFFECT OF EDUCATION ON MIGRATION AND WAGE RATE

	Probability of migrating		Wage rate if migrate	
	(1)	(2)	(3)	(4)
Dep. variable: Migration/Wage	b/se	b/se	b/se	b/se
Years Education	0.004***	0.007**	45.672***	28.451*
	(0.001)	(0.002)	(13.121)	(16.459)
Village-Year FE	No	Yes	No	Yes
Mean dep. variable	0.110	0.110	205.835	205.835
R-squared	0.005	0.076	0.041	0.353
Number observations	2563	2563	284	284

Notes: OLS regressions of probability of ever migrating on education and wage rate if migrate on education. Standard errors clustered at village level for column 2 and village-year level for column 4.

Appendix Table 2: STRUCTURAL POINT ESTIMATES

	All	Village				
	b	b	b	b	b	b
Parameters at village level: estimated						
Mean of village shock process		1.487	1.084	1.260	1.260	1.207
Std. dev of village shock process		0.634	0.577	0.762	0.768	0.687
Utility cost of migrating		0.073	0.026	0.085	0.148	0.169
Mean of migration income process		1.852	1.328	2.099	1.888	1.475
Std. dev of migration income process		0.887	1.199	0.787	0.804	1.223
Coefficient of relative risk aversion		1.900	1.937	2.228	2.228	1.271
Discount factor		0.600	0.581	0.457	0.411	0.702
Scaling utility cost for male		-0.945	-0.827	-0.443	-0.599	-0.036
Scaling mean for land		0.553	0.442	0.232	0.232	0.315
Parameters constant across villages: set exogenously						
Scaling factor good aggregate shock	0.200					
Share of household income from migration	0.600					

Notes: Table gives point estimates from structural estimation by simulated method of moments. The share of household income from migration is the budget share from migration (viz. village income) for households when they migrate. This is set exogenously to match the statistic in the data.