

The Poor Get Poorer:
General Equilibrium Effects of Labor Supply
as a Smoothing Mechanism

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October 5, 2003

JOB MARKET PAPER

Preliminary version

Abstract

In an agrarian economy in which individuals vary in landownership, the poorer workers are and the less easily they can borrow, save, or migrate in response to productivity shocks, the more inelastically they supply labor. Underdeveloped and isolated areas therefore experience more wage volatility. This makes the poor worse off. But for landowners, inelastic labor supply is a form of insurance. One ramification is that a village-wide reduction in the cost of borrowing and saving can make a landowner worse off. For a given level of income volatility, he can smooth consumption better; but general equilibrium effects increase the volatility of his income. Data on the agricultural wage in 271 districts in India for 1956-87 are consistent with the model. In districts with a more developed banking sector or more integration with other areas (e.g., higher road density), the agricultural wage is less influenced by weather shocks, controlling for factors such as geography, irrigation, and sectoral composition. Landlessness among agricultural workers also decreases volatility. This may be because the landless are especially likely to migrate in response to negative shocks. In sum, productivity risk is one of the roots of underdevelopment; poverty and isolation exacerbate this very risk.

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1 Introduction

Several papers suggest that labor supply is inelastic, perhaps even backward-bending, in poor countries.¹ This paper models the general equilibrium effects of inelastic labor supply on wage volatility and income distribution, and tests the model using data on 271 districts in India from 1956 to 1987.

I present a model of an agrarian economy in which individuals vary in the amount of land they own and each decides how much labor to supply. The model demonstrates how wage volatility—the responsiveness of the equilibrium wage to shocks to total factor productivity—varies with workers’ ability to smooth consumption, and how this differentially affects the welfare of wealthier versus poorer individuals (that is, those who own more or less land). Consider an economy in which individuals are able to save or borrow and can therefore consume smoothly even in the face of volatile income. When agricultural labor productivity is low—for example when bad weather has lowered the crop yield, reducing the demand for labor at harvest time—individuals will supply less labor, drawing upon savings or borrowing to fund their consumption. In contrast, in an economy with limited financial services, workers will cut back their labor supply by less or might in fact increase it in order to meet their consumption needs. For a given negative shock to labor demand, equilibrium labor productivity and the wage are lower in the second economy. For a worker, the consequence is that he is exposed to more wage volatility if he participates in the second labor market, the one with a less developed banking sector. Even if a particular individual cannot smooth consumption, he would be better off if his neighbors could.

Another way to describe this phenomenon is in terms of the substitution effect, which operates in the direction of increasing the labor supply elasticity (substitute away from labor when labor is less valuable), and the income effect, which acts to decrease the elasticity (increase labor supply when income has fallen). The more pronounced the income effect or less pronounced the substitution effect, the less that individuals’ behavioral response cushions the aggregate impact of a shock. In the example above, the inability to smooth consumption by saving or borrowing leads to a stronger income effect. Poverty also makes the income effect more pronounced. Being able to consume more and, hence, having more income are very valuable to someone near subsistence. Another factor that affects wage volatility is whether workers are able to shift their labor elsewhere, that is to substitute toward other labor markets. Productivity shocks are typically local to an area, so workers who can migrate more easily will supply labor more elastically in the home market.

General equilibrium effects act as a multiplier on the wage volatility that results from produc-

¹Rosenzweig (1980) estimates a labor supply elasticity of -0.16 for landless males in rural India, and a larger but also negative elasticity for landowners. Lamb (1996) also finds a negative elasticity in rural India. Frankenberg, Smith, and Thomas (2003) find that labor supply increased when the wage fell during the financial crisis in Indonesia.

tivity shocks, and the effects act in a particular way: underdeveloped areas, for example those with limited financial services or transportation links, are exposed to more volatility. Thus, institutions that enable an individual to mitigate risk have a broader aggregate benefit.

General equilibrium effects also have distributional implications. For landowners who employ labor, inelastic labor supply serves as a form of insurance. A negative shock to agricultural productivity reduces the income earned from land, but the more inelastic the labor supply, the lower the wage a landowner must pay in lean times, and the less profits are hurt by the shock. As the model helps characterize, measures that enable individuals to better respond to risk—such as a reduction in the cost of financial transactions—may in fact make landowners worse off. This occurs because wage volatility declines and a landowner’s profit function is convex in the wage.

After presenting the model, I test its predictions using data on the agricultural wage in 271 districts in India from 1956 to 1987. I examine how the wage responds differently to labor demand shocks depending on the availability of smoothing mechanisms which make labor supply more elastic. In this setting, the general equilibrium effects are sizeable. I find, first, that wage volatility is less pronounced if an area has better opportunities for smoothing consumption intertemporally, for example if the banking sector is more developed. Second, openness to other areas (as measured by road density) leads to large reductions in wage volatility. Individuals are able to substitute toward other labor markets instead of “selling low” in the home market. Third, and perhaps most surprisingly, landlessness among agricultural workers decreases volatility. One explanation is that the landless may be able to migrate in response to negative shocks more easily than landowners who are tied to their land.

This paper is related to an extensive literature that examines income risk in rural developing countries. A main focus of the literature is informal village insurance, or the extent to which a community pools idiosyncratic risk. In an influential study of villages in India, Townsend (1994) finds that individuals within a village are to a large degree insured against idiosyncratic income shocks.² I emphasize locally aggregate risk rather than idiosyncratic risk. When an area suffers a drought, some may suffer more than others because of particularities of their plots, but by and large, all suffer in lock step. Village insurance cannot address the component of risk that is common across villagers. A conclusion in the informal insurance literature is that close-knit or closed environments may be advantageous: self-enforcing contracts are more sustainable when the costs of autarky are high and information problems are less severe. Townsend (1995) finds very limited informal insurance in one of the Thai villages he studies and speculates that its location by a major highway may have caused the village support system to deteriorate.³ Rodrik (1998),

²Others find less complete sharing of idiosyncratic risk using the same or different data (Ravallion and Chaudhuri 1997, Deaton 1997, Morduch 2001).

³Attanasio and Rios-Rull (2000) demonstrate theoretically that insurance against aggregate shocks can reduce

focusing on a very different aspect of openness (open economies that specialize face terms-of-trade risk that may be sizeable and uninsurable), reaches the same conclusion that openness may expose individuals to greater risk.

I sound a different theme. Integration with other markets can improve the welfare of the poor. If risk is common to an area but diversified across areas, then openness provides opportunities to smooth risk. Labor force mobility dampens the effects of shocks as workers in low-productivity areas migrate to higher-productivity areas. Similarly, if financial markets are insular and everyone borrows or saves in response to the same shock, the pecuniary effect on interest rates undermines their efforts to offset the shock. An integrated financial sector dilutes this effect.

Section 2 sets up a model of an agrarian economy subject to productivity shocks, and section 3 presents the theoretical results. Section 4 describes the empirical strategy and data used to test the predictions of the model. The empirical results are presented in section 5. Section 6 concludes.

2 A Model of Agrarian Labor Supply and Productivity Shocks

I model a rural agricultural economy subject to exogenous productivity shocks. Villagers choose their labor supply, landowning villagers choose their labor demand, and the labor market clears. The purpose of the model is to characterize general equilibrium effects in a labor market in which workers are reliant on their labor income. I examine how the poverty level, cost of financial transactions, and cost of migrating to other labor markets affect wage volatility. I find that the land distribution also has general equilibrium effects.

Wage volatility has important distributional properties. As shown below, volatile wages hurt the landless but may benefit landowners. One implication is that an intervention such as reducing banking fees, which benefits everyone in partial equilibrium, has very different welfare implications for the rich and the poor once general equilibrium effects are considered.

2.1 Basic Assumptions

The economy (village) has a continuum of agents indexed by i whose mass is normalized to 1. All agents live for two periods ($t = 1, 2$). Each agent is endowed with landholding k_i . This is the only exogenous difference among agents, and there is no market for land. All agents have the same endowment of time \bar{h} which they allocate between labor and leisure.

Production

In period 1, output follows a Cobb-Douglas production function in labor and land.

welfare if a reduction in the costs of autarky leads to the collapse of informal insurance against idiosyncratic shocks.

$$f(d_i, k_i) = \tilde{A} d_i^\beta k_i^{1-\beta}$$

where $\beta \in (0, 1)$ and d_i is the labor input (demand) used by individual i . Total factor productivity $\tilde{A} = A(1 + \tilde{\sigma})$ is subject to a stochastic shock with the following distribution:

$$\tilde{\sigma} = \begin{cases} +\sigma & \text{with probability } \frac{1}{2} \\ -\sigma & \text{with probability } \frac{1}{2} \end{cases}$$

In period 2, production income is exogenous. An individual earns y_{i2} which is a function of his landholding.⁴

Utility function

Individuals have identical Stone-Geary preferences over consumption and leisure

$$u(c_{it}, l_{it}) = \log(c_{it} - \underline{c}) + \frac{1-\alpha}{\alpha} \log l_{it}$$

where $\alpha \in (0, 1)$. The consumption good is nonstorable and different from the production good, and its price is normalized to 1. Individuals must consume at least the subsistence level $\underline{c} \geq 0$. (The additional condition $\underline{c} \leq \beta A(1 - \sigma) \bar{h}^\beta K^{1-\beta}$ ensures that subsistence consumption is always attainable.) Note that setting $\underline{c} = 0$ gives Cobb-Douglas preferences.

Utility is additive and separable across periods with a subjective discount factor b .

Migration

An individual can choose to migrate in period 1 to another labor market that pays a fixed wage W . Individuals have independent migration costs drawn from $\tilde{\Delta}_i \sim U[\Delta_{min}, \Delta_{min} + \psi]$. For comparative statics, $\psi > 0$ will parameterize the overall *level of migration costs*. For simplicity I assume that Δ_{min} is sufficiently large given W that migration is never optimal when there is a good shock. I state the precise condition in the mathematical appendix.

Borrowing and saving

An individual may borrow or save at an exogenous gross interest rate $R > 0$; the village is a small open economy with respect to the financial market. Agents must have non-negative assets at the end of period 2. Financial transactions are costly. The effective interest rate for savings is $R - \phi$ and the effective interest rate for borrowing is $R + \phi$. I refer to $\phi \in [0, \infty)$, which may depend on landholding, as the *banking cost*.

⁴In the appendix I will be more specific about the value of y_{i2} , restricting it to a range such that if there is a good shock in period 1, individuals want to save in order to optimize the relative marginal utility of consumption across periods, and conversely individuals want to borrow if there is a bad shock.

Land distribution

I assume that the village has total land K and that there are two types of individuals, the landless and the landowners. A proportion θ of the village is landless or has $k_i = 0$, and the remaining villagers have equally sized plots of land. That is, a proportion $1 - \theta$ of the villagers have $k_i = \frac{K}{1-\theta}$.

Labor market clearing

The labor market clears at the endogenous wage w . At this wage $\int_i d_i = \int_i (\bar{h} - l_i)$.

Rational expectations

Agents make their choices after observing the shock $\tilde{\sigma}$, and they have rational expectations about other agents' choices. Therefore an agent's choices are optimal at the equilibrium wage.

2.2 Individual maximization problem

Gathering all of the assumptions gives the following maximization problem:

$$\begin{aligned} \max_{\substack{c_{i1} \geq \underline{c}, c_{i2} \geq \underline{c} \\ \bar{h} \geq l_i \geq 0, d_i \geq 0 \\ Migrate_i \in \{0,1\}}} \log(c_{i1} - \underline{c}) + \frac{1-\alpha}{\alpha} \log l_i + b \log(c_{i2} - \underline{c}) \quad (2.1) \\ \text{subject to} \end{aligned}$$

$$c_{i2} \leq \left(R + (-1)^{\mathbb{1}(c_{i2} < y_{i2})} \phi \right) \left(\tilde{A} d_i^\beta k_i^{1-\beta} - d_i w + w(\bar{h} - l_i) + ((W - w)(\bar{h} - l_i) - \tilde{\Delta}_i) Migrate_i - c_{i1} \right) + y_{i2}$$

An individual has four choice variables in period 1: his leisure l_i , the quantity of labor d_i to use on his land, consumption c_{i1} (where the subscript 1 denotes period 1), and whether to stay in the village or migrate ($Migrate_i \in \{0, 1\}$).⁵ The only choice for period 2 is consumption c_{i2} .

The agent maximizes the sum of period-1 utility and period-2 utility discounted by b . Utility in period 1 depends on how much is consumed beyond subsistence and on leisure. Since leisure is not a choice in period 2, it enters the maximand as a constant which I set to 0. Thus period-2 utility depends only on consumption net of \underline{c} .

The intertemporal budget constraint requires that c_{i2} not exceed the amount transferred from period 1, which may be positive or negative and includes interest payments, plus y_{i2} . The interest rate is $R - \phi$ if the individual transfers a positive amount from period 1 to period 2, i.e. saves, and $R + \phi$ if he borrows. (The symbol $\mathbb{1}$ is an indicator function.)

One source of period-1 income are land profits which equal output minus the wage bill. The second source is labor income. When the agent stays in the village, he earns the wage w , and when he migrates he earns W but must pay the migration cost $\tilde{\Delta}_i$.

⁵I omit time subscripts when a variable is only applicable in period 1.

2.3 Labor demand

The labor demand decision is separable from other choices that an individual makes. A landowner chooses his labor demand by equating the marginal product of labor and the wage,

$$\frac{\partial f}{\partial d_i} = \beta \tilde{A} \left(\frac{k_i}{d_i} \right)^{1-\beta} = w, \quad \text{or} \quad d_i^* = k_i \left(\frac{\beta \tilde{A}}{w} \right)^{\frac{1}{1-\beta}}.$$

Land profits are thus

$$\pi_i = \tilde{A} d_i^{*\beta} k_i^{1-\beta} - d_i^* w = \tilde{A} (1-\beta) k_i \left(\frac{\tilde{A} \beta}{w} \right)^{\frac{\beta}{1-\beta}}.$$

Since there are constant returns to scale, labor demand decisions are linear in landownership, implying that the total amount of land in the village affects aggregate labor demand, but how it is distributed does not.

3 Theoretical Results

In this section I solve the model to derive the relationships between wage volatility and exogenous factors, namely poverty, the ability to migrate, and the ability to save and borrow. I also consider both how the wealth distribution affects wage volatility, and the distributional implications of changes in wage volatility.

I examine the effects of poverty, migration, and intertemporal smoothing separately. That is, I solve simplified versions of model, isolating the effects of one factor at a time. For example, section 3.3 focuses on migration with the subsistence level $\underline{c} = 0$ and the banking cost $\phi \rightarrow \infty$. This facilitates derivations of the results. While I do not believe that the main intuitions are sensitive to this simplification, I have not proved this. In section 3.5 I return to this issue and discuss possible interaction effects among parameters of the model.

Note that all proofs are in the mathematical appendix.

3.1 Effects of Poverty

A defining characteristic of developing countries is that productivity relative to the subsistence level is lower than in developed countries. In the model, the subsistence level can be regarded as a measure of poverty, holding constant productivity among other parameters. Poverty will affect wage volatility because when workers are closer to subsistence, they supply labor more inelastically.

For simplicity in this section I rule out migration ($\Delta_{min} \rightarrow \infty$) and transfers of assets between periods ($\phi \rightarrow \infty$), and focus on period 1. The individual maximization problem specified in (2.1) reduces to

$$\begin{aligned} & \max_{c_i \geq \underline{c}, \bar{h} \geq l_i \geq 0} \log(c_i - \underline{c}) + \frac{1 - \alpha}{\alpha} \log l_i \\ & \text{subject to } c_i \leq \pi_i + w(\bar{h} - l_i) \end{aligned}$$

The solution to this problem is that an agent consumes \underline{c} and then spends a fraction α of his remaining wealth on consumption and the rest on leisure.⁶

$$\begin{aligned} c_i^* &= \alpha(w\bar{h} + \pi_i - \underline{c}) \\ l_i^* &= (1 - \alpha) \left(\frac{w\bar{h} + (\pi_i - \underline{c})}{w} \right) \end{aligned}$$

which gives the following expression for labor supply,

$$h_i^* = \bar{h} - l_i^* = \alpha\bar{h} + \frac{\underline{c} - \pi_i}{w} = \alpha\bar{h} + \underline{c}w^{-1} - \tilde{A}(1 - \beta)(\tilde{A}\beta)^{\frac{\beta}{1-\beta}} w^{\frac{\beta}{1-\beta}} k_i.$$

Remark. *Individual labor supply is declining in landownership.*

Leisure is a normal good, so wealthier individuals—those with more land—supply less labor, as seen from the last term of the expression for h_i . Two other features of labor supply are worth noting. First, since profits are linear in landownership, given the utility function, labor supply is as well. Thus, aggregate labor supply is independent of the land distribution (absent migration). Second, $\frac{\partial h_i}{\partial w} < 0$ if $\underline{c} > \pi_i$. The landless, for whom $\pi_i = 0$, have a negative labor supply elasticity for $\underline{c} > 0$ and an elasticity of 0 if $\underline{c} = 0$.

Setting aggregate labor supply equal to aggregate labor demand determines the equilibrium wage. I now define wage volatility.

Definition. *Wage volatility is the coefficient of variation of the wage, or the standard deviation of the wage divided by the average wage:*

$$\nu \equiv \frac{\sqrt{E_\sigma(w - (E_\sigma w))^2}}{E_\sigma w}$$

where E_σ is the expectation operator over the stochastic productivity shock.

Note that to first order, wage volatility is proportional to the elasticity of the wage with respect to productivity. To see this, let w^+ indicate the wage in the state $\tilde{\sigma} = \sigma$, w^- indicate the wage

⁶I assume that all agents are at an interior solution and have positive labor supply. If landowners supply no labor, then changes in the land distribution could affect the level and volatility of the wage.

when $\tilde{\sigma} = -\sigma$, and \bar{w} indicate the wage in the hypothetical case that $\tilde{\sigma} = 0$.

$$\begin{aligned}
\nu &= \frac{\sqrt{\frac{1}{2}(w^+ - \frac{1}{2}(w^+ + w^-))^2 + \frac{1}{2}(w^- - \frac{1}{2}(w^+ + w^-))^2}}{\frac{1}{2}(w^+ + w^-)} \\
&= \frac{1}{\sqrt{2}} \left(\frac{w^+ - w^-}{w^+ + w^-} \right) \\
&\approx \frac{\bar{w} + A\sigma \frac{\partial w}{\partial A} \Big|_A - \left(\bar{w} - A\sigma \frac{\partial w}{\partial A} \Big|_A \right)}{2\sqrt{2}\bar{w}} \\
&= \frac{\sigma}{\sqrt{2}} \left(\frac{\partial w}{\partial \tilde{A}} \frac{A}{w} \right) \Big|_A
\end{aligned}$$

Using this definition of wage volatility, the first result I present is on its relationship with poverty.

Proposition 1. *For sufficiently small σ , $\frac{\partial \nu}{\partial \underline{c}} > 0$, or wage volatility is increasing in \underline{c} .*

I conjecture that this result holds for all σ , but prove the restricted result which uses a linear approximation of wage volatility. According to the result, when the subsistence consumption level is larger, holding constant average productivity A among other parameters, the wage is more volatile. This is because labor supply is more inelastic when consumption is closer to \underline{c} . The implication is that general equilibrium effects are especially likely to amplify shocks in developing countries and, within developing countries, in the poorest areas.

3.2 Autarkic equilibrium and preferences for wage volatility

For the remainder of the paper I set $\underline{c} = 0$. A useful next step is to solve for the market-clearing wage in autarky ($\Delta_{min} \rightarrow \infty, \psi \rightarrow \infty$), both to provide a benchmark wage and to establish the basic distributional properties of wage volatility. In this case the wage can be solved for explicitly: $w = \beta^\beta \left(\frac{1}{\alpha} - (1 - \beta) \right)^{1-\beta} \tilde{A} \left(\frac{K}{h} \right)^{1-\beta}$. Averaging this expression over good and bad shocks, I define the expected autarkic wage as

$$w_{aut} \equiv \beta^\beta \left(\frac{1}{\alpha} - (1 - \beta) \right)^{1-\beta} A \left(\frac{K}{h} \right)^{1-\beta}.$$

This expression is also the sensitivity of the wage to the stochastic shock, $\frac{\partial w}{\partial \sigma}$, in autarky.

An important facet of wage volatility is that it affects landless and landowning individuals differently. Wage volatility therefore will have welfare implications in social welfare functions that depend on distribution. In addition, if a policy affects wage volatility, rich and poor people will have different preferences toward it. For example, it is possible that landowners would oppose a reduction in the cost of financial transactions, as will be seen below in Propositions 8 and 9. Here I establish the result in a more general form.

Proposition 2. *Let V denote indirect utility. $\exists k^*$ such that $\frac{\partial^2 V}{\partial w^2} < 0$ for $k_i < k^*$, and $\frac{\partial^2 V}{\partial w^2} \geq 0$ for $k_i \geq k^*$.*

The landless are averse to wage volatility, while sufficiently large landowners prefer volatile wages. The starting point in understanding this result is that with risk aversion, individuals are averse to income fluctuations. For the landless, income is proportional to the wage, and therefore indirect utility is concave in the wage. Landowners have a different preference since they also earn income from their land for which the wage is an input price. The fact that wage volatility may benefit landowners follows from the more general result that profit functions are convex in input prices. Aversion to volatility is declining in landholding, and a landowner with a sufficiently large landholding prefers wage volatility.

In autarky with the assumed land distribution and utility function, the landowners in the model in fact do prefer volatile wages. (That is, $\frac{K}{1-\theta} > k^*$, where the statement of the proposition defines k^* . This is shown formally alongside the proof to Proposition 2 in the appendix.) Each landowner owns a larger portion of the economy's land than labor, and given the utility and production functions, this means that on net his utility is convex in the wage. In section 3.4 I will extend this result to show that because of a landowner's preference for volatile wages, an increase in the exogenous banking cost ϕ could make him worse off.

3.3 Effects of Migration

In this section I examine how migration costs and the distribution of land affect wage volatility. I rule out transfers of assets between periods ($\phi \rightarrow \infty$) and focus on period 1. I solve the model for the realization $\tilde{\sigma}_1 = -\sigma$ when migration occurs.⁷ In this case, the maximization problem becomes

$$\begin{aligned} & \max_{\substack{c_i \geq 0, \bar{h} \geq l_i \geq 0 \\ Migrate_i \in \{0,1\}}} \log c_i + \frac{1-\alpha}{\alpha} \log l_i \\ \text{subject to } & c_i \leq \pi_i + w(\bar{h} - l_i) + ((W - w)(\bar{h} - l_i) - \tilde{\Delta}_i) Migrate_i \end{aligned}$$

Given the individual's decision about whether to migrate and how much labor to use on his land, he will spend a fraction α of wealth (net of any migration costs) on consumption, and the remainder on leisure.

$$\begin{aligned} c_i^* &= \alpha(w_i \bar{h} + \pi_i - \Delta_i) = \alpha(w_i \bar{h} + \tilde{A}(1-\beta)k \left(\frac{\tilde{A}\beta}{w}\right)^{\frac{\beta}{1-\beta}} - \Delta_i) \\ l_i^* &= \frac{(1-\alpha)(w_i \bar{h} + \pi_i - \Delta_i)}{w_i} = \frac{(1-\alpha)(w_i \bar{h} + \tilde{A}(1-\beta)k_i \left(\frac{\tilde{A}\beta}{w}\right)^{\frac{\beta}{1-\beta}} - \Delta_i)}{w_i} \end{aligned}$$

⁷I model out-migration only. It is possible to extend the model to two symmetric economies with uncorrelated productivity shocks and to allow for both out- and in-migration. Then when one village has a better shock than the other, in-migration will increase labor supply, reduce the wage, and also act to dampen wage volatility.

where

$$w_i = \begin{cases} w & \text{if } Migrate_i = 0 \\ W & \text{if } Migrate_i = 1 \end{cases} \quad \text{and} \quad \Delta_i = \begin{cases} 0 & \text{if } Migrate_i = 0 \\ \tilde{\Delta}_i & \text{if } Migrate_i = 1 \end{cases}$$

The decision about whether to migrate depends on the cost $\tilde{\Delta}_i$. Define Δ_r as the maximum migration cost such that migrating is individually optimal for a landowner (r denotes ‘rich’), and Δ_p as the maximum migration cost such that migrating is optimal for a landless individual (p denotes ‘poor’), given the equilibrium wage.

Proposition 3. $\Delta_p > \Delta_r$, *or the landless have a higher propensity to move than landowners.*

The intuition for this result is straightforward. A landowner, in virtue of having greater total wealth, supplies less labor than a landless person. Thus he benefits less from the higher price for his labor that is available if he migrates. (No one would migrate if the outside wage W were less than w .) Moreover, his total income is less sensitive to the wage he earns since his land income is independent of it.

Proposition 4. $\frac{\partial \nu}{\partial \psi} > 0$, *or a reduction in the level of migration costs reduces wage volatility.*

In equilibrium a proportion $\frac{\Delta_r - \Delta_{min}}{\psi}$ of landowners migrate and a proportion $\frac{\Delta_p - \Delta_{min}}{\psi}$ of the landless migrate. When migration costs are lower, more individuals migrate and labor supply in the economy is lower. Therefore the wage is higher, and a higher wage in the event of $\tilde{\sigma}_1 = -\sigma$ is equivalent to a reduction in wage volatility (see Lemma 1 in the appendix).

Proposition 5. $\frac{\partial \nu}{\partial \theta} < 0$, *or wage volatility is decreasing in the proportion of individuals who are landless.*

When there are more landless individuals, more workers migrate out in the event of a bad shock. This is offset in part by the fact that each landowner is wealthier and less likely to migrate, but the first effect dominates and on net wage volatility increases. This result relies on assumptions about the utility function. Because landholding enters linearly in the labor supply choice, the land distribution affects aggregate labor supply only through its effect on migration. With more general utility functions, the land distribution could have a direct effect on labor supply. This result should be interpreted less as a statement about the overall effect that the land distribution has on wage volatility, and more as an illustration that there are channels such as migration through which increases in the proportion of workers who are landless could decrease wage volatility.

Using from Proposition 2 the fact that wage volatility makes the landless worse off, it follows that a decrease in θ has a negative pecuniary effect on individuals who remain landless.

Corollary 6. *Partial land redistribution ($\theta \rightarrow \hat{\theta}$ where $\theta > \hat{\theta} > 0$) reduces the expected utility of individuals who remain landless.*

3.4 Effects of Borrowing and Saving

I next examine how the ability to smooth consumption intertemporally affects wage volatility. As the banking cost varies, individuals change the amount of income they shift between periods 1 and 2. Given the assumed level of y_{i2} (as specified in the appendix), individuals save in period 1 if there is a good shock and borrow if there is a bad shock.

In this section I rule out migration ($\Delta_{min} \rightarrow \infty$). An individual solves the following maximization problem:

$$\begin{aligned} \max_{c_{i1} \geq 0, \bar{h} \geq l_i \geq 0} \quad & \log c_{i1} + \frac{1-\alpha}{\alpha} \log l_i + b \log c_{i2} \\ \text{subject to} \quad & c_{i2} \leq y_{i2} + \left(R + (-1)^{\mathbb{1}(c_{i2} < y_{i2})} \phi \right) (\pi_{i1} + wh_i - c_{i1}) \end{aligned} \quad (3.1)$$

where b is the subjective discount rate, R is the exogenous interest rate, and ϕ is the banking fee. $\mathbb{1}$ is an indicator function and is used to express the fact that the banking fee reduces the interest rate if an individual is saving and increases the interest rate if an individual is borrowing.

Proposition 7. *$\frac{\partial v}{\partial \phi} > 0$, or an increase in banking costs increases wage volatility.*

When there is a good shock, a worker has a greater incentive to supply labor if he can more easily shift income to period 2 when the marginal utility of consumption is lower. Conversely, when shifting income becomes more difficult, labor supply during high-productivity times declines. This more inelastic labor supply makes the wage more volatile. Similarly, when there is a negative shock, if individuals cannot borrow as easily against their period 2 income, they are compelled to work more in period 1, driving down the wage and exacerbating wage volatility.

Proposition 8. *Suppose $\phi = \phi_r$ if $k_i > 0$ and $\phi = \phi_p > 0$ if $k_i = 0$. Denote expected indirect utility as EV . For k_i sufficiently large, $\frac{\partial EV}{\partial \phi_p} < 0$.*

This result considers the welfare implications for a large landowner if landless workers' ability to borrow and save changes. When workers are better able to smooth consumption intertemporally, wage volatility declines. This makes a sufficiently large landowner worse off. This result follows from Proposition 2 and Proposition 7.

Proposition 9. *Suppose all agents face the banking cost ϕ . For $k_i = 0$, $\frac{\partial EV}{\partial \phi} > 0$. For k_i sufficiently large, \exists parameter values such that $\frac{\partial EV}{\partial \phi} < 0$.*

A reduction in the *village-wide* cost of borrowing and saving also can make a landowner worse off. This is arguably the most surprising result presented. It is a stronger result than Proposition 8

since here a landowner’s own cost of borrowing and saving is lowered. In partial equilibrium lower banking fees in the village are Pareto-improving: Every agent benefits from being able to smooth consumption better. However, the general equilibrium effect—lower wage volatility—further helps the landless, but hurts landowners. If the general equilibrium effect is strong enough, on net a landowner is worse off with a lower banking cost.

3.5 Generalizability of the results

This section has shown that poverty, costly migration, and costly financial transactions each amplify the wage volatility caused by productivity shocks. The results were derived “turning on” one factor at a time in the model. Here I speculate on how the solution to the full model might differ.

The subsistence consumption level in essence accentuates the income effect, particularly for poorer individuals. With $\underline{c} > 0$, there is a greater incentive to migrate and borrow in response to a negative shock. One likely implication is that landowners would be more opposed to a reduction in the cost of banking (Proposition 9) since workers’ lack of credit delivers an even larger pecuniary benefit to landowners when $\underline{c} > 0$. Landless workers increase labor supply in bad times if they lack credit, precisely the behavior that functions as insurance for a landowner.

If migration and borrowing were considered together, as modelled they would be substitute means by which an individual could smooth consumption. An increase in the cost of migration would be less harmful to workers if they were better able to borrow. Migration also has the effect of lowering aggregate labor supply in the event of bad shocks, which reduces the income of wage-paying landowners. For landowners, being able to borrow to smooth consumption would increase in value. On the other hand, *workers’* ability to borrow would further reduce labor supply from its already-reduced level, and the wage would increase even more. I conjecture that the first effect would dominate in most instances, and the rich would be more aligned with the poor in preferring lower banking costs.

The model implicitly assumes that migrants simultaneously receive their labor income and pay the migration cost. Interestingly, migration and banking might be complements if this assumption were changed and the migration cost was incurred at the start of period 1. Then workers who could borrow to pay the migration cost would be best able to respond to shocks.

I now turn to testing the model’s predictions about the determinants of wage volatility.

4 Empirical Strategy and Data

4.1 Empirical Strategy

The theory suggests that the availability of smoothing mechanisms increases the aggregate labor supply elasticity and therefore decreases the sensitivity of the wage to labor demand shocks. I examine this prediction empirically by making comparisons across labor markets. The unit of observation, or a distinct labor market, is a geographic area (district) in a given year. The agricultural wage is the market equilibrium outcome in the following model:

$$w_{jt} = \beta_1(H_{jt} - \bar{H}_j) + \beta_2 S_{jt} + \beta_3 S_{jt} * (H_{jt} - \bar{H}_j) + \beta_4 X_{jt} + \beta_5 X_{jt} * (H_{jt} - \bar{H}_j) + \delta_t + \alpha_j + \varepsilon_{jt}$$

w_{jt} is the log of the wage for district j in year t . H_{jt} is the log of labor demand and \bar{H}_j is its average over all t ; $H_{jt} - \bar{H}_j$, the deviation from the average labor demand in the district, is the labor demand shock. As explained below, S_{jt} are characteristics that affect the aggregate labor supply elasticity. X_{jt} are control variables, δ_t and α_j are year and district fixed effects, and ε_{jt} is the disturbance term.

In practice I use measures of good weather (rainfall in excess of the district's normal rainfall) as a proxy for the labor demand shock since good weather typically raises agricultural labor productivity. Thus I estimate

$$\begin{aligned} w_{jt} = & \beta_1 RainShock_{jt} + \beta_2 S_{jt} + \beta_3 S_{jt} * RainShock_{jt} + \beta_4 X_{jt} + \beta_5 X_{jt} * RainShock_{jt} \\ & + \delta_t + \alpha_j + \varepsilon_{jt} \end{aligned} \tag{4.1}$$

The starting premise is that the agricultural wage is positively correlated with the proxy, or $\beta_1 > 0$, which is verified in the empirical results.

Workers in some labor markets are better able to smooth consumption or income in the face of labor demand shocks, for example by adjusting how much they save or dissave and whether they migrate to work in another area. The availability of these smoothing mechanisms, measured by S_{jt} , should increase the aggregate labor supply elasticity and therefore mitigate the effect that labor demand shocks have on the wage. For example, when there is a bad shock, if workers have savings that they can draw from, this reduces their labor supply and the wage will fall by less. Similarly, the wage will increase less in response to good shocks if there are better opportunities to save because workers will have a greater incentive to take advantage of the temporarily high labor productivity and supply more labor. Thus, the theoretical prediction is that $\beta_3 < 0$: smoothing mechanisms reduce the sensitivity of the wage to labor demand shocks, or in shorthand, wage volatility. Testing this prediction is the objective of this section.

The identification strategy assumes that rainfall shifts the labor demand curve and does not shift

the labor supply curve. Another important assumption is that S_{jt} measures differences in the labor supply elasticity and not differences in the size of the labor demand shock.⁸ It is this assumption that arguably warrants the most scrutiny. I interpret banks and roads as smoothing mechanisms, but these are not placed randomly. S_{jt} could be correlated with unobserved heterogeneity of the labor demand shocks if areas that are more economically developed are characterized by more banks and roads and also by geography or technology that makes agricultural productivity less sensitive to weather. Then in labor markets with high values of S_{jt} , the labor demand shock associated with a rain shock would be smaller, and β_3 would be negative. This endogeneity problem could arise through reverse causation; places where agricultural output is insensitive to weather might enjoy higher agricultural output on average, and with their higher income might build banks and roads. A related omitted variable concern is that the labor demand shock caused by a weather shock might be smaller in more developed places because agriculture is a less significant part of the labor market. The dependent variable I use is specifically the agricultural wage, but the agricultural labor market might be integrated with a broader low-skill labor market.

If there were policies that led to exogenous placement of smoothing mechanisms, then one could address this problem with an instrumental variable approach. For example, a road construction initiative that occurred only in certain districts or began in different years in different districts (all for arbitrary reasons) could serve as an instrument for the observed level of road density. This variation in road density would less likely be correlated with unobserved heterogeneity among districts. Alternatively, if there were sufficient within-district variation over time in smoothing mechanisms, I could include in the estimating equation district dummies interacted with the shock variable to absorb time-invariant omitted characteristics of a district. In practice, these approaches are not available. Instead, I am able to partially address this concern, first, by including the interaction of $RainShock_{jt}$ with factors X_{jt} that might affect the sensitivity of agricultural productivity to weather. X_{jt} includes the latitude, longitude, and altitude of the district, the percentage of cultivated land that is irrigated, and the percentage of the workforce in agriculture. Second, in section 5.6, I present a specification test that helps distinguish between the labor supply elasticity interpretation of the results and the omitted variable interpretation. The test uses crop yield or area cropped as the dependent variable in a model analogous to that described by Equation 4.1, and is based on the logic that these outcomes should be more sensitive to shocks if labor supply is more elastic, but less sensitive to the shock variable if weather has a smaller impact on labor productivity. The results of the test lend support to the conclusion that smoothing mechanisms reduce wage volatility because they increase the elasticity of labor supply.

⁸Another assumption is that S_{jt} raises the elasticity of labor supply because of the income effect or substitution toward other forms of labor, and not because of substitution toward leisure, e.g., it is not the case that leisure is more substitutable with consumption where there are roads.

4.2 Data

I estimate Equation 4.1 where the unit of observation is a district in India in a given year. The panel comprises 271 districts, defined by 1961 boundaries, in 13 states (Haryana, Punjab, Uttar Pradesh, Gujarat, Rajasthan, Bihar, Orissa, West Bengal, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Madhya Pradesh), observed from 1956 to 1987. The sample covers 85% of India’s land area, including the major agricultural regions.

The geographic unit used in the empirical analysis should be a distinct labor market. While no labor market is completely distinct (and in fact the degree of integration is part of what I examine), in India a district is the most appropriate unit. For example, roughly three fourths of rural migration in India is intra-district (Bardhan 1977, Foster and Rosenzweig 2003). A district in the sample has on average 400,000 agricultural workers.

Table 1 presents descriptive statistics for the data used, with more detail provided in the data appendix. The dependent variable, the district-level agricultural wage, is from the World Bank India Agriculture and Climate data set and was collected originally by the Indian Ministry of Agriculture. Weather data are annual rainfall figures for the district, measured at the closest point on a 1° latitude by 1° longitude grid. The rainfall data are from the Center for Climactic Research at the University of Delaware. I examine five types of district traits: financial services, access to other areas, human capital, poverty and landownership. Most of these data are from the World Bank data set or the Census of Population (cross-sectional measures from 1981 or 1961, 1971, and 1981 measures, interpolated between years). Other data sources include the Reserve Bank of India, the National Sample Survey, and the 1981 Agricultural Census.

5 Empirical Results on the Determinants of Wage Volatility

5.1 Relationship between Rainfall and the Agricultural Wage

Rainfall is used as a proxy for labor demand. The relationship between the agricultural wage and rainfall in the data suggests that rain improves agricultural productivity in India over the sample period—the wage increases monotonically with rainfall.⁹ I construct the variable *RainShock* accordingly, treating a surplus of rain as a good shock and a shortfall as a bad shock.

The first measure of *RainShock* equals 1 if the annual rainfall is above the 80th percentile for the district, 0 if it is between the 80th and 20th percentiles, or -1 if it is below the 20th percentile. When coefficients for rainfall above the 80th percentile and for rainfall below the 20th

⁹India differs from other settings in which either below- or above-normal rainfall might hurt agricultural productivity. The Indian Ministry of Agriculture publishes bulletins during the rainy season on the fraction of areas with average or above average rainfall, suggesting that rainfall shortfalls are of greatest concern. Extreme flooding presumably would be an exception.

percentile are estimated separately, one cannot reject that they have equal magnitude. I thus impose this restriction to improve power. The second shock measure is the fractional deviation from the district's mean annual rainfall. The distribution of rainfall used to construct these variables is for the period 1956 to 1987.

The rainfall measures are positively correlated with the log of the agricultural wage as shown in Table 2. Column 1 presents the correlation between the log wage and the categorical *RainShock* measure, allowing for district and year fixed effects. A shock causes a 1% change in the wage. Column 3 presents the results for the continuous rainfall measure described above. A one-standard-deviation change in rainfall (28%) is associated with a 0.6% change in the wage. Note that these coefficients are not large. Ideally, one would begin with a stronger proxy for labor demand shocks. A higher-order polynomial in rainfall would better predict the wage, but there would be a tradeoff: the labor demand proxy would no longer be univariate, and interpreting the results would be less straightforward. The effects of interest—how the elasticity of the wage with respect to demand shocks varies with the availability of smoothing mechanisms—would be represented by a combination of coefficients rather than a single coefficient. Since the focus of the empirical analysis is to test the *relative* sensitivity of the wage to demand shocks in different labor markets (i.e., the interaction effect between the proxy and another variable), it seems preferable to use the weaker but more transparent proxy.

As discussed above, an important concern is that in some places agricultural yield may be intrinsically more sensitive to weather, and if unaddressed this could lead to an omitted variable problem when I measure the impact of smoothing mechanisms. An area that is more sensitive to weather may be less productive, impeding its development and resulting in fewer banks or roads. To address this I control for the interaction of the rainfall variable with geographic traits (altitude, latitude, and longitude) and with the fraction of cultivated land that is irrigated. The main effect for the time-varying irrigation variable is also included. Note that since irrigation is increasing over time, its interaction with *RainShock* also absorbs other potential omitted measures of secular technological change that might have reduced the sensitivity of agriculture to rainfall over time. I also include the interaction of rainfall with the fraction of the workforce in agriculture to control for how important the agricultural sector is in the labor market. The agricultural wage may be less sensitive to agricultural productivity (rain shocks) if the non-agricultural sector is more important in the local economy.

Columns 2 and 4 show the results with these control variables added. The main effect of the shock on the wage is unchanged for the categorical variable while it decreases for the continuous measure. All variables interacted with *RainShock* have been standardized to have a mean of 0 and standard deviation of 1 to ease interpretation. Thus, for example, the second coefficient in Column

2 implies that for every standard deviation increase in altitude, the wage become less sensitive to the weather shock by 0.7 log points. As expected, more irrigation is associated with lower wage volatility, but surprisingly wage volatility is higher where agricultural workers are a smaller part of the workforce. These coefficients are statistically insignificant, however.

5.2 Banking and Wage Volatility

Table 3 presents results for the relationship between financial development and wage volatility. Proposition 7 suggests that access to banking should reduce the sensitivity of the wage to demand shocks, or that the coefficient on *Banking*RainShock* should be negative. In columns 1-3 banking is measured as the number of bank branches per capita, average deposits per capita, and average credit per capita, respectively. In each case, banking significantly reduces the responsiveness of the wage to shocks.¹⁰ In discussing the results, I focus on the categorical *RainShock* variable; these are the estimates in Table 3. I find similar results using the continuous *RainShock* measure which are presented in Appendix Table 1 (along with results corresponding to Tables 4, 5, and 9).

The estimated coefficients on the interaction terms are sizeable. In column 2 moving from the mean level of bank deposits to one standard deviation below the mean, the wage becomes twice as sensitive to weather shocks (an increase from 1% to 2%). In fact, one might worry that for large positive values of *Banking*, this implies that the wage is decreasing in *RainShock*. *Banking*, however, rarely takes on large positive values. For example, for 90% of the sample the bank deposit variable (for which the estimated interaction coefficient has the largest magnitude) is below 0.81, the threshold at which the wage begins to decrease with *RainShock*. Moreover, taking into account the estimation error (i.e. using a t-test), I cannot reject that the wage is increasing in *RainShock* up to the 95th percentile of the bank deposit variable. The final measure of banking, the fraction of villages in the district with a rural bank branch, does not affect wage volatility (Column 4). The coefficient is positive, but small and statistically insignificant.

Workers need not directly use the formal banking sector to benefit from it. Probably few landless workers borrow through the formal sector during this period, but many receive informal loans from moneylenders or landlords who in turn use the formal banking sector. Banking might also enable entrepreneurs to expand non-agricultural businesses when agricultural productivity is low, creating an alternative use for labor, or if agriculture production requires upfront costs, a bad shock might result in a smaller decline in labor demand if landowners have access to credit.

Note that the purpose of using different measures of financial services is to test whether certain facets of financial services have a stronger relationship with wage volatility than others and to

¹⁰While the wage is positively serially correlated, the rain measure is not, so correcting standard errors for clustering within districts is not warranted. The estimated standard errors in fact would be smaller for almost all of the results presented were I to apply this correction.

check whether the results are robust to changing the way that financial services are measured. The different measures, not surprisingly, are positively correlated. Thus, if all of the *Banking * RainShock* variables are included in a single regression, they do not all reduce wage volatility. This is also true within the other categories of smoothing mechanisms I examine below.

5.3 Access to Neighboring Areas and Wage Volatility

In places where workers can migrate more easily to other labor markets if the local labor market conditions are unfavorable (or where there is more in-migration when labor market conditions are strong), wage volatility should be lower, as seen in Proposition 4. I use measures of a district's physical connectedness with neighboring areas, which should be associated with lower costs of migration, to test this prediction.¹¹ The results are presented in Table 4. Column 1 uses road density (length of paved roads per area of land) as the measure of access to other areas. Areas with lower road density have more wage volatility. While a bad shock (categorical *RainShock* equals -1), reduces the wage by 1% evaluated at the mean road density, it reduces the wage by 2% in area with road density one standard deviation below the mean. This result is statistically significant at the 1% level. In columns 2 and 3, the measures of accessibility are the proportion of villages with bus service and with a railway station. These are also associated with a reduction in wage volatility, although the interaction coefficient for rail stations is statistically insignificant. Finally in column 4 I find that if a district is closer to a city, which would facilitate rural-to-urban migration, then wage volatility is reduced. The closeness variable is defined as the inverse of the distance between the geographic center of the district and the nearest city with a 1981 population of at least 500,000.

5.4 Human Capital and Wage Volatility

The theory I presented did not explicitly predict a relationship between human capital and wage volatility, but there are reasons to expect that human capital reduces an agricultural worker's exposure to risk. In India as in many other settings, more educated individuals are more likely to migrate, both from rural to urban areas and between rural areas, perhaps because they speak Hindi or English in addition to the local language (Greenwood 1971, Dhar 1984). While the available evidence does not firmly establish a causal relationship, it suggests that education may reduce the costs or increase the benefits of migration. Also, individuals with a broader skill set may be better able to substitute toward working in the non-agricultural sector when agricultural productivity is low. On the other hand, if bad shocks cause individuals to quit school either because they cannot afford school fees or because their labor income is needed, there might be a lower wage elasticity

¹¹These variables might also be measuring how open the goods markets or other markets are. An integrated market for the goods produced by the agricultural sector would likely exacerbate the impact of shocks.

of labor supply in areas with schools (see Jacoby and Skoufias (1997)).

I estimate the relationship between wage volatility and four measures of human capital, the literacy rate and the fraction of villages in a district that have a primary school, a middle school, and a high school. Table 5 presents the results. The wage in the agricultural sector is less sensitive to productivity shocks in areas with a higher literacy rate or with a greater penetration of schools.

5.5 Correlation of Banking, Access to Other Areas, and Human Capital

Thus far I have examined the effects of financial services, access to other areas, and human capital separately, leaving open the possibility that these three characteristics, which are positively correlated, are different measures of some single factor, such as “economic development,” that reduces wage volatility. Table 6 provides evidence that in fact financial development, accessibility, and human capital each seem to reduce wage volatility independently. I present results for regressions that include all combinations of average bank deposits, road density, and literacy and each interacted with *RainShock*. In all cases, the estimated coefficients on $S * \text{RainShock}$ are negative and similar in magnitude to the results discussed earlier where they were estimated separately. The coefficients remain, for the most part, statistically significant. In Panel A, *RainShock* is the categorical measure, and in Panel B I present results using the continuous *RainShock* measure.

5.6 Specification Tests Using Crop Yield and Area Planted

As mentioned earlier, an important concern is that banks or roads might be measuring an omitted variable, namely insensitivity of agricultural productivity to weather due to geographical or technological factors. That is, the concern is that smoothing mechanisms may not be identifying varying labor supply responses to a given labor demand shock, but instead differences in the intensity of the labor demand shock caused by a given weather shock. I address this in part by including control variables for measures of geography and irrigation and the fraction of the workforce in agriculture. To further allay this concern, as a specification test I examine the relationship between the smoothing mechanisms and two other dependent variables. The first is quantity of crops produced per area which I call crop yield, although it is important to note—and in fact the basis of the specification test—that variation in the yield includes variation in the quantity of labor used. The second dependent variable is the area of land planted for the major crops.

The usefulness of these dependent variables is that they can help distinguish between the labor supply explanation that I have put forth and the omitted variable explanation. Consider crop yield as the dependent variable in a model otherwise identical to that described by Equation 4.1. If the omitted variable explanation is correct, then in a place with a higher value of S , the demand shock associated with *RainShock* is less intense and the coefficient on $S * \text{RainShock}$ should be

negative, just as when the wage is the dependent variable. In contrast, under the interpretation that the labor supply elasticity is larger when there are roads or banks, in the event of a good shock more labor is available. Thus the labor used per area and, in turn, the output per area should be higher as S increases, or the coefficient on $S * RainShock$ should be *positive*. In short, a negative coefficient on $S * RainShock$ would suggest that an omitted variable problem drives the wage volatility results presented above, while a positive coefficient supports the interpretation that smoothing mechanisms reduce wage volatility because they raise the labor supply elasticity.¹²

Table 7, Panel A presents the results of this test. (Appendix Table 2 presents the corresponding results using the continuous *RainShock* measure.) Column 1 shows the positive correlation of *RainShock* and the crop yield. Crop yield is calculated as the revenue-weighted average of $\ln(\text{volume of crop produced}/\text{area cropped})$ for the 10 major crops by revenue. (Area cropped which is used below is constructed similarly. See the data appendix.) The discrete rain shock variable leads to an approximately 6% change in crop yield, and a one-standard deviation change in the continuous shock measure results in a 3.6% change in crop yield. The next three columns include the interaction of the rainfall variable with bank deposits, road density, and literacy. The estimated coefficients for the interaction effects are positive in all cases and are statistically significantly positive for bank deposits and literacy, providing support for the labor supply elasticity explanation of the main results.

The area cropped serves as the dependent variable in a related test. Farmers have latitude in the amount of land they farm since they can choose to use marginal land or to leave more land fallow. When agricultural productivity is high, the area planted should be higher, so *RainShock* should (and does) lead to an increase in the area cropped. The smaller the good shock, the smaller the increase in area planted, so the omitted variable problem would lead to the coefficient on $S * RainShock$ being negative. If instead the presence of smoothing mechanisms indicates that relatively more labor is supplied during high-productivity years (e.g., workers migrate in from elsewhere if road access is good), then with complementary labor and land, the area cropped will increase more if S is larger. The interaction effect will be positive. Panel B of Table 7 presents the results of this test. Each of the estimated interaction coefficients is positive and statistically significant at the 1%, 5%, or 10% level. These results suggest that smoothing mechanisms are measuring differences in the slope of the labor supply curve.

¹²This test does not rule out the concern that where there are more smoothing mechanisms, there is a larger non-agricultural sector which workers can switch to in bad times (or from in good times) which also predicts positive coefficients on the interaction terms.

5.7 Effects Of Poverty and Landholding

As discussed in the theory section, income effects may be particularly pronounced for the very poor. This implies that aggregate labor supply elasticity may decline as the poverty level in an area increases. On the other hand, the poor have a greater incentive to migrate to a neighboring area where labor productivity is higher. If the poor are more likely to out-migrate in response to negative shocks, as a group they might reduce overall wage volatility in the home market. This might be especially true if the poor are landless. In a region of Gujarat studied by Breman (1996), 25% of the population but 50% of out-migrants are landless. Anecdotal evidence suggests that there is a moral hazard cost of being an absentee landlord that might deter an equally poor landowner from migrating (Bardhan 1977).

While I will focus below on the propensity to migrate, there are additional reasons the landless could have a higher labor supply elasticity than landowners. An important possibility is that described by Dasgupta and Ray (1986) in their model of malnourishment and unemployment. If a worker's productivity depends on how much he consumes, then a landless person whose consumption is low may be more likely than a landowner to be unemployed. Such an effect would be more common when agricultural productivity is low, so the presence of poor people in the labor force would lead to a lower labor supply in the event of a negative shock, increasing the aggregate labor supply elasticity. Wage volatility has different welfare implications in this case; a reduction in wage volatility would no longer be welfare-enhancing for the very poor if they were not earning wages in lean times.

5.7.1 Labor supply elasticity and migration of the landless versus landowners

Before examining the effect of landownership and poverty on the wage, I provide evidence on the basic facts that, first, among individuals who stay in the home market, the labor supply elasticity is declining in landownership and, second, landless individuals have a higher propensity to migrate in response to bad shocks. To do so, I turn to another data set on rural India that has individual-level data, namely the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) village-level study. ICRISAT surveyed 40 households in each of 6 villages between 1975 and 1980 and in each of the original 6 plus 4 more villages from 1980 to 1985.

Table 8a presents the descriptive statistics for the ICRISAT samples used. Data on labor supply are not available for the entire sample, so I use a subsample of 3 villages during 1975-9. The sample consists of adult family members in the sampled households who are supplying labor in the village (which excludes live-in workers and family members who have migrated). The unit of observation is an individual-month. Rainfall during the months of July and August, collected by ICRISAT,

serves as a proxy for a labor demand. The amount of rain during these monsoon months is the most critical for agriculture, but the reason for this restriction is more pragmatic: the rainfall data for other months are missing in many cases. Since the panel is short, the *RainShock* variable is not measured relative the village mean, but this should not affect the comparisons across landholding groups since the sample is stratified by landholding. (The results are the same when I include a full set of village dummy variables interacted with *RainShock*.) There are four categories of landholding: landless, small landowner, medium landowner, and large landowner. Ten landless households were sampled per village, and then 10 households for each tercile of the village-specific land distribution. The measure of labor supply is hours worked in agriculture per day. For the estimates of migration, the sample consists of individuals between 18 and 60 years old. Households provided information about absent members (e.g., whether they moved temporarily, the reason for the move) that I use to construct a measure of individuals who have migrated temporarily for work. The average migration rate is 2% for the full sample and 4% for the subsample of males.

Table 8b provides evidence that an individual's labor supply elasticity is increasing in land ownership, or that the poor supply labor more inelastically. As shown in column 1, landowners have a positive labor supply elasticity; a one standard deviation decrease in rainfall (-.16 in the units of *RainShock*) leads to a 5.6% decrease in labor supply. The landless have a significantly lower labor supply elasticity than landowners; they reduce labor supply by only 0.7% in response to the same shock. Note that the landless also work more hours overall. In column 2, I separately estimate the labor supply and labor supply elasticity for the 4 landholding categories. While the estimates are imprecise, the pattern of coefficients is remarkably strong: the poorer the stratum, the more hours worked and the more inelastic the labor supply. The labor supply behavior of men and women is similar, although the point estimates suggest that among landowners, men supply labor more elastically than women, as seen from columns 3 and 4 where the sample is restricted to males. Note that all the regressions in this and the next table include village, year, and month fixed effects, and control for the number of working adults in the household (or number of working males in the subsample of males) and its interaction with *RainShock*. Standard errors are corrected for clustering within households.

Conditional on their staying in an area beset by a bad shock, landless workers lower the aggregate labor supply elasticity. The fact that landless individuals work more hours than landowners suggests that they also would have more to gain from migrating to work in a higher-wage market. Indeed, consistent with Proposition 3, I find that the landless are more likely to migrate to work elsewhere in the event of a bad shock. Columns 1 and 2 of Table 8c compare the propensity to temporarily migrate among landowners and landless individuals, using first a probit and then a linear specification. The behavior of landowners is unaffected by the rain shock, while a negative shock

significantly increases a landless individual's likelihood of migrating.^{13,14} Columns 3 and 4 show the propensity to migrate for all 4 landholding groups. One interesting result is that small landowners have a *lower* propensity to migrate than medium and large landowners. This is suggestive that smaller landowners may be disadvantaged in using hired help and managing their land in absentia. In other words, the high propensity of the landless to migrate may not only be because they are the poorest group, but also because they do not face the cost of leaving behind their land.¹⁵ In columns 5-8, the sample is restricted to males (half the sample) and the coefficients on *Landless* and *RainShock * Landless* double. The differential migration of the landless is due almost entirely to men. At the mean rainfall, the probability of a landless male migrating is 4.4%. In the event of a one-standard-deviation negative shock (-.24), the probability increases to 5.9%.

Landless individuals, or more generally the poor, have offsetting effects on labor supply elasticity. Within the home market, they supply labor more inelastically and contribute to greater declines in the wage when labor productivity suffers a negative shock, but they are also more likely to migrate to other areas, mitigating the impact of a bad shock on the home labor market. I now turn to estimating the impact that poor or landless individuals have on wage volatility in the main agricultural wage data set.

5.7.2 Poverty and landholding patterns and wage volatility

Table 9 presents the empirical relationship between poverty or landlessness and wage volatility. First, I use three poverty measures from the National Sample Survey (1987-88), average per capital expenditure, the fraction of households below a poverty line of 14,000 rupees per year (approximately the World Bank poverty line), and the Gini coefficient of per capita expenditure. None of the poverty measures has a statistically significant impact on wage volatility (columns 1-3). It is difficult to know whether this reflects the true relationship between poverty and wage volatility or limitations of the poverty data.

In columns 4 and 5 I examine two measures of landholding patterns. The first is the proportion of agricultural workers who are landless. The Census categorizes agricultural workers as wage laborers if they work on others' land, or as cultivators if they work on their own land. The proportion of wage laborers in the agricultural workforce is to first approximation a measure of landlessness within the agricultural sector. I find that wage volatility is significantly lower if the fraction landless is higher.

¹³Households with more adults or adult men might be more able to send one member elsewhere as a migrant worker. Landless households in fact have fewer adults and adult males than landowning households in the sample.

¹⁴Averaging across households, bad shocks increase migration. Yang (2003), in contrast, finds that in the Philippines negative rain shocks reduce overseas migration. In his context, migration is not in response to the income shock, and the shock could make moving overseas unaffordable.

¹⁵In the mathematical appendix I show that this pattern of migration is consistent with an extension of the model in which absentee landownership is costly.

It is worth noting that unlike bank or road density, the proportion landless is *negatively* correlated with most measures of economic development, so this result is unlikely to be driven by an omitted measure of economic development.¹⁶

Landless workers appear to have more elastic labor supply in the home market. A plausible explanation in light of the ICRISAT evidence is that labor migration in response to shocks is increasing in the fraction landless. Another possibility is that malnourishment causes landless individuals to supply less labor in the event of bad shocks (Dasgupta and Ray 1986).

The second measure of landownership I examine is the Gini coefficient of landholding calculated among landowners only. The measure is constructed using data on the number of landowners in five size categories (see the data appendix). I find that greater land inequality among the landed does not have a significant impact on wage volatility.

6 Conclusion

Productivity risk is one of the roots of underdevelopment. Agricultural production is sensitive to drought, floods, pestilence, price fluctuations, and more. This paper has argued that poverty and isolation exacerbate this very risk.

In a model of an agricultural sector that employs labor and land, the closer workers are to subsistence, the more inelastically they supply labor and the more volatile the wage is. The model also showed that higher costs of migrating, borrowing, and saving amplify wage volatility. Empirically, a better developed banking system and more access to other areas are important in explaining the sensitivity of the wage to productivity shocks. In a sample of 271 Indian districts observed over a 32-year period, moving from the mean level of transportation infrastructure to one standard deviation below the mean makes the wage twice as sensitive to weather-cum-productivity shocks, for example.

The wealth distribution is important both in explaining wage volatility and in understanding its welfare implications. The proportion of agricultural workers who are landless was found to reduce wage volatility. Individual-level data supported the explanation that the landless have a particularly high propensity to migrate for work. In terms of welfare implications, wage volatility differentially hurts poorer individuals. For the rich who are net buyers of labor, wage volatility is in fact beneficial. This result suggests a different way of viewing measures such as improving the banking sector: They have a redistributive as well as a level effect on welfare.

The results have at least three broader implications. First, living in a more open economy helps

¹⁶Using the specification test described in section 5.6, the estimated coefficient for $\%Landless * RainShock$ is positive when either crop yield or area cropped is the dependent variable and either the categorical or continuous *RainShock* measure is used. The coefficient is significant at the 1% level in three of the four cases.

the poor. Labor mobility is an important means of responding to productivity risk when shocks are local to an area. A better developed financial sector, particularly when linked to the world market so that the interest rate is not determined locally, is also beneficial.

Second, land redistribution from the rich to the poor could have counterintuitive effects. If such a policy decreased the amount of out-migration, it could have a negative pecuniary effect on individuals who remain landless. The empirical result that small landowners are particularly unlikely to migrate is further reason to believe that land redistribution would have complex effects on individual choices and, in turn, on general equilibrium outcomes.

Third, rich and poor differ in their preference toward institutions that enable consumption smoothing, and this could have important political economy implications. At first blush, improving financial services—a village gains access to the world financial market—would seem to benefit all individuals in an economy subject to productivity risk. Indeed, both landowners and the landless have volatile income, and all benefit from the ability to smooth their consumption. However, when effects on the equilibrium wage are considered, an improvement in financial services could do more harm than good for a landowner; the benefit of smoother consumption is outweighed by the cost of a less volatile wage.

One ramification is that the rich might prefer to keep an economy closed. Whether their preferences would be the decisive ones in collective decision-making would likely depend on the land distribution. If land is held by more individuals, *ceteris paribus*, each landowner has a smaller ratio of land to labor, so his interests are more aligned with the landless. There is a higher probability that a landowner is in favor of improving banking, for example. On the other hand, when land is more widely held, landowners are also a larger voting bloc. Depending on how a community reaches political decisions, a more equal land distribution could be either more or less in the interest of the very poor.

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A Mathematical Appendix

A.1 Proofs

The following lemma will be useful for later proofs. In words, it establishes that a decrease in the wage in the event of a bad shock and an increase in the event of a good shock are sufficient conditions for an increase in wage volatility. Recall that ν is wage volatility, and let w^+ be the wage in the state $\tilde{\sigma} = \sigma$ and w^- be the wage in the state $\tilde{\sigma} = \sigma$.

Lemma 1. *For any parameter λ , if $\frac{\partial w^+}{\partial \lambda} \geq 0$ and $\frac{\partial w^-}{\partial \lambda} \leq 0$, then $\frac{\partial \nu}{\partial \lambda} \geq 0$. If $\frac{\partial w^+}{\partial \lambda} \leq 0$ and $\frac{\partial w^-}{\partial \lambda} \geq 0$, then $\frac{\partial \nu}{\partial \lambda} \leq 0$.*

Proof.

$$\frac{\partial \nu}{\partial \lambda} = \frac{\partial \nu}{\partial w^+} \frac{\partial w^+}{\partial \lambda} + \frac{\partial \nu}{\partial w^-} \frac{\partial w^-}{\partial \lambda}$$

$$\text{Since } \nu = \frac{1}{\sqrt{2}} \left(\frac{w^+ - w^-}{w^+ + w^-} \right),$$

$$\begin{aligned} \frac{\partial \nu}{\partial w^+} &= \frac{1}{w^+ + w^-} \left(1 - \frac{w^+ - w^-}{w^+ + w^-} \right) > 0 \\ \frac{\partial \nu}{\partial w^-} &= -\frac{1}{w^+ + w^-} \left(1 - \frac{w^+ - w^-}{w^+ + w^-} \right) < 0 \quad \blacksquare \end{aligned}$$

Proof of Proposition 1

Setting labor supply equal to labor demand gives

$$\alpha \bar{h} + \underline{c} w^{-1} - (1 - \beta) \tilde{A}^{1-\beta} \beta^{1-\beta} w^{\frac{-\beta}{1-\beta}} K w^{-1} = \tilde{A}^{\frac{1}{1-\beta}} \beta^{\frac{1}{1-\beta}} w^{\frac{-1}{1-\beta}} K$$

Rearranging this, define

$$g_1 \equiv \tilde{A}^{\frac{1}{1-\beta}} \beta^{\frac{\beta}{1-\beta}} w^{\frac{-1}{1-\beta}} K w - \underline{c} w^{-1} + \alpha \bar{h} = 0$$

Using the fact that $\frac{\partial w}{\partial \tilde{A}} = -\frac{\partial g_1}{\partial \tilde{A}} / \frac{\partial g_1}{\partial w}$ by the implicit value theorem,

$$\nu \approx \frac{\sigma}{\sqrt{2}} \frac{\partial w}{\partial \tilde{A}} \frac{\tilde{A}}{w} = \frac{\sigma}{\sqrt{2}} \frac{\tilde{A}^{\frac{1}{1-\beta}} \beta^{\frac{\beta}{1-\beta}} w^{\frac{-1}{1-\beta}} K}{\tilde{A}^{\frac{1}{1-\beta}} \beta^{\frac{\beta}{1-\beta}} w^{\frac{-1}{1-\beta}} K - (1 - \beta) \underline{c} w^{-1}}$$

and

$$\frac{\partial \nu}{\partial \underline{c}} = \frac{\sigma}{\sqrt{2}} \left(\tilde{A}^{\frac{1}{1-\beta}} \beta^{\frac{\beta}{1-\beta}} w^{\frac{-1}{1-\beta}} K \right) \left(\tilde{A}^{\frac{1}{1-\beta}} \beta^{\frac{\beta}{1-\beta}} w^{\frac{-1}{1-\beta}} K - (1 - \beta) \underline{c} w^{-1} \right)^{-2} w^{-1} > 0 \quad \blacksquare$$

Proof of Proposition 2

Indirect utility is

$$\begin{aligned} V(w, k_i) &= \alpha^{-1} \log \left((\bar{h} w + \pi_i) w^{-(1-\alpha)} \right) - \log \alpha (1 - \alpha)^{\frac{1-\alpha}{\alpha}} \\ &= \alpha^{-1} \log \left((\bar{h} w^\alpha + \tilde{A}^{\frac{1}{1-\beta}} \beta^{\frac{\beta}{1-\beta}} (1 - \beta) k_i w^{-(1-\alpha) - \frac{\beta}{1-\beta}}) \right) - \log \alpha (1 - \alpha)^{\frac{1-\alpha}{\alpha}}. \end{aligned}$$

Preferences for wage volatility depend on

$$\frac{\partial^2 V}{\partial w^2} = \left(-\alpha(1-\beta)\bar{h}^2 w + (2-2\alpha(1-\beta)^2 - \beta) \tilde{A}^{\frac{1}{1-\beta}} \beta^{\frac{\beta}{1-\beta}} \bar{h} k_i w^{-\frac{\beta}{1-\beta}} \right. \\ \left. + \tilde{A}^{\frac{2}{1-\beta}} \beta^{\frac{2\beta}{1-\beta}} (1-\alpha + \alpha\beta)(1-\beta)^2 k_i^2 w^{\frac{1+\beta}{1-\beta}} \right) / \left(\alpha(1-\beta)w^3 \left(\bar{h} + (1-\beta)\tilde{A}^{\frac{1}{1-\beta}} \beta^{\frac{\beta}{1-\beta}} k_i w^{-\frac{1}{1-\beta}} \right)^2 \right)$$

The denominator is positive, so the overall sign is determined by relative size of the first term in the numerator which is negative and the second two terms which are positive. Since the second two terms drop out for $k_i = 0$, for the landless $\frac{\partial^2 V}{\partial w^2} < 0$. The second two terms are increasing in k_i , so aversion to wage volatility is declining in landholding, and for a sufficiently large landholding, $\frac{\partial^2 V}{\partial w^2}$ is positive.

Evaluated at the autarkic equilibrium wage, the numerator of the expression above for $\frac{\partial^2 V}{\partial w^2}$ is

$$\alpha\beta^\beta \tilde{A} \left(-(1-\beta) \left(\frac{1}{\alpha} - (1-\beta) \right)^{1-\beta} \left(\frac{K}{\bar{h}} \right)^{-\beta} \bar{h} K \right. \\ \left. + 2 \left(\frac{1}{\alpha} - (1-\beta)^2 + \frac{\beta}{2\alpha} \right) \left(\frac{1}{\alpha} - (1-\beta) \right)^{-\beta} \left(\frac{K}{\bar{h}} \right)^{-\beta} \bar{h} k_i + (1-\beta)^2 \left(\frac{1}{\alpha} - (1-\beta) \right)^{-\beta} \beta^{-2} \bar{h} K^{-1} k_i^2 \right)$$

First note that $\frac{1}{\alpha} - (1-\beta) < \frac{1}{\alpha} - (1-\beta)^2 + \frac{\beta}{2\alpha}$. Also, with the assumed distribution of land each landowner owns $k_i = \frac{K}{1-\theta} > K$. Therefore the second term is larger in magnitude than the first term. As the third term is positive, the overall expression is positive for landowners. ■

Proof of Proposition 3

$$V(w)|_{Migrate_i=0} = \alpha^{-1} \log \left(\bar{h} w^\alpha + \tilde{A}^{\frac{1}{1-\beta}} \beta^{\frac{\beta}{1-\beta}} (1-\beta) k_i w^{-(1-\alpha) - \frac{\beta}{1-\beta}} \right) - \log \alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}}$$

$$V(w)|_{Migrate_i=1} = \alpha^{-1} \log \left(\bar{h} W^\alpha + \tilde{A}^{\frac{1}{1-\beta}} \beta^{\frac{\beta}{1-\beta}} (1-\beta) k_i W^{-(1-\alpha)} w^{-\frac{\beta}{1-\beta}} - \tilde{\Delta}_i W^{-(1-\alpha)} \right) - \log \alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}}$$

Defining $Gain_i \equiv V(w)|_{Migrate_i=1} - V(w)|_{Migrate_i=0}$ and $\pi_k \equiv (1-\beta)\tilde{A}^{\frac{1}{1-\beta}}\beta^{\frac{\beta}{1-\beta}}w^{\frac{\beta}{1-\beta}}$,

$$\frac{\partial Gain_i}{\partial k_i} = \alpha^{-1} \pi_k w^{-\frac{\beta}{1-\beta}} \left(-\frac{(W/w)^{1-\alpha}}{\bar{h} w^\alpha + \pi_k w^{-(1-\alpha)} k_i} + \frac{1}{\bar{h} W^\alpha + \pi_k W^{-(1-\alpha)} - \tilde{\Delta}_i W^{-(1-\alpha)}} \right)$$

This expression is positive whenever $\bar{h} W^\alpha (W/w)^{1-\alpha} - \tilde{\Delta}_i W^{-(1-\alpha)} > \bar{h} w^\alpha$ which is true whenever $Gain_i > 0$. Next note that $\frac{\partial Gain_i}{\partial \tilde{\Delta}_i} < 0$. The maximum value of $\tilde{\Delta}_i$ such that an individual prefers to migrate in the event of a bad shock can be derived by solving for $\tilde{\Delta}_i$ when $Gain_i = 0$ and $w = w_{aut}(1-\sigma)$. Using the implicit value theorem, the derivative of this cutoff Δ_i with respect to k_i is equal to $-\frac{\partial Gain_i}{\partial k_i} / \frac{\partial Gain_i}{\partial \tilde{\Delta}_i} < 0$. Thus $\Delta_p > \Delta_r$. ■

Proof of Proposition 4

A higher equilibrium wage in the event of $\tilde{\sigma}_1 = -\sigma$ is equivalent to a reduction in wage volatility, using Lemma 1. The equilibrium wage when there is migration is

$$w = w_{aut}(1-\sigma) \left(\frac{\beta\psi + (1-\alpha)(1-\beta)(\Delta_{min} + \psi - \Delta_r)}{(1-\alpha(1-\beta))(\Delta_{min} + \psi - \Delta_r - \theta(\Delta_p - \Delta_r))} \right)^{1-\beta}$$

(See section A.2 for the derivation.)

$$\frac{\partial w}{\partial \psi} = -(1-\beta)w_{aut}(1-\sigma) \left(\frac{\beta\psi + (1-\alpha)(1-\beta)(\Delta_{min} + \psi - \Delta_r)}{(1-\alpha(1-\beta))(\Delta_{min} + \psi - \Delta_r - \theta(\Delta_p - \Delta_r))} \right)^{-\beta} \\ (1-\alpha(1-\beta)) \left(\left(\frac{\beta\psi + (1-\alpha)(1-\beta)(\Delta_{min} + \psi - \Delta_r)}{(1-\alpha(1-\beta))(\Delta_{min} + \psi - \Delta_r - \theta(\Delta_p - \Delta_r))} \right) - 1 \right)$$

Since $\Delta_r \geq \Delta_{min}$ by definition and $\Delta_p \geq \Delta_r$ by Proposition 3, this expression is less than or equal to 0. ■

Proof of Proposition 5

Using Lemma 1 and the fact that no one migrates when $\tilde{\sigma} = \sigma$, the proposition is equivalent to $\frac{dw}{d\theta} > 0$ for the state $\tilde{\sigma} = -\sigma$. Changing the proportion landless entails two distinct effects: a change in the size of the landless class and a change in the average landholding for the landed class. If $\Delta_r = \Delta_{min}$, or no landowners move, infinitesimal changes in θ have no effect on landowners' propensity to move ($\frac{\partial \Delta_r}{\partial \theta} = 0$). Then

$$\frac{dw}{d\theta} = \frac{\partial w}{\partial \theta} = (1-\beta)w_{aut}(1-\sigma) \left(\frac{\beta\psi + (1-\alpha)(1-\beta)(\Delta_{min} + \psi - \Delta_r)}{(1-\alpha(1-\beta))(\Delta_{min} + \psi - \Delta_r - \theta(\Delta_p - \Delta_r))} \right)^{-\beta} \\ ((1-\alpha(1-\beta))(\Delta_{min} + \psi - \Delta_r - \theta(\Delta_p - \Delta_r)))^{-1} (\Delta_p - \Delta_r)(1-\alpha(1-\beta)) > 0,$$

using the result in Proposition 3 that $\Delta_p > \Delta_r$. The direct effect of increasing θ is that, because landless individuals are more likely to migrate, more labor supply shifts to outside areas in the event of a bad shock, and the village wage is higher.

More generally, $\frac{dw}{d\theta} = \frac{\partial w}{\partial \theta} + \frac{\partial \Delta_r}{\partial \theta} \frac{\partial w}{\partial \Delta_r}$. If there is a positive amount of migration among landowners, then $\frac{\partial \Delta_r}{\partial \theta} < 0$. When a landowner has a larger plot of land, he is less likely to migrate which acts to increase wage volatility (note that $\frac{\partial w}{\partial \Delta_r} > 0$). However one can demonstrate that this effect is always dominated by the positive direct effect. To see this, first note that $\frac{\partial \Delta_r}{\partial \theta} = \frac{\partial \Delta_r}{\partial k_i} \frac{\partial k_i}{\partial \theta}$ where $\frac{\partial \Delta_r}{\partial k_i} k_i = -(\Delta_p - \Delta_r)$ and $\frac{\partial k_i}{\partial \theta} = K(1-\theta)^{-2}$. Then

$$\frac{dw}{d\theta} = C_1 \left(-(1-\alpha)(1-\beta) + (1-\theta)(1-\alpha(1-\beta)) \left(\frac{\beta\psi + (1-\alpha)(1-\beta)(\Delta_{min} + \psi - \Delta_r)}{(1-\alpha(1-\beta))(\Delta_{min} + \psi - \Delta_r - \theta(\Delta_p - \Delta_r))} \right) \right)$$

where

$$C_1 \equiv (1-\beta)w_{aut}(1-\sigma) \left(\frac{\beta\psi + (1-\alpha)(1-\beta)(\Delta_{min} + \psi - \Delta_r)}{(1-\alpha(1-\beta))(\Delta_{min} + \psi - \Delta_r - \theta(\Delta_p - \Delta_r))} \right)^{-\beta} \\ ((1-\alpha(1-\beta))(\Delta_{min} + \psi - \Delta_r - \theta(\Delta_p - \Delta_r)))^{-1}.$$

The non-negativity of landowners' labor supply implies that $\frac{\partial \Delta_r}{\partial \theta} > 0$. ■

Proof of Corollary 6

This follows from Propositions 2 and 5.

Proof of Proposition 7

Proof is partially complete.

Step 1: Solve for the equilibrium.

Define $\widehat{R} = R \pm \phi$. For $\widehat{R} > 0$, the solution to the individual maximization problem specified in (3.1) is

$$c_{i1} = \frac{w\bar{h} + \widetilde{A}(1-\beta) \left(\frac{\widetilde{A}\beta}{w}\right)^{\frac{\beta}{1-\beta}} k_i + \frac{y_{i2}}{\widehat{R}}}{1+b+\gamma} \quad c_{i2} = b\widehat{R}c_{i1}$$

$$h_i = \frac{(1+b)c_{i1} - \frac{y_{i2}}{\widehat{R}} - \widetilde{A}(1-\beta) \left(\frac{\widetilde{A}\beta}{w}\right)^{\frac{\beta}{1-\beta}} k_i}{w}$$

This gives a market-clearing condition

$$\left(1 + \frac{1-\beta}{\beta} \left(\frac{\gamma}{1+b+\gamma}\right)\right) \left(\frac{\beta\widetilde{A}}{w}\right)^{\frac{1}{1-\beta}} K - \frac{1+b}{1+b+\gamma} \bar{h} + \frac{\gamma}{1+b+\gamma} Y_{i2} \widehat{R}^{-1} w^{-1} = 0 \equiv g$$

where Y_{i2} is the aggregate value of y_{i2} . (For $\widehat{R} \leq 0$, there is no intertemporal transfers. $c_{i2} = y_{i2}$ and the period 1 outcomes are the autarkic case solved in section 3.3.)

Step 2: Show that $\frac{\partial w}{\partial \phi} > 0$ when workers are saving and $\frac{\partial w}{\partial \phi} < 0$ when workers are borrowing.

When individuals are saving and $\widehat{R} = R - \phi$,

$$\frac{dg}{d\phi} = \frac{\gamma}{1+b+\gamma} Y_{i2} w^{-1} (R - \phi)^{-2} > 0$$

$$\frac{dg}{dw} = - \left(\frac{1}{1-\beta} + \frac{1}{\beta} \left(\frac{\gamma}{1+b+\gamma} \right) \right) \left(\frac{\beta\widetilde{A}}{w} \right)^{\frac{1}{1-\beta}} w^{-1} K - \frac{\gamma}{1+b+\gamma} Y_{i2} w^{-2} (R - \phi)^{-1} < 0$$

Therefore by the implicit function theorem $\frac{dw}{d\phi} > 0$. Similarly, when individuals are borrowing and $\widehat{R} = R + \phi$, it can be shown that $\frac{dg}{d\phi} < 0$ and $\frac{dg}{dw} < 0$ and therefore $\frac{dw}{d\phi} < 0$. In other words, as ϕ increases, the wage is higher when individuals are saving and lower when individuals are borrowing.

Step 3 (TO BE COMPLETED): Show that y_{i2} can be restricted to a range such that workers save if there is a good shock and borrow if there is a bad shock. It then follows that higher ϕ leads to higher wage volatility.

If c_{i2} is increasing in \widetilde{A} , then with fixed y_{i2} , the incentive to save is increasing in \widetilde{A} . ■

Proof of Proposition 8

This follows from Proposition 2 and Proposition 7. TO BE WRITTEN FORMALLY. ■

Proof of Proposition 9

TO BE COMPLETED.

A.2 Other derivations

Derivation of w with migration and $\tilde{\sigma} = -\sigma$

A proportion $f_r \equiv \frac{\psi - (\Delta_r - \Delta_{min})}{\psi}$ of landowners and a proportion $f_p \equiv \frac{\psi - (\Delta_p - \Delta_{min})}{\psi}$ of the landless remain in the village. Each landowner supplies $h_i = \alpha\bar{h} - \Pi w^{-1}(1 - \theta)^{-1}$ and each landless agent

supplies $h_i = \alpha \bar{h}$, where Π are aggregate land profits. Using the fact that $\Pi = \frac{1-\beta}{\beta} Hw$ where H is aggregate labor in equilibrium, the labor market clearing is $H = \theta f_p(\alpha \bar{h}) + (1-\theta) f_r(\alpha \bar{h} - (1-\alpha) \frac{1-\beta}{\beta} (1-\theta)^{-1} H)$. This gives

$$H = \alpha \beta \bar{h} \left(\frac{\Delta_{min} + \psi - \Delta_r - \theta(\Delta_p - \Delta_r)}{\beta \psi + (1-\alpha)(1-\beta)(\Delta_{min} + \psi - \Delta_r)} \right).$$

which in turn gives

$$w = w_{aut}(1-\sigma) \left(\frac{\beta \psi + (1-\alpha)(1-\beta)(\Delta_{min} + \psi - \Delta_r)}{(1-\alpha(1-\beta))(\Delta_{min} + \psi - \Delta_r - \theta(\Delta_p - \Delta_r))} \right)^{1-\beta}$$

Restriction on Δ_{min}

The assumed minimum value of Δ_{min} that ensures that no one migrates in the event of a good shock can be derived by solving for $\tilde{\Delta}_i$ when $Gain_i = 0$ and $w = w_{aut}(1+\sigma)$, and also $k_i = 0$ (since, from Proposition 3, the constraint for the landless is the one that binds). The restriction on Δ_{min} is therefore

$$\Delta_{min} > \bar{h}W \left(1 - \left(\beta^\beta \left(\frac{1}{\alpha} - (1-\beta) \right)^{1-\beta} A(1+\sigma) \left(\frac{K}{\bar{h}} \right)^{1-\beta} \right)^\alpha W^{-\alpha} \right).$$

Costly absentee landownership

Section 5.7 presented empirical evidence that small landowners in the ICRISAT villages have a lower propensity to migrate than larger landowners. I consider an extension to the model (specifically to the case examined in section 3.3) in which being an absentee landlord is costly. There may be search costs associated with hiring someone to manage one's land, or the probability of theft may be higher when one manages in absentia. I assume that these costs are decreasing in landownership. A larger landowner may already be employing someone who can serve as a manager, for example. If a landowner migrates, he must pay a cost κk_i^{-1} where $\kappa \geq 0$.¹⁷

Under this assumption, small landowners may in fact be less likely to migrate than large landowners. While a smaller landowner is poorer, which increases his likelihood of migrating, he also faces a larger relative cost of being an absentee landlord.

Proposition 10. $\exists \kappa^*$ such that for $\kappa > \kappa^*$, the propensity to migrate among landowners is decreasing in the landholding, and for $\kappa < \kappa^*$, the propensity to migrate among landowners is increasing in the landholding.

Proof. With costly absentee landownership, the utility of a landowner who migrates is

$$V(w)|_{Migrate_i=1} = \alpha^{-1} \log \left(\bar{h}W^\alpha + \left(\pi_k k_i - \kappa k_i^{-1} - \tilde{\Delta}_i \right) W^{-(1-\alpha)} \right) - \log \alpha (1-\alpha)^{\frac{1-\alpha}{\alpha}}$$

¹⁷There is no option to forgo land profits and migrate. This can be thought of as the reduced form of a longer-horizon model in which the risk of losing unattended land outweighs the short-term benefit of migration. If landowners could forgo their land, then for any κ , the probability of migrating would be decreasing in landownership at sufficiently small values of k_i .

where $\pi_k \equiv (1 - \beta) \tilde{A}^{\frac{1}{1-\beta}} \beta^{\frac{\beta}{1-\beta}} w^{\frac{\beta}{1-\beta}}$.

$$\begin{aligned} \frac{\partial Gain_i}{\partial k_i} &= \alpha^{-1} \pi_k w^{-\frac{\beta}{1-\beta}} \left(-\frac{(W/w)^{1-\alpha}}{\bar{h}w^\alpha + \pi_k w^{-(1-\alpha)} k_i} + \frac{1}{\bar{h}W^\alpha + \pi_k W^{-(1-\alpha)} - \tilde{\Delta}_i W^{-(1-\alpha)}} \right) \\ &+ \alpha^{-1} \pi_k w^{-\frac{\beta}{1-\beta}} \left(\frac{2\kappa \left(\bar{h} + \frac{3}{2} \pi_k k_i W^{-1} - \tilde{\Delta}_i W^{-1} \right)}{k_i^3 \left(\bar{h} + \pi_k k_i W^{-1} - \tilde{\Delta}_i W^{-1} \right) \left(\bar{h}W + \pi_k k_i - \tilde{\Delta}_i - \kappa k_i^{-2} \right)} \right) \end{aligned}$$

When $\kappa = 0$, only the first term remains which, by Proposition 3, is negative. By inspection, the second term is monotonically increasing in κ . Defining κ^* as the value of κ such that $\frac{\partial Gain_i}{\partial k_i} = 0$, it follows that the gain from migration is decreasing in landownership for $\kappa > \kappa^*$ and increasing in landownership for $\kappa < \kappa^*$. ■

B Data Appendix

Agricultural wage

The agricultural wage data are from the World Bank India Agricultural and Climate data set (www-esd.worldbank.org/indian). The database covers 271 districts, defined by 1961 boundaries. Changes in district boundaries have been accounted for by consolidating new districts into their parent districts.

The wage data were compiled by Robert E. Evenson and James W. McKinsey, Jr., using data from the Directorate of Economics and Statistics within the Indian Ministry of Agriculture. Each state is responsible for collecting monthly data on the male and female wage (cash and in-kind) for several agricultural and non-agricultural occupations, by district, and submitting the data to the Directorate for inclusion in its Agricultural Wages in India annual publication. The Directorate suggests that states use public servants such as patwaris (revenue officials), primary school teachers, or panchayat board (local council) members to collect the data.

Evenson and McKinsey constructed an annual measure of the male daily agricultural wage using weighted monthly data. June and August were weighted more heavily than other months because of the high intensity of field work during those months. Missing data prevented their using a single agricultural occupation throughout the series, so their measure uses the wage for a ploughman if available, then for a field laborer, and then for other agricultural labor. The daily wage data does not account for possible variation in the length of the work day.

Rainfall

The rainfall data set, Terrestrial Air Temperature and Precipitation: Monthly and Annual Time Series (1950-99), Version 1.02, was constructed by Cort J. Willmott and Kenji Matsuura at the Center for Climatic Research, University of Delaware. The rainfall measure for a latitude-longitude node combines data from 20 nearby weather stations using an interpolation algorithm based on the spherical version of Shepard's distance-weighting method. The mean distance between the geographic center of a district (as specified in the World Bank data set) and the nearest grid point ranges from 1 to 59 km, with a mean of 20 km.

Geography and other control variables

Latitude, longitude, altitude are calculated at the geographic center of the district and are from the World Bank data set. The proportion of cultivated land that is irrigated is also from the World Bank data set. The fraction of the working population in agriculture is from Indian District Data, 1961–1991 (Reeve Vanneman and Douglas Barnes, 2000), available at www.inform.umd.edu/~districts/index.html. The original source is the decennial Census of India.

Banking

Bank branches, average deposits, and average credit per capita are from the Indian district data set. Data on rural bank branches are from the Reserve Bank of India.

Access to other areas

Data on roads are from the World Bank data set. Railways and buses are from the 1981 Census. I constructed distance to the nearest city using the latitude and longitude of districts from the World Bank data set, the location of cities from the World Gazetteer (www.world-gazetteer.com), and data from the 1981 Census on population by city.

Human capital

Literacy measures are from the World Bank data set. Data on schools are from the 1981 census.

Poverty

Poverty measures are from the National Sample Survey, Round 43. This is the earliest round of NSS data in which it is possible to identify a respondent's district.

Land distribution

Data on landlessness are from the Indian District data set. The Census categorizes agricultural workers as either laborers or cultivators, defining an agricultural laborer as “a person who worked in another person’s land for wages in cash, kind or share. . . Such a person had no risk in cultivation but merely worked in another person’s land for wages. An agricultural laborer had no right of lease or contract on land on which he worked.” The fraction landless is the number of laborers divided by the sum of laborers and cultivators.

Data on the number of landowners in five landholding categories (<1 hectare (ha), 1-2 ha, 2-4 ha, 4-10 ha, and >10 ha) are from the 1981 Agricultural Census. The Gini coefficient among landowners is constructed by assuming that plot size is distributed uniformly within each category and that the maximum plot size is 30 ha.

Yield and area cropped

Data on the volume produced and the area cropped, by crop, are from the World Bank data set. I construct the variable $\ln(\text{yield})$ as the weighted average of $\ln(\text{volume of crop produced/area cropped})$ for the 10 major crops by revenue which are rice, wheat, sugar, gram, jowar (sorghum), groundnut, bajra (millet), maize, tur (lentil), and miscellaneous lentils. The weights are the district-average revenue share of the crop, and the yield for each crop has been normalized to mean 1 for comparability across crops. The $\ln(\text{area cropped})$ variable is constructed similarly.

Individual-level labor supply and migration

The individual-level data on labor supply and migration are from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) village-level study. ICRISAT surveyors were present and conducting interviews continuously in each village, resulting in each household being observed approximately every 3 weeks. See Walker and Ryan (1990) for a detailed description of the survey.

Landless households are defined as those with less than 0.2 hectares of land who hired themselves out as laborers as their main occupation and source of income. Ten landless households per village were randomly sampled. In each village, landowners with more 0.2 hectares were divided into three equally-sized strata, and 10 households were sampled per stratum per village. The village-specific land categories are as follows.

Village	Maximum Size of	Maximum Size of
	Small Landholding (ha)	Medium Landholding (ha)
Aurepalle	2.5	5.3
Dokur	1.0	3.0
Shirapur	2.5	5.9
Kalman	6.1	10.8
Kanzara	2.3	5.6
Kinkheda	3.0	5.6
Boriya	1.0	5.9
Rampura	6.1	10.8
Papda	2.3	5.6
Rampura Kalan	3.0	5.6

Table 1
Summary Statistics

	Mean	Std. Dev	N	Source
Ln(agricultural wage)	1.24	0.83	8670	World Bank
Proportional deviation from mean district rainfall	2.5E-03	0.28	8670	Willmott and Matsuura
Annual rainfall (millimeters)	1053	543	8670	Willmott and Matsuura
<u>Financial development</u>				
Bank branches per 1000 people in 1981	0.04	0.03	8094	Census of India
Per capita deposits in 1981 (rupees 1000s/person)	0.28	0.34	8094	Census of India
Per capita credit in 1981 (rupees 1000s/person)	0.17	0.22	8030	Census of India
Proportion of villages with a rural bank branch	0.01	0.03	8126	Reserve Bank of India
<u>Access to other areas</u>				
Road density (km/km ²)	1.92	2.04	8399	World Bank
Proportion of villages with bus service in 1981	0.325	0.246	8254	Census of India
Proportion of villages with railway in 1981	0.018	0.021	8254	Census of India
Distance to city (km ⁻¹)	0.012	0.013	8670	Census of India
<u>Education</u>				
Literacy rate	0.32	0.11	8400	Census of India 1961/71/81
Proportion of villages with primary school in 1981	0.75	0.18	8254	Census of India
Proportion of villages with middle school in 1981	0.20	0.14	7678	Census of India
Proportion of villages with high school in 1981	0.08	0.08	6878	Census of India
<u>Poverty (among agricultural households)</u>				
Per capita expenditure (rupees/year) in 1987	34971	89297	8542	National Sample Survey
Proportion poor (annual PCE < 14000 rupees) in 1987	0.50	0.17	8542	National Sample Survey
Gini coefficient of poverty in 1987	0.35	0.17	8542	National Sample Survey
<u>Land ownership</u>				
Proportion of agricultural workers who are landless	0.28	0.16	8670	Census of India 1961/71/81
Gini of land ownership (excluding landless) in 1981	0.53	0.05	8127	Agricultural Census 1981
<u>Geographic and other control variables</u>				
Latitude (degrees north)	22.6	5.0	8670	World Bank
Longitude (degrees east)	78.9	4.4	8670	World Bank
Altitude (meters above sea level)	351	140	8670	World Bank
Proportion of cultivated land that is irrigated	0.24	0.21	8670	Census of India 1961/71/81
Proportion of workforce in agriculture in 1961	0.79	0.10	8670	Census of India
<u>Agricultural measures used in specification checks</u>				
Ln(yield)	0.05	0.40	8671	World Bank
Ln(area cropped)	0.42	0.68	8671	World Bank

Notes: The agricultural wage data is an annual series for 1956-1987 for 271 districts in India for a ploughman or other comparable worker. Rainfall for a district is measured at the nearest point on a 1 degree latitude by 1 degree longitude grid. Proportional deviation from mean rainfall is (annual rain - mean annual rain for district for 1956-87)/mean annual district rain. Variables constructed from multiple Censuses are linearly extrapolated between Census years. Closeness to city is 1/(distance to nearest city with 1981 population above 500,000). Ln(yield) is the weighted average ln(volume of crop produced/area cropped) for the 10 major crops by revenue (rice, wheat, sugar, gram, jowar, groundnut, bajra, maize, tur, and miscellaneous lentils) where the weights are the district-average revenue share of the crop, and the yield for each crop has been normalized to mean 1 for comparability across crops. Ln(area cropped) is constructed similarly.

Table 2
Rainfall Shock and Agricultural Wages

Dependent variable: log(ag wages), 1956-1987

	Measure of RainShock			
	+1 if rain > 80th percentile -1 if < 20th percentile 0 otherwise		Proportional deviation from mean rain	
	(1)	(2)	(3)	(4)
RainShock	.0098 *** (.0037)	.0098 *** (.0037)	.0223 *** (.0083)	.0151 * (.0091)
Altitude * RainShock		-.0071 * (.0036)		-.0156 ** (.0079)
Latitude * RainShock		.0078 ** (.0035)		.0121 (.0081)
Longitude * RainShock		-.0051 (.0036)		-.0057 (.0076)
% Irrigated		.0453 *** (.0069)		.0452 *** (.0069)
% Irrigated * RainShock		-.0030 (.0036)		-.0051 (.0083)
% Agricultural * RainShock		-.0020 (.0035)		-.0026 (.0076)
N	8670	8670	8670	8670
R ²	0.94	0.94	0.94	0.94
District and year fixed effects?	Y	Y	Y	Y

Notes: Standard error in parentheses below coefficient. *** indicates p<.01; ** indicates p<.05, * indicates p<.10. In columns 1-2, RainShock = 1 if annual rainfall > district's 80th percentile of rainfall, 0 if between the 20th and 80th percentiles, and -1 if below the 20th percentile. In columns 3-4, RainShock = (rainfall-mean district rainfall)/mean district rainfall. Variables interacted with RainShock have been transformed to be mean 0, standard deviation 1. Sources: Wages, altitude, latitude, longitude, and % of cropped land that is irrigated are from the World Bank; rainfall from Willmott and Matsuura; fraction of the work force in agriculture from the Census (as compiled in the Indian District dataset, Univ. of Maryland).

Table 3
Financial Services & Wage Volatility

RainShock = +1 if rain>80th percentile, -1 if rain<20th percentile, 0 otherwise

Dependent variable: log(ag wages), 1956-1987

	Measure of Banking			
	Bank branches per capita	Bank deposits per capita	Bank credit per capital	% of villages with rural bank branch
	(1)	(2)	(3)	(4)
RainShock	.0093 ** (.0038)	.0094 ** (.0038)	.0095 ** (.0038)	.0088 ** (.0038)
Banking				-.0143 *** (.0035)
Banking * RainShock	-.0078 * (.0047)	-.0116 *** (.0041)	-.0083 ** (.0038)	.0016 (.0039)
N	8094	8094	8030	8126
R ²	.94	.94	.94	.94
District and year FE?	Y	Y	Y	Y
Other controls?	Y	Y	Y	Y

Notes: Standard error in parentheses below coefficient. *** indicates p<.01; ** indicates p<.05, * indicates p<.10. Variables interacted with RainShock have been transformed to be mean 0, standard deviation 1. All regressions include as control variables % of cultivated land that is irrigated and the interaction between RainShock and each of latitude, longitude, altitude, % of cultivated land that is irrigated, and % of workforce in agriculture. Sources for banking measures: columns 1-3, Census 1981; column 4: Reserve Bank of India.

Table 4
Access to Neighboring Areas & Wage Volatility

RainShock = +1 if rain>80th percentile, -1 if rain<20th percentile, 0 otherwise

Dependent variable: log(ag wages), 1956-1987

	Measure of Accessibility			
	Road density (km/km ²)	Bus service (% of villages)	Railway (% villages with one)	Closeness to city
	(1)	(2)	(3)	(4)
RainShock	.0089 ** (.0037)	.0095 ** (.0038)	.0095 ** (.0038)	.0098 *** (.0037)
Accessibility	-.0278 *** (.0034)			
Accessibility * RainShock	-.0111 *** (.0033)	-.0119 ** (.0052)	-.0045 (.0037)	-.0077 ** (.0034)
N	8399	8254	8254	8670
R ²	.94	.94	.94	.94
District and year FE?	Y	Y	Y	Y
Other controls?	Y	Y	Y	Y

Notes: Standard error in parentheses below coefficient. *** indicates p<.01; ** indicates p<.05, * indicates p<.10.

Variables interacted with RainShock have been transformed to be mean 0, standard deviation 1. All regressions include as control variables % of cultivated land that is irrigated and the interaction between RainShock and each of latitude, longitude, altitude, % of cultivated land that is irrigated, and % of workforce in agriculture. Sources for access measures: Road density, World Bank; railway, bus, 1981 Census; closeness to city =1/(distance to nearest city with 1981 Census population above 500,000).

Table 5
Human Capital

RainShock = +1 if rain>80th percentile, -1 if rain<20th percentile, 0 otherwise
Dependent variable: log(ag wages), 1956-1987

	Measure of Human Capital			
	Literacy	Primary School (% of villages)	Middle School (% of villages)	High School (% of villages)
	(1)	(2)	(3)	(4)
RainShock	.0095 ** (.0037)	.0094 ** (.0038)	.0126 *** (.0040)	.0092 ** (.0041)
HumanCap	-.0888 *** (.0083)			
HumanCap * RainShock	-.0092 ** (.0038)	-.0169 *** (.0041)	-.0078 (.0048)	-.0128 *** (.0044)
N	8400	8254	7678	6878
R ²	.94	.94	.94	.94
District and year FE?	Y	Y	Y	Y
Other controls?	Y	Y	Y	Y

Notes: Standard error in parentheses below coefficient. *** indicates p<.01; ** indicates p<.05, * indicates p<.10. Variables interacted with RainShock have been transformed to be mean 0, standard deviation 1. All regressions include as control variables % of cultivated land that is irrigated and the interaction between RainShock and each of latitude, longitude, altitude, % of cultivated land that is irrigated, and % of workforce in agriculture. Sources for human capital measures: column 1 : World Bank; columns 2-4: Census 1981.

Table 6
Multiple Traits

Panel A: RainShock = +1 if rain>80th percentile, -1 if rain<20th percentile, 0 otherwise

	(1)	(2)	(3)	(4)
Bank deposits per capita * RainShock	-.0105 ** (.0042)	-.0087 ** (.0044)		-.0094 ** (.0044)
Road Density * RainShock	-.0110 *** (.0033)		-.0091 *** (.0035)	-.0098 *** (.0035)
Literacy * RainShock		-.0069 * (.0041)	-.0064 (.0039)	-.0035 (.0043)
N	7841	7842	8399	7841
R ²	.94	.94	.94	.94
District and year FE?	Y	Y	Y	Y
Other controls?	Y	Y	Y	Y

Panel B: RainShock = Proportional deviation from mean district rainfall

	(1)	(2)	(3)	(4)
Bank deposits * RainShock	-.0179 ** (.0083)	-.0135 (.0088)		-.0167 * (.0090)
Road Density * RainShock	-.0175 ** (.0073)		-.0145 * (.0075)	-.0166 ** (.0076)
Literacy * RainShock		-.0095 (.0089)	-.0091 (.0084)	-.0025 (.0093)
N	7841	7842	8399	7841
R ²	.94	.94	.94	.94
District and year FE?	Y	Y	Y	Y
Other controls?	Y	Y	Y	Y

Notes: Standard error in parentheses below coefficient. *** indicates p<.01; ** indicates p<.05, * indicates p<.10. In Panel B, RainShock = (rainfall-mean district rainfall)/mean district rainfall (annual measures for 1956-1987). Variables interacted with RainShock have been transformed to be mean 0, standard deviation 1. All regressions include as control variables % of cultivated land that is irrigated and the interaction between RainShock and each of latitude, longitude, altitude, % of cultivated land that is irrigated, and % of workforce in agriculture. Main effects for RainShock are in all regressions.

Table 7
Specification Test Based on Crop Yield and Area Cropped

RainShock = +1 if rain>80th percentile, -1 if rain<20th percentile, 0 otherwise

Panel A: Dependent variable: log(crop yield), 1956-1987

	District Trait			
	None	Bank deposits per capita	Road density	Literacy
	(1)	(2)	(3)	(4)
RainShock	.0591 *** (.0045)	.0596 *** (.0047)	.0631 *** (.0046)	.0628 *** (.0045)
District Trait			.0055 (.0041)	.0387 *** (.0102)
District Trait * RainShock		.0107 ** (.0051)	.0005 (.0041)	.0181 *** (.0047)
N	8670	8094	8399	8400
R ²	.33	.33	.33	.33
District and year FE?	Y	Y	Y	Y
Other controls?	Y	Y	Y	Y

Panel B: Dependent variable: log(area cropped), 1956-1987

	District Trait			
	None	Bank deposits per capita	Road density	Literacy
	(1)	(2)	(3)	(4)
RainShock	.0337 *** (.0027)	.0355 *** (.0028)	.0354 *** (.0027)	.0356 *** (.0027)
District Trait			-.0037 (.0025)	.0192 *** (.0060)
District Trait * RainShock		.0066 ** (.0031)	.0046 * (.0024)	.0082 *** (.0028)
N	8670	8094	8399	8400
R ²	.33	.33	.32	.32
District and year FE?	Y	Y	Y	Y
Other controls?	Y	Y	Y	Y

Notes: Standard error in parentheses below coefficient. *** indicates p<.01; ** indicates p<.05, * indicates p<.10. Variables interacted with RainShock have been transformed to be mean 0, standard deviation 1. All regressions include as control variables % of cultivated land that is irrigated and the interaction between RainShock and each of latitude, longitude, altitude, % of cultivated land that is irrigated, and % of workforce in agriculture. Ln(yield) is the weighted average ln(volume of crop produced/area cropped) for the 10 major crops by revenue (rice, wheat, sugar, gram, jowar, groundnut, bajra, maize, tur, and miscellaneous lentils) where the weights are the district-average revenue share of the crop, and the yield for each crop has been normalized to mean 1 for comparability across crops. Ln(area cropped) is constructed analogously.

Table 8a
ICRISAT Summary Statistics

Sample for analysis of labor supply

Villages: Aurepalle, Shirapur, and Kanzara

Years: 1975-1979

<u>Variable</u>	<u>Mean</u>	<u>Std. Dev</u>	<u>N</u>
Monsoon rainfall (July and August) in meters	0.35	0.16	5322
Proportion who are landless	0.20	0.40	5322
Proportion who are small landowners	0.23	0.42	5322
Proportion who are medium landowners	0.30	0.46	5322
Proportion who are large landowners	0.28	0.45	5322
Ln(hours worked in agriculture/day)	1.87	0.37	5322
Household adults	2.81	1.87	5322
Male	0.51	0.50	5322
Male Ln(hours worked in agriculture/day)	1.79	0.45	2716
Household male adults	1.90	1.35	2716

Sample for analysis of migration

Villages: Aurepalle, Dokur, Shirapur, Kalman, Kanzara, Kinkheda, Boriya Becharji, Rampura, Rampura Klan, and Papda

Years: 1975-1984

<u>Variable</u>	<u>Mean</u>	<u>Std. Dev</u>	<u>N</u>
Monsoon rainfall (July and August) in meters	0.36	0.24	3676
Proportion who are landless	0.22	0.41	3676
Proportion who are small landowners	0.21	0.41	3676
Proportion who are medium landowners	0.25	0.43	3676
Proportion who are large landowners	0.32	0.47	3676
Individual has temporarily migrated for work	0.020	0.14	3676
Household adults	3.48	2.08	3676
Male	0.53	0.50	3676
Male has temporarily migrated for work	0.037	0.19	1933
Household male adults	2.13	1.16	1933

Notes: The sample for the labor supply estimates are adult family members (as defined by the survey) who supply labor in the home village and, for the migration estimates, adults between the age of 18 and 60. Each observation is an individual-month. In each village 10 landless households and 10 households from each tercile of the village-specific land distribution were sampled. Small, medium, and large landowners denote these terciles. Source: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Village-Level Survey, India.

Table 8b
Labor Supply Elasticity by Land Ownership

Dependent variable: Ln(hours worked in agriculture/day)

	All adults		Adult males	
	(1)	(2)	(3)	(4)
RainShock	.349 *** (.092)	.430 *** (.153)	.508 *** (.148)	.570 ** (.239)
Landless	.291 *** (.058)	.418 *** (.074)	.326 *** (.109)	.401 *** (.132)
Small landholding		.295 *** (.059)		.256 ** (.103)
Medium landholding		.155 ** (.070)		.069 (.101)
Landless * RainShock	-.309 ** (.123)	-.365 ** (.176)	-.283 (.227)	-.334 (.289)
SmallLand * RainShock		-.253 (.156)		-.318 (.247)
MediumLand * RainShock		-.077 (.162)		-.007 (.241)
N	5322	5322	2716	2688
R ²	0.08	.12	.13	.14
Village, year, and month FE?	Y	Y	Y	Y

Notes: Standard errors are in parentheses below coefficients and are adjusted for clustering within a household. *** indicates $p < .01$; ** indicates $p < .05$; * indicates $p < .10$. The unit of observation is an individual-month. RainShock = rainfall in meters for July and August. Small, medium, and large landholdings as the bottom, middle, and top third of the village-specific land distribution. In columns 1-2, the number of working adults in the household and its with MoreRain are included as controls. In columns 3-4, number of working males in the household and its interaction with MoreRain are included. Sources: ICRISAT (years=1975-1979, villages = Aurepalle, Shirapur, and Kanzara).

Table 8c
Migration by Land Ownership

Dependent variable: Has migrated temporarily for work								
Model	All adults				Adult males			
	<u>Probit</u> (1)	<u>OLS</u> (2)	<u>Probit</u> (3)	<u>OLS</u> (4)	<u>Probit</u> (5)	<u>OLS</u> (6)	<u>Probit</u> (7)	<u>OLS</u> (8)
RainShock	.005 (.006)	.006 (.014)	.002 (.006)	-.008 (.020)	.009 (.011)	.008 (.026)	.001 (.014)	-.024 (.038)
Landless	.025 (.016)	.018 (.011)	.019 (.015)	.016 (.013)	.044 (.032)	.037 * (.022)	.035 (.031)	.032 (.024)
Small landholding			-.015 *** (.006)	-.016 * (.009)			-.027 *** (.010)	-.028 (.018)
Medium landholding			.007 (.008)	.006 (.012)			.014 (.017)	.009 (.023)
Landless * RainShock	-.028 ** (.014)	-.035 * (.020)	-.020 * (.012)	-.023 (.024)	-.060 ** (.026)	-.080 ** (.038)	-.039 (.024)	-.050 (.045)
SmallLand * RainShock			.033 ** (.017)	.017 (.027)			.062 * (.033)	(.034) (.054)
MediumLand * Rainshock			-.001 (.008)	.026 (.029)			.003 (.017)	(.067) (.054)
N	2972	3676	2972	3676	1577	1933	1577	1933
R ²		.05		.05		0.09		.10
Village, year, and month FE?	Y	Y	Y	Y	Y	Y	Y	Y

Notes: Standard errors are in parentheses below coefficients and are adjusted for clustering within a household. *** indicates p<.01; ** indicates p<.05, * indicates p<.10. For probit regressions the coefficients reported are changes in the probability of migration (as derivatives for continuous independent variables and discrete differences for land category dummies) evaluated at the mean of the independent variables. The unit of observation is an individual-month. Adults are defined as 20-60 year olds. RainShock = rainfall in meters for July and August. Small, medium, and large landholdings as the bottom, middle, and top third of the village-specific land distribution. In columns 1-4, male and the number of working adults in the household, and each interacted with MoreRain are included as controls. In columns 5-8, number of working males in the household and its interaction with MoreRain are included. Sources: ICRISAT (years=1975-1984, villages = Aurepalle, Dokur, Shirapur, Kalman, Kanzara, Kinkheda, Boriya Becharji, Rampura, Rampura Klan, and Papda).

Table 9
Poverty & Landholding

Panel A: RainShock = +1 if rain>80th percentile, -1 if rain<20th percentile, 0 otherwise

Dependent variable: log(ag wages), 1956-1987

	Measure of poverty			Measure of land inequality	
	<u>Per capita expenditure</u>	<u>Poverty head count</u>	<u>Gini coefficient of per capita expenditure</u>	<u>% of agricultural workers who are wage earners</u>	<u>Gini coefficient of land ownership (excluding landless)</u>
	(1)	(2)	(3)	(4)	(5)
RainShock	.0102 *** (.0038)	.0103 *** (.0038)	.0102 *** (.0038)	.0083 ** (.0037)	.0099 *** (.0038)
District Trait				-.0824 *** (.0100)	
District Trait * RainShock	-.0052 (.0034)	.0031 (.0043)	-.0035 (.0034)	-.0118 *** (.0039)	-.0002 (.0035)
N	8350	8350	8350	8670	8127
R ²	0.94	0.94	0.94	0.94	0.94
District and year FE?	Y	Y	Y	Y	Y
Other controls?	Y	Y	Y	Y	Y

Notes: Standard error in parentheses below coefficient. *** indicates p<.01; ** indicates p<.05, * indicates p<.10. Variables interacted with RainShock have been transformed to be mean 0, standard deviation 1. All regressions include as control variables % of cultivated land that is irrigated and the interaction between RainShock and each of latitude, longitude, altitude, % of cultivated land that is irrigated, and % of workforce in agriculture. Poverty head count is the % of households with per capital expenditure below 14000 rupees/year. Ratio of agricultural laborers to cultivators computed from 1961, 1971, and 1981 Censuses and linearly extrapolated between Census years. The data appendix describes how the Gini coefficient of land ownership is calculated. Sources for poverty and land measures: columns 1-3, National Sample Survey, Round 43 (1987-8); column 4: World Bank; column 5: Census 1981.

Appendix Table 1
Results with Continuous RainShock Measure

Note: This table presents results similar to those in Tables 3, 4, 5, and 9 except using the continuous measure of RainShock

RainShock = Proportional deviation from mean district rainfall

Dependent variable: log(ag wages), 1956-1987

	Trait = Banking				Trait = Accessibility			
	Bank branches per capita	Bank deposits per capita	Bank credit per capita	% of villages with rural bank branch	Road density (km/km ²)	Bus service (% of villages)	Railway (% villages with one)	Closeness to city
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RainShock	.0124 (.0095)	.0124 (.0095)	.0133 (.0095)	.0096 (.0095)	.0148 (.0092)	.0145 (.0093)	.0139 (.0093)	.0151 * (.0091)
District Trait				-.0145 *** (.0035)	-.0268 *** (.0033)			
District Trait * RainShock	-.0166 * (.0101)	-.0178 ** (.0081)	-.0138 * (.0073)	.0026 (.0091)	-.0167 ** (.0073)	-.0260 ** (.0107)	-.0199 ** (.0085)	-.0171 ** (.0078)
N	8094	8094	8030	8126	8399	8254	8254	8670

	Trait = Human Capital				Trait = Poverty or landholding				
	Literacy	Primary School (% of villages)	Middle School (% of villages)	High School (% of villages)	Per capita expenditure	Poverty head count	Gini of per capita expenditure	% of ag. workers who are wage earners	Gini coefficient of land ownership
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
RainShock	.0145 (.0091)	.0145 (.0093)	.0239 ** (.0097)	.0129 (.0099)	.0173 * (.0093)	.0179 * (.0093)	.0174 * (.0093)	.0107 (.0090)	.0175 * (.0095)
District Trait	-.0883 *** (.0083)							-.0825 *** (.0100)	
District Trait * RainShock	-.0142 * (.0082)	-.0345 *** (.0088)	-.0292 *** (.0107)	-.0476 *** (.0106)	-.0093 (.0094)	.0102 (.0097)	-.0072 (.0084)	-.0294 *** (.0094)	-.0017 (.0074)
N	8400	8254	7678	6878	8350	8350	8350	8670	8127

Notes: Standard error in parentheses below coefficient. *** indicates p<.01; ** indicates p<.05, * indicates p<.10. RainShock = (rainfall-mean district rainfall)/mean district rainfall (annual measures for 1956-1987). Variables interacted with RainShock have been transformed to be mean 0, standard deviation 1. All regressions include year and district fixed effects, % of cultivated land that is irrigated and the interaction between RainShock and each of latitude, longitude, altitude, % of cultivated land that is irrigated, and % of workforce in agriculture. See Tables 3, 4, 5, and 9 for data sources.

Appendix Table 2
Specification Test Based on Crop Yield and Area Cropped with Continuous RainShock

This table presents results similar to those in Table 7 except using the continuous measure of RainShock

RainShock = Proportional deviation from mean district rainfall

Panel A: Dependent variable: log(crop yield), 1956-1987

	District Trait			
	None	Bank deposits per capita	Road density	Literacy
	(1)	(2)	(3)	(4)
RainShock	.1324 *** (.0110)	.1350 *** (.0117)	.1412 *** (.0112)	.1385 *** (.0111)
District Trait			.0038 (.0041)	.0425 *** (.0101)
District Trait * RainShock		.0227 ** (.0100)	-.0081 (.0089)	.0428 *** (.0100)
N	8670	8094	8399	8400
R ²	.34	.33	.33	.34
District and year FE?	Y	Y	Y	Y
Other controls?	Y	Y	Y	Y

Panel B: Dependent variable: log(area cropped), 1956-1987

	District Trait			
	None	Bank deposits per capita	Road density	Literacy
	(1)	(2)	(3)	(4)
RainShock	.0849 *** (.0066)	.0885 *** (.0070)	.0875 *** (.0067)	.0870 *** (.0066)
District Trait			-.0048 ** (.0024)	.0207 *** (.0060)
District Trait * RainShock		.0175 *** (.0060)	.0012 (.0053)	.0213 *** (.0060)
N	8670	8094	8399	8400
R ²	.33	.33	.32	.32
District and year FE?	Y	Y	Y	Y
Other controls?	Y	Y	Y	Y

Notes: Standard error in parentheses below coefficient. *** indicates $p < .01$; ** indicates $p < .05$, * indicates $p < .10$. RainShock = (rainfall-mean district rainfall)/mean district rainfall (annual measures for 1956-1987). Variables interacted with RainShock have been transformed to be mean 0, standard deviation 1. All regressions include as control variables % of cultivated land that is irrigated and the interaction between RainShock and each of latitude, longitude, altitude, % of cultivated land that is irrigated, and % of workforce in agriculture. Ln(yield) is the weighted average ln(volume of crop produced/area cropped) for the 10 major crops by revenue (rice, wheat, sugar, gram, jowar, groundnut, bajra, maize, tur, and miscellaneous lentils) where the weights are the district-average revenue share of the crop, and the yield for each crop has been normalized to mean 1 for comparability across crops. Ln(area cropped) is constructed analogously.