Wage Volatility and Development:
How Poor Workers Respond to Productivity Shocks

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Abstract

In a model of an agrarian economy in which individuals vary in landownership, workers supply labor more inelastically the poorer they are and the less easily they can borrow, save, or migrate in response to productivity shocks. Consequently, underdeveloped and isolated areas experience more wage volatility. The poor are made worse off by this equilibrium effect. But for landowners, inelastic labor supply is a form of insurance. One ramification is that an economy-wide reduction in the cost of borrowing and saving can actually hurt a landowner. For a given level of income volatility, he can smooth consumption better; but his income becomes more volatile due to changes in the equilibrium wage. Data on the agricultural wage in 271 districts in India for 1956-87 are consistent with the model. In districts with better banking or access to other areas (e.g., higher road density), the agricultural wage is less influenced by weather shocks, controlling for geography, irrigation, and sectoral composition. In sum, the poor are vulnerable to productivity risk; I show that underdevelopment exacerbates this risk.

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1 Introduction

Several papers suggest that labor supply in poor countries is inelastic, perhaps even downward-sloping in the wage.[1] This paper models the 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 work more in order to meet their consumption needs. For a given negative shock to productivity, the equilibrium wage is lower in the second economy. The consequence for a worker 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 acts in the direction of increasing the labor supply elasticity (substitute away from labor when labor is less valuable), and the income effect, which decreases 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 heightens the income effect. 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 labor supply in

[1] Rosenzweig (1980) estimates a labor supply elasticity of -0.16 for landless males in rural India, and higher but also negative elasticity for landowners. Lamb (1996) estimates a negative labor supply elasticity, and Rose (2001) finds that off-farm labor market participation increases in response to bad weather shocks, both in rural India. Sharif (1991) reports a negative elasticity for landless workers and positive elasticity for landowning workers in rural Bangladesh. Frankenberg, Smith, and Thomas (2003) find that labor supply increased when the wage fell during the financial crisis in Indonesia.

an area will be more elastic when workers can migrate between areas more easily.[2]

General equilibrium effects act as a multiplier on the wage fluctuations that result from productivity 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 wage volatility. Volatile wages adversely affect laborers, so underdevelopment exacerbates the risk they face. Moreover, institutions that enable some workers to mitigate risk have a pecuniary benefit for other workers.

But for landowners who employ labor, inelastic labor supply and the ensuing wage volatility act as 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. Land profits are also less responsive to positive shocks when labor is supplied inelastically, but a risk averse landowner is better off on net when good and bad profit swings are dampened. As the model helps show, because of equilibrium effects on the wage, measures that enable individuals to better respond to risk—such as a reduction in the cost of financial transactions—may in fact hurt landowners.

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 productivity shocks depending on the availability of smoothing mechanisms which make labor supply more elastic. In this setting, the equilibrium effects are sizeable. I find, first, that wage volatility is less pronounced if an area has better opportunities for shifting income intertemporally, for example if the banking sector is more developed. Second, openness to other areas, which enables workers to substitute toward other labor markets instead of "selling low" in the home market, leads to large reductions in wage variability. An area with the mean road density has half the wage volatility of an area whose road density is one standard deviation below the mean. Third, and perhaps most surprisingly, landlessness among agricultural workers decreases wage volatility. One explanation may be that the landless migrate in response to negative shocks more readily 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.[3] 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 lockstep. Village insurance cannot address the component of risk that is common across

[2] I use *elastic* to mean that the elasticity is high, not large in magnitude.

[3] Some others find less complete sharing of idiosyncratic risk within rural villages (Ravallion and Chaudhuri 1997, Deaton 1997, Morduch 2001).

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 little 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.[4] Rodrik (1997, 1998), focusing on very different aspects of openness (e.g., 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. Openness alleviates risk that is common to an area but diversified across areas. Thus, integration with other markets can improve the welfare of the poor. 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 side 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 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. The land distribution is also found to have 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 equilibrium effects on the wage are considered.

2.1 Basic Assumptions

The economy (village) has a continuum of agents whose mass is normalized to 1. Agents live for two periods ($t = 1, 2$). Each agent i is endowed with landholding k_i. This is the only exogenous

[4] Attanasio and Rios-Rull (2000) demonstrate theoretically that insurance against aggregate shocks can reduce welfare if lowered costs of autarky lead to the collapse of informal insurance against idiosyncratic shocks.

difference among agents, and there is no market for land. All agents have the same endowment of time, $\overline{h}$, which they allocate between labor and leisure.

Production

In period 1, production is Cobb-Douglas in labor and land,

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

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

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

where $\sigma \in (0,1)$.

In period 2, income is exogenous. An individual earns y_{i2} which is an increasing function of landholding. The value of y_{i2} is assumed to be such that if there is a positive shock in period 1, individuals would want to save in order to optimize the relative marginal utility of consumption across periods, and conversely, if there is a negative shock, individuals would want to borrow.[5]

Utility function

Individuals have identical Stone-Geary preferences over consumption and leisure,

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

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 $\beta A(1-\sigma)\overline{h}^{\beta} K^{1-\beta} \geq \underline{c}$, where K is the total land in the economy, ensures that $\underline{c}$ 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. Indirect utility is denoted by V and, as shorthand, $V_i \equiv V(w; k_i)$.

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 $\widetilde{\Delta}_i \sim U[\Delta_{min}, \Delta_{min} + \psi]$. 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. The precise condition is given in the mathematical appendix.

[5] The proof of Proposition 3 shows that for all parameter values, there exist values of y_{i2} such that, in equilibrium, individuals transfer non-negative assets from period 1 to period 2 if $\widetilde{\sigma} = \sigma$, and non-positive assets from period 1 to period 2 if $\widetilde{\sigma} = -\sigma$.

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.*

Land distribution

The village has total land K, and there are two types of individuals, landless and landowning. A proportion $\theta \in (0, 1)$ 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 $\int_i d_i = \int_i (\overline{h} - l_i)$.

Rational expectations

Agents make their choices after observing the shock $\widetilde{\sigma}$, 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:

$$\max_{\substack{c_{i1} \geq \underline{c},\ c_{i2} \geq \underline{c} \\ \overline{h} \geq l_i \geq 0,\ d_i \geq 0 \\ Migrate_i \in \{0,1\}}} \log(c_{i1} - \underline{c}) + \frac{1-\alpha}{\alpha} \log l_i + b \log(c_{i2} - \underline{c}) \tag{2.1}$$

subject to

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

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}, and whether to stay in the village or migrate, $Migrate_i \in \{0, 1\}$. The only choice for period 2 is consumption c_{i2}. (The subscript for consumption indicates individual i and period t. I omit the time subscript for other variables.)

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 $\widetilde{\Delta}_i$.

2.3 Labor Demand

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

$$\frac{\partial f}{\partial d_i} = \beta \widetilde{A} \left(\frac{k_i}{d_i} \right)^{1-\beta} = w, \qquad \text{or} \qquad d_i^* = k_i \left(\frac{\widetilde{A}\beta}{w} \right)^{\frac{1}{1-\beta}}. \tag{2.2}$$

Land profits are thus

$$\pi_i = \widetilde{A} {d_i^*}^{\beta} k_i^{1-\beta} - d_i^* w = \widetilde{A}(1-\beta) k_i \left(\frac{\widetilde{A}\beta}{w} \right)^{\frac{\beta}{1-\beta}}. \tag{2.3}$$

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 the 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 $\phi \to \infty$. 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. 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 average level of productivity, A, relative to the subsistence level, $\underline{c}$, can be regarded as a measure of how rich (specifically technology-rich) the economy is. Conversely, the subsistence level $\underline{c}$, for a given level of A, is a measure of poverty. Poverty here is defined as a characteristic of the economy rather than of certain individuals within the economy. Poverty will have an effect on wage volatility because when workers are closer to subsistence, they supply labor less elastically.

I refer to labor supply as less elastic when the elasticity is lower, not smaller in magnitude. With this usage, if the labor supply elasticity becomes more negative, it becomes more inelastic.

Note that poverty could have other effects on labor supply that are not in the model. For example, a worker's productivity may improve when he is better nourished and healthier (Leibenstein 1957, Dasgupta and Ray 1986). If bad shocks force poor workers out of the labor market because of malnourishment, then poverty instead could increase the labor supply elasticity.

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

$$\begin{aligned} &\max_{c_i \geq \underline{c},\ \overline{h} \geq l_i \geq 0} \log(c_i - \underline{c}) + \frac{1-\alpha}{\alpha} \log l_i \\ &\text{subject to} \quad c_i \leq \pi_i + w(\overline{h} - l_i) \end{aligned} \tag{3.1}$$

The interior 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,

$$c_i^* = \alpha(w\overline{h} + \pi_i - \underline{c}) + \underline{c}$$
$$l_i^* = (1-\alpha)\left(\frac{w\overline{h} + \pi_i - \underline{c}}{w}\right)$$

which gives the following expression for labor supply:

$$\begin{aligned} h_i^* = \overline{h} - l_i^* =& \alpha\overline{h} + (1-\alpha)\left(\frac{\underline{c} - \pi_i}{w}\right) \\ =& \alpha\overline{h} + (1-\alpha)\underline{c}w^{-1} - (1-\alpha)\widetilde{A}(1-\beta)(\widetilde{A}\beta)^{\frac{\beta}{1-\beta}} w^{-\frac{1}{1-\beta}} k_i. \end{aligned} \tag{3.2}$$

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 in the expression for h_i^*. Three 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. (This result would not necessarily hold with migration or at a corner solution in which landowners supply no labor.) Second, landowners supply labor more elastically than the landless. The derivative with respect to w of the last term in the expression for h_i^* is increasing in k_i. Third, if the subsistence level is positive, then the labor supply elasticity can be negative. For example, the landless, for whom $\pi_i = 0$, have a negative labor supply elasticity for $\underline{c} > 0$ and an elasticity of 0 if $\underline{c} = 0$. Rosenzweig

(1980) and others find empirical evidence that the labor supply elasticity is negative, and also lower for the landless, in agrarian labor markets.

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.

To first order in σ, wage volatility is proportional to the elasticity of the wage with respect to productivity. To see this, let w^+ denote the wage in the state $\widetilde{\sigma} = \sigma$, w^- denote the wage when $\widetilde{\sigma} = -\sigma$, and $\overline{w}$ denote the wage in the hypothetical state $\widetilde{\sigma} = 0$. The Taylor expansion of ν gives

$$\begin{aligned}
\nu &= \frac{\sqrt{\frac{1}{2}(w^+ - \frac{1}{2}(w^+ + w^-))^2 + \frac{1}{2}(w^- - \frac{1}{2}(w^+ + w^-))^2}}{\frac{1}{2}(w^+ + w^-)} = \frac{w^+ - w^-}{w^+ + w^-} \\
&\approx \frac{\overline{w} + A\sigma \frac{\partial w}{\partial \widetilde{A}}\big|_A - \left(\overline{w} - A\sigma \frac{\partial w}{\partial \widetilde{A}}\big|_A\right)}{2\overline{w}} \\
&= \sigma \left(\frac{\partial w}{\partial \widetilde{A}} \frac{\widetilde{A}}{w} \right) \Bigg|_A \qquad (3.3)
\end{aligned}$$

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

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

I prove this result using a linear approximation of wage volatility but conjecture that it holds for all σ. According to the result, for a given subsistence level, when average productivity is lower, or the economy is poorer, the wage is more volatile. The reasoning behind the result is that the income elasticity of labor supply becomes more pronounced as consumption approaches $\underline{c}$. Labor supply is more inelastic in poor places, and the implication is that equilibrium effects are especially likely to amplify the effect of productivity shocks on wages in developing countries and, within developing countries, in poorer areas.[6]

[6] Evidence in the real business cycle literature suggests that the wage is more responsive to shocks in poor countries. For example, in the five developing countries studied by Agenor, McDermott, and Prasad (2000), the correlation between the quarterly real wage and contemporaneous domestic output ranges from .31 to .68 for 1978-95. (They do not report the variance of the wage.) The correlation coefficient in the U.S. is about .12 (King and Rebelo 1999).

3.2 Distributional Implications of 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 ($\Delta_{min} \to \infty, \phi \to \infty$), 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: $w = \beta^{\beta} \left(\frac{1}{\alpha} - (1-\beta)\right)^{1-\beta} \widetilde{A} \left(\frac{K}{\overline{h}}\right)^{1-\beta}$. Averaging this expression over good and bad shocks, I define the expected autarkic wage as

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

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 Proposition 4. Here I establish the result in a more general form. Recall that V_i denotes indirect utility.

Lemma 1. *$\exists\, k^* > 0$ such that $\frac{\partial^2 V_i}{\partial w^2} < 0$ for $k_i < k^*$, and $\frac{\partial^2 V_i}{\partial w^2} \geq 0$ for $k_i \geq k^*$.*

All individuals are averse to volatile productivity (i.e., increases in σ reduce their expected utility). However, Lemma 1 establishes that, conditional on σ, while the landless are averse to wage volatility, sufficiently large landowners in fact prefer volatile wages. The wage is endogenous in the model; this partial equilibrium result simply helps with the intuition for why changes in exogenous parameters, by affecting the elasticity of labor supply, will have different welfare consequences for rich and poor.

The starting point in understanding this result is that given their risk aversion, agents are averse to income fluctuations (holding the price of the consumption good fixed). For the landless, income is proportional to the wage, and therefore indirect utility is concave in the wage. Landowners, on the other hand, also earn income from their land for which the wage is an input price. The fact that higher variance of the wage 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. Each landowner owns a larger portion of the economy's land than labor, and given the utility and production functions, on net his utility is therefore convex in the wage. (This is shown alongside the proof to Lemma 1 in the appendix.) In section 3.4, I will extend this result to show that because of landowners' preference for volatile wages, an increase in the exogenous banking cost ϕ could make them better off.

3.3 Effects of Migration

In this section I examine how migration costs and the distribution of land affect wage volatility.

I model out-migration in response to shocks. When the economy has a negative shock, out-migration decreases local labor supply, increasing the wage and reducing wage volatility. It is possible to extend the model to two symmetric economies with uncorrelated productivity shocks and to allow for both out- and in-migration. When one village has a better shock than the other, in-migration would increase labor supply in the temporarily higher-productivity village. The influx of labor would reduce the wage associated with a positive productivity shock, so in-migration would also dampen wage volatility.

Ruling out intertemporal transfers ($\phi \to \infty$) and focusing on period 1, the maximization problem becomes

$$\max_{\substack{c_i \geq 0,\ \overline{h} \geq l_i \geq 0 \\ Migrate_i \in \{0,1\}}} \log c_i + \frac{1-\alpha}{\alpha} \log l_i \tag{3.4}$$

$$\text{subject to} \quad c_i \leq \pi_i + w(\overline{h} - l_i) + ((W - w)(\overline{h} - l_i) - \widetilde{\Delta}_i) Migrate_i$$

Given the individual's decision about whether to migrate, he will spend a fraction α of wealth (net of any migration costs) on consumption, and the remainder on leisure:

$$c_i^* = \alpha(w_i \overline{h} + \pi_i - \Delta_i)$$
$$l_i^* = (1-\alpha)\left(\frac{w_i \overline{h} + \pi_i - \Delta_i}{w_i}\right)$$

where

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

The incentive to migrate is decreasing in the cost $\widetilde{\Delta}_i$. 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 2.

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

(ii) $\Delta_p > \Delta_r$, *or the landless have a higher propensity to move than landowners.*

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

Part (i) formalizes the fact that when migration costs are lower, more individuals migrate out, and labor supply in the economy is lower. This implies a higher wage, and a higher wage in the event of $\widetilde{\sigma}_1 = -\sigma$ is equivalent to a reduction in wage volatility (see Lemma 2 in the appendix).

The intuition for why the landless have a higher propensity to migrate (part (ii)) is straightforward. A landowner, by virtue of having greater 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.)

Part (iii) relates the land distribution to wage volatility. 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 declines. 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 other utility functions, the land distribution could have a direct effect on labor supply. This result should be interpreted less as a comprehensive statement about the 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.

One implication is that redistribution of land will affect even individuals whose own landholding is unchanged.[7] Since wage volatility makes the landless worse off, a decrease in θ—for example, taking land from landowners and giving it to some of the landless population—has a negative pecuniary effect on individuals who remain landless.

Corollary 2.1. *Suppose $\theta \to \hat{\theta}$ where $\theta > \hat{\theta} > 0$. EV_i decreases for individuals with $k_i = 0$ after the change, or partial land redistribution reduces the expected utility of those 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. The level of y_{i2} is assumed to be such that individuals transfer non-negative assets from period 1 to period 2 (save) if there is a good shock, and they transfer non-positive assets (borrow) if there is a bad shock. The proof of Proposition 3 shows that such values exist.

Ruling out migration ($\Delta_{min} \to \infty$), the individual maximization problem is:

$$\max_{c_{it}\geq 0,\ \overline{h}\geq l_i \geq 0} \log c_{i1} + \frac{1-\alpha}{\alpha}\log l_i + b\log c_{i2} \tag{3.5}$$
$$\text{subject to } \ c_{i2} \leq y_{i2} + \left(R + (-1)^{\mathbb{1}(c_{i2}>y_{i2})}\phi\right)(\pi_{i1} + w(\overline{h} - l_i) - c_{i1})$$

where b is the subjective discount rate, R is the exogenous interest rate, and ϕ is the banking fee.

[7] A related literature discusses indirect effects of agrarian land reform, focusing on the provision of public goods (e.g., irrigation). For example, Bardhan, Ghatak, and Karaivanov (2002) find theoretically that land redistribution could either ameliorate or worsen collective action problems. See also Bardhan (1984) and Boyce (1987).

$\mathbb{1}$ 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 3. $\frac{\partial \nu}{\partial \phi} > 0$*, 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. Without the ability to save, working more will raise a worker's period-1 consumption, which has a decreasing marginal benefit. Adding to period-1 income is more valuable to him if he can also shift income to period 2, when the marginal utility of consumption is higher. High banking costs therefore imply more inelastic labor supply and, in turn, more wage volatility. 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 4.

(i) Suppose $\phi = \phi_r$ *if* $k_i > 0$ *and* $\phi = \phi_p$ *if* $k_i = 0$*. For* $k_i > 0$*,* $\exists$ *parameter values such that* $\frac{\partial EV_i}{\partial \phi_p} > 0$*, or an increase in the banking fee of the landless can make a landowner better off.*

(ii) Suppose all agents face the banking cost ϕ*. For* $k_i > 0$*,* $\exists$ *parameter values such that* $\frac{\partial EV_i}{\partial \phi} > 0$*, or an increase in the economy-wide banking fee can make a landowner better off.*

Part (i) considers the welfare implications if landless workers' ability to borrow and save changes. Landless individuals enjoy a direct benefit if their banking cost declines since they are better able to smooth consumption. In addition, wage volatility declines—the wage in the event of bad shocks increases, and the wage in the event of good shocks decreases. A landowner experiences only the equilibrium effect, and the effect can make a sufficiently large landowner worse off.

A reduction in the economy-wide cost of banking can also hurt a landowner, according to part (ii). This is arguably the most surprising result presented. It is stronger than part (i) since here a landowner's *own* cost of borrowing and saving is lowered. In partial equilibrium, lower banking costs are Pareto-improving: every agent benefits from being better able to smooth consumption. However, the equilibrium wage effect—lower wage volatility—further helps the landless, but may hurt landowners. If the effects on the wage are strong enough, on net a landowner is better off with more friction in the banking sector, despite his lessened ability to shift his income intertemporally.

For a large landowner, lower wage volatility has the adverse effect of making his income more volatile. Consider the case of a negative shock to total factor productivity. The shock lowers the productivity of land, but with more inelastic labor supply, a landowner pays a lower wage and his profits fall by less. For a risk averse landowner, this benefit outweighs the cost of inelastic labor supply, namely a higher wage in the event of good shocks.

Said differently, inelastic labor supply is like insurance for a landowner: it boosts profits in bad times and reduces profits in good times. As is well known, a market may play more than one role when some markets are missing. In this economy, which lacks an insurance market, the labor market allocates workers' time, and it also allocates income risk between workers and landowners. An intervention like a lower banking cost that makes labor supply more elastic amplifies the effect that shocks have on land profits and shifts income risk toward landowners.

3.5 Generalizability of the Results

Poverty, costly migration, and costly financial transactions each amplify the wage volatility caused by productivity shocks. These results were derived "turning on" one factor at a time in the model. Here I speculate on some ways in which the solution to the full model might differ.

If migration and borrowing were considered together, as modelled they would be substitute ways of smoothing consumption. An increase in the cost of migration would still harm workers, but less so if they were better able to borrow, for example. The model implicitly assumes that migrants simultaneously receive their labor income and pay the migration cost. Interestingly, migration and banking might be complements if instead the migration cost were incurred at the start of period 1. Workers who could borrow to pay the migration cost would be best able to respond to shocks.

A subsistence requirement increases the amount of labor that is supplied, particularly when there is a bad shock, so the wage in an isolated economy would fall more sharply in bad times if $\underline{c} > 0$. The benefits of out-migration are higher in this case. Subsistence also would affect intertemporal transfers. For example, since utility is more concave at a given consumption level when $\underline{c} > 0$, individuals, especially the poor, would have a stronger incentive to smooth consumption across periods. It is likely that borrowing and saving to smooth income fluctuations would be less sensitive to the effective interest rate, and hence labor supply and the wage would respond less to changes in banking costs.

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 productivity 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:

$$w_{jt} = \beta_1 A_{jt} + \beta_2 S_{jt} + \beta_3 S_{jt} * A_{jt} + \beta_4 X_{jt} + \beta_5 X_{jt} * A_{jt} + \delta_t + \alpha_j + \varepsilon_{jt}$$

The dependent variable w_{jt} is the natural log of the wage for district j in year t. A_{jt} is the log of agricultural productivity. 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.

The coefficient β_1 measures the elasticity of the wage with respect to productivity which is proportional to wage volatility, as seen in (3.3). With district fixed effects included, deviations from the district's average productivity identify β_1. In practice I use measures of weather shocks (rainfall in excess of the district's normal rainfall) as a proxy for productivity shocks, since good weather typically raises agricultural 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 productivity 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 productivity 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 falls 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 productivity shocks, or, in shorthand, wage volatility. Testing this prediction is the objective of this section.

The identification strategy assumes that rainfall affects total factor productivity and does not affect the shape of the production function, workers' endowment of time, or preferences. Another important assumption is that S_{jt} measures differences in the labor supply elasticity and not differences in the size of the productivity 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 productivity shocks if areas that are

[8]Another 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.

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 productivity 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 productivity 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 how sensitive agricultural productivity or low-skill labor productivity is to weather. X_{jt} includes the latitude, longitude, and altitude of the district, the percentage of cultivated land that is irrigated, the percentage of the workforce in agriculture, and the population density.

In addition, section 5.6 presents a specification test that helps distinguish between the labor supply 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. The basis of the test is that these outcomes, since they are increasing in both productivity and the quantity of available labor, should be more sensitive to shocks when labor supply is more elastic. In contrast, the outcomes should respond less to the shock variable when weather has a smaller impact on agricultural productivity. The results of the test support the conclusion that smoothing mechanisms reduce wage volatility because they increase the elasticity of labor supply.

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 rural 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. 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 male 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 agricultural productivity. 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. In this sense, India 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 shortfalls are of greatest concern.[9]

I construct the variable, *RainShock*, accordingly, treating a surplus of rain as a good shock and a shortfall as a bad shock. Previous studies of India use similar specifications when measuring agricultural shocks with rainfall (Jacoby and Skoufias 1997, Kochar 1997, Rose 2001). The first *RainShock* variable 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 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.

[9]Extreme flooding presumably would be an exception. See also Das (1995) and Economic Research Foundation (2000) on the relationship between rainfall and agricultural productivity in India.

The rainfall measures are positively correlated with the log of the agricultural wage, as shown in Table 2.[10] 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 productivity shocks. A higher-order polynomial in rainfall would better predict the wage, but there is a tradeoff: the 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 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 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. 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. The agricultural wage might also be less sensitive to agricultural productivity (rain shocks) if the non-agricultural sector is more important in the local economy. I therefore include as controls *RainShock* interacted with the fraction of the workforce in agriculture, as well as population density and its interaction with *RainShock* since more densely populated areas might be more industrialized.[11]

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 0.6 log points. As expected, more irrigation is associated with

[10]Theoretically, lagged shocks also might affect the wage, for example if workers use savings to cushion a first bad shock, and then, with buffer stocks depleted, supply labor more inelastically if a second bad shock hits. Empirically, I do not find an effect of lagged shocks and therefore do not include them in this analysis.

[11]Population density might affect the wage not only because it is a control for industrialization but also more directly since it measures the relative abundance of labor and land in the economy, or $\frac{\bar{h}}{K}$ in the model.

lower wage volatility, although the coefficient is statistically insignificant. Wage volatility is higher, surprisingly, when population density is higher, and the proportion of the workforce employed in agriculture has no effect. Columns 2 and 4 are the specifications that I augment below when testing whether banking and other factors affect wage volatility.

5.2 Banking and Wage Volatility

Table 3 presents results on the relationship between financial development and wage volatility. Proposition 3 suggests that access to banking should reduce the sensitivity of the wage to productivity 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. 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). Also note that for time-invariant measures of $Banking$, the level effect is absorbed by the district fixed effect.

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 90% of the sample, the bank deposit variable, for which the estimated interaction coefficient has the largest magnitude, is below 0.73, 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.

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 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 in response to unfavorable local labor market conditions (or where there is more in-migration when the local labor market is strong), wage volatility should be lower, as seen in Proposition 2(i). 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.[12] 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, consistent with the prediction. While a bad shock ($RainShock$ equals -1), reduces the wage by 1% evaluated at the mean road density, it reduces the wage by 2% in area whose road density is 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 likely facilitates rural-to-urban migration, then the wage is less sensitive to local shocks. The closeness variable is 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

[12] These 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, for example if prices become less countercyclical as discussed by Newbery and Stiglitz (1984).

afford school fees or because their labor income is needed, there might be a lower wage elasticity 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 $S * RainShock$ 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 productivity shock, but instead differences in the intensity of the productivity shock caused by a given weather shock. I address this in part by including control variables for measures of geography, irrigation and sectoral composition. 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 the 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 productivity shock associated with $RainShock$ is less intense and the coefficient on $S * RainShock$ 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.[13]

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(volume of crop produced/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 a roughly 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 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 larger, 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. The results suggest that banking, transportation, and human capital are measuring differences in the elasticity of labor supply. In other words, these findings support the interpretation that wage volatility is more pronounced in underdeveloped areas because workers have more limited means of responding to risk.

[13]This 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 the 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 other reasons that the landless could have a higher labor supply elasticity than landowners. An important possibility is that malnourishment reduces labor productivity and causes unemployment (Leibenstein 1957, Dasgupta and Ray 1986). If the landless consume less and are less healthy than landowners, then they may be more likely to be forced into unemployment when hit by a negative shock. A greater proportion of poor people in the potential labor force could lead to lower aggregate labor supply in bad times relative to good times, or more elastic aggregate labor supply. Wage volatility has different welfare implications in this case. A reduction in wage volatility would not be welfare-enhancing for the 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 increasing 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 productivity. 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 whether an individual has 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 landownership, or that the poor supply labor less elastically. 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. 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 less elastic 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. 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 2(ii), I find that the landless are more likely to out-migrate for work in response to bad shocks. 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. 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.[14] In columns 5-8, the sample is restricted to males (half the sample) and the coefficients on $Landless$ and $Landless * RainShock$ 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 and landlessness and wage volatility. First, I use three poverty or income distribution measures constructed from expenditure data in the National Sample Survey (1987-88): average per capita expenditure, the fraction of households below a poverty line of 14,000 rupees per year in expenditures (approximately the World Bank poverty line), and the Gini coefficient of per capita expenditure (columns 1-3). The interaction between per capita expenditure and $RainShock$ is negative and significant at the 10% level; wage volatility seems to be lower in areas that are richer. The poverty head count ratio and Gini coefficient do not have a statistically significant impact on wage volatility. It is difficult to know whether this reflects their true relationship with wage volatility or poor quality of the expenditure 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 an approximate measure of landlessness among agricultural workers.[15] I find that wage volatility is significantly lower if the fraction landless is higher. It is worth noting that unlike bank or road density, the proportion landless is *negatively*

[14]This pattern of migration is consistent with an extension of the model in which absentee landownership is costly, and the costs are decreasing in landownership because, for example, a small landowner must search for someone to manage his land while a large landowner already employs a manager.

[15]The ideal measure would include out-migrants and exclude in-migrants, i.e. the sample would be the potential agricultural workforce. This is unlikely to pose a problem in practice since the measure is decennial while the weather fluctuations and wage data are annual.

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. Among other possibilities is that malnourishment causes landless individuals to supply less labor in the event of bad shocks (although I find the opposite result along the hours margin in the ICRISAT sample).

The second measure of landownership I examine is the Gini coefficient of landholding calculated among landowners. The measure is constructed using data on the number of landowners in five size categories, as described in 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 characteristic of underdeveloped areas. Agricultural production is sensitive to drought, floods, pestilence, price fluctuations, and other events. This paper has argued that poverty and isolation exacerbate this risk.

In a model of an agricultural sector that employs labor and land and faces productivity risk, the closer workers are to subsistence, the more inelastically they supply labor, and the more volatile the wage is. Higher costs of migrating, borrowing, and saving also 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. For example, in a sample of 271 Indian districts observed over a 32-year period, moving from the average level of transportation infrastructure to one standard deviation below the average makes the wage twice as sensitive to weather-cum-productivity shocks. I also find suggestive evidence of higher wage volatility in poorer areas.

The distribution of wealth is important both in explaining wage volatility and in understanding its welfare consequences. The prevalence of landlessness among agricultural workers 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 addition, wage volatility has different welfare implications for rich and poor: fluctuations in the wage differentially hurt the poor, those whose main asset is their labor. For the rich who are net buyers of labor, wage volatility in fact can be beneficial. This result suggests that improvements in the banking sector—or other measures that affect how labor responds to shocks—have redistributional as well as level effects on welfare.

[16] Using 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 findings have at least three broader implications. First, certain types of openness may help the poor. Labor mobility is an important means of responding to productivity risk when shocks are local. A better developed financial sector is also beneficial, particularly when integrated with other areas so that the interest rate does not move in lockstep with local shocks.

Second, land redistribution from the rich to the poor could have counterintuitive effects. If land redistribution decreases 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 could have unexpected effects on individual choices and, in turn, on 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 an outside 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 decisive in collective decision-making would likely depend on the land distribution. When land is held by more individuals, landowners are a larger voting bloc. On the other hand, if land is held more widely, each landowner has a smaller ratio of land to labor, ceteris paribus, so his interests are more aligned with the landless. Depending on how a community reaches political decisions and how exposed the economy is to productivity shocks, a more equal land distribution could either encourage or hinder policies such as improved banking that are in the interest of the poor and, in addition, promote general economic growth.

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A Mathematical Appendix

A.1 Proofs

Proof of Proposition 1

Setting labor demand (line 2.2) equal to labor supply (line 3.2) gives

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

Rearranging this, define

$$g_1 \equiv \left(\frac{1-\alpha+\alpha\beta}{\beta}\right)\left(\frac{\widetilde{A}\beta}{w}\right)^{\frac{1}{1-\beta}}K - (1-\alpha)\underline{c}w^{-1} - \alpha\overline{h} = 0 \equiv \frac{x_1}{1-\beta}\left(\frac{\widetilde{A}}{w}\right)^{\frac{1}{1-\beta}} - (1-\alpha)\underline{c}w^{-1} - \alpha\overline{h} = 0$$

By the implicit value theorem, $\frac{\partial w}{\partial \widetilde{A}} = -\frac{\partial g_1}{\partial \widetilde{A}} / \frac{\partial g_1}{\partial w}$, so

$$\nu = \sigma\frac{A}{w}\frac{\partial w}{\partial \widetilde{A}}\bigg|_A + \mathcal{O}(\sigma^2) = \frac{x_1\left(\frac{A}{w}\right)^{\frac{1}{1-\beta}}\sigma}{x_1\left(\frac{A}{w}\right)^{\frac{1}{1-\beta}} - (1-\alpha)\underline{c}w^{-1}} + \mathcal{O}(\sigma^2) = \sigma\left(1 + \frac{(1-\alpha)\underline{c}w^{-1}}{x_1\left(\frac{A}{w}\right)^{\frac{1}{1-\beta}} - (1-\alpha)\underline{c}w^{-1}}\right) + \mathcal{O}(\sigma^2)$$

Note that $x_1 > 0$. By inspection, the term that is linear in σ is decreasing in A, so for sufficiently small σ, $\frac{\partial \nu}{\partial A} < 0$. ■

Proof of Lemma 1

Indirect utility is

$$\begin{aligned} V_i &= \log c_i^*(w) + \frac{1-\alpha}{\alpha}\log l_i^*(w) = \alpha^{-1}\log\left((\overline{h}w + \pi_i)w^{-(1-\alpha)}\right) + \log\alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}} \\ &= \alpha^{-1}\log\left(\overline{h}w^{\alpha} + \widetilde{A}^{\frac{1}{1-\beta}}\beta^{\frac{\beta}{1-\beta}}(1-\beta)k_i w^{-(1-\alpha)-\frac{\beta}{1-\beta}}\right) + \log\alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}} \\ &\equiv \alpha^{-1}\log\left(\overline{h}w^{\alpha} + x_2 k_i w^{-(1-\alpha)-\frac{\beta}{1-\beta}}\right) + \log\alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}} \equiv \alpha^{-1}\log g_2(w) + \log\alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}} \end{aligned}$$

where x_2 and g_2 are defined implicitly. Let $x_3 \equiv x_2 w^{-\frac{1}{1-\beta}} = \widetilde{A}^{\frac{1}{1-\beta}}\beta^{\frac{\beta}{1-\beta}}(1-\beta)w^{-\frac{1}{1-\beta}}$. This gives

$$\begin{aligned} \frac{\partial^2 V_i}{\partial w^2} &= \frac{1}{g_2(w)}\left(g''(w) - \frac{(g_2'(w))^2}{g_2(w)}\right) \\ &= \frac{w^{-2+\alpha}}{g_2(w)}\left(-\alpha(1-\alpha)\overline{h} + \left(1-\alpha+\frac{\beta}{1-\beta}\right)\left(1-\alpha+\frac{1}{1-\beta}\right)x_3k_i - \frac{\left(\alpha\overline{h} - \left(1-\alpha+\frac{\beta}{1-\beta}\right)x_3k_i\right)^2}{\overline{h}+x_3k_i}\right) \end{aligned}$$

The expression in large parentheses reduces to $-\alpha\overline{h}$ when $k_i = 0$, and the factor outside the parentheses is positive. Thus for the landless $\frac{\partial^2 V_i}{\partial w^2} < 0$. If $k_i = K$ (that is, an individual has the same share of the economy's land as he has of the economy's time), the third term in parentheses can be shown to equal 0, using the fact that labor receives β of output and land receives $1-\beta$ of output in equilibrium, and the fact that aggregate income to labor is $\alpha\overline{h}w - (1-\alpha)\Pi$, where aggregate land profits are denoted Π. Note that $x_3 = \Pi K^{-1}w^{-1}$. The same facts enable one to show that for $k_i \geq K$, the third term is negative and decreasing in magnitude in k_i. The second term in parentheses is positive and increasing in k_i. Thus, overall, $\frac{\partial^2 V_i}{\partial w^2}$ is increasing in landholding, and for a sufficiently large landholding, $\frac{\partial^2 V_i}{\partial w^2}$ is positive.

For $k_i = K$, when the third term vanishes, the expression in parentheses equals $(1 - \alpha + \frac{\beta}{1-\beta})\Pi w^{-1}(1-\beta)^{-1} > 0$, and therefore $\frac{\partial^2 V_i}{\partial w^2} > 0$. As established above, $\frac{\partial^2 V_i}{\partial w^2} > 0$ is increasing in k_i for all $k_i \geq K$, or alternatively all $\theta \geq 0$. Therefore $\frac{\partial^2 V_i}{\partial w^2} > 0$ for landowners who own $k_i = \frac{K}{1-\theta}$. ■

Statement and Proof of Lemma 2

The following lemma, which will be used in the proof of Proposition 2, 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 $\widetilde{\sigma} = \sigma$ and w^- be the wage in the state $\widetilde{\sigma} = -\sigma$.

Lemma 2. *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. Since $\nu = \frac{w^+ - w^-}{w^+ + w^-}$ from (3.3),

$$\frac{\partial \nu}{\partial w^+} = \frac{1}{w^+ + w^-}\left(1 - \frac{w^+ - w^-}{w^+ + w^-}\right) > 0$$

$$\frac{\partial \nu}{\partial w^-} = -\frac{1}{w^+ + w^-}\left(1 + \frac{w^+ - w^-}{w^+ + w^-}\right) < 0$$

Also

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

Proof of Proposition 2(i)

A higher equilibrium wage in the event of $\widetilde{\sigma} = -\sigma$ is equivalent to a reduction in wage volatility, using Lemma 2 and the fact that there is no migration when $\widetilde{\sigma} = \sigma$. The derivations below apply to the state $\widetilde{\sigma} = -\sigma$. 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. Among non-migrants, each landowner supplies $h_i = \alpha\overline{h} - \Pi w^{-1}(1-\theta)^{-1}$ and each landless agent supplies $h_i = \alpha\overline{h}$, 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 condition is $H = \theta f_p(\alpha\overline{h}) + (1-\theta)f_r(\alpha\overline{h} - (1-\alpha)\frac{1-\beta}{\beta}(1-\theta)^{-1}H)$. This gives

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

which in turn gives the following equilibrium wage:

$$w = \beta A(1-\sigma)\left(\frac{K}{H}\right)^{1-\beta} \equiv x_4\left(\frac{\beta\psi + (1-\alpha)(1-\beta)(\Delta_{min} + \psi - \Delta_r)}{\Delta_{min} + \psi - \Delta_r - \theta(\Delta_p - \Delta_r)}\right)^{1-\beta} \equiv x_4\left(\frac{N}{D}\right)^{1-\beta} \quad \text{(A.1)}$$

Taking the derivative with respect to ψ and simplifying gives

$$\frac{\partial w}{\partial \psi} = -\,x_4(1-\beta)\left(\frac{N}{D}\right)^{-\beta} D^{-2}(\theta(1-\alpha+\alpha\beta)(\Delta_p - \Delta_r) + \beta(\Delta_r - \Delta_{min})).$$

Since $\Delta_r \geq \Delta_{min}$ by definition, and $\Delta_p \geq \Delta_r$ by Proposition 2(ii), this expression is less than or equal to 0. ■

Proof of Proposition 2(ii)

$$V_i|_{Migrate_i=0} = \alpha^{-1}\log\left(\overline{h}w^\alpha + \widetilde{A}^{\frac{1}{1-\beta}}\beta^{\frac{\beta}{1-\beta}}(1-\beta)k_i w^{-(1-\alpha)-\frac{\beta}{1-\beta}}\right) + \log\alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}}$$
$$V_i|_{Migrate_i=1} = \alpha^{-1}\log\left(\overline{h}W^\alpha + \widetilde{A}^{\frac{1}{1-\beta}}\beta^{\frac{\beta}{1-\beta}}(1-\beta)k_i W^{-(1-\alpha)} w^{-\frac{\beta}{1-\beta}} - \widetilde{\Delta}_i W^{-(1-\alpha)}\right) + \log\alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}}$$

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

$$\left.\frac{\partial Gain_i}{\partial k_i}\right|_w = \alpha^{-1}\pi_k W^{-(1-\alpha)}\left(\frac{-(W/w)^{1-\alpha}}{\overline{h}w^\alpha + \pi_k w^{-(1-\alpha)}k_i} + \frac{1}{\overline{h}W^\alpha + \pi_k W^{-(1-\alpha)}k_i - \widetilde{\Delta}_i W^{-(1-\alpha)}}\right)$$

This expression is negative whenever $\overline{h}W - \widetilde{\Delta}_i > \overline{h}w$ which is true if $Gain_i \geq 0$. Also note that $\frac{\partial Gain_i}{\partial \widetilde{\Delta}_i} < 0$. The maximum value of $\widetilde{\Delta}_i$ such that an individual prefers to migrate in the event of a bad shock can be derived by solving for $\widetilde{\Delta}_i$ when $Gain_i = 0$. Define this cutoff, which is a function of k_i, as Δ_{cut}. Using the implicit value theorem, the derivative of Δ_{cut} with respect to k_i is equal to $-\frac{\partial Gain_i}{\partial k_i}/\left.\frac{\partial Gain_i}{\partial \widetilde{\Delta}_i}\right|_{\Delta_{cut}} < 0$. Thus $\Delta_p > \Delta_r$. ■

Proof of Proposition 2(iii)

Using Lemma 2 and the fact that no one migrates in or out when $\widetilde{\sigma} = \sigma$, the proposition is equivalent to $\frac{dw}{d\theta} > 0$ for the state $\widetilde{\sigma} = -\sigma$. Define x_4 as in the proof to Proposition 2(i). Then, using the expression for w given in (A.1),

$$g_3 \equiv w - x_4\left(\frac{\beta\psi + (1-\alpha)(1-\beta)(\Delta_{min} + \psi - \Delta_r)}{\Delta_{min} + \psi - \Delta_r - \theta(\Delta_p - \Delta_r)}\right)^{1-\beta} \equiv w - x_4\left(\frac{N}{D}\right)^{1-\beta} = 0,$$

and $\frac{dw}{d\theta} = -\frac{dg_3}{d\theta}/\frac{dg_3}{dw}$ by the implicit value theorem.

A preliminary step is to find the maximum migration cost at which agents migrate (i.e., solve for $\widetilde{\Delta}_i$ when $Gain_i = 0$):

$$\Delta_{cut} = \overline{h}W\left(1 - \left(\frac{w}{W}\right)^\alpha\right) - \pi_i\left(\left(\frac{W}{w}\right)^{1-\alpha} - 1\right).$$

where π_i is given in (2.3). Note, first, that Δ_{cut} is decreasing in w: the benefit of migrating is that the price received for one's own labor increases by $W - w$ which is decreasing in w. Formally, it is straightforward to show that $\frac{\partial Gain_i}{\partial w} < 0$ at $Gain_i = 0$; then, by the implicit function theorem, $\left.\frac{\partial \Delta_r}{\partial k_i}\right|_{K(1-\theta)^{-1}} = -(\Delta_p - \Delta_r)(1-\theta)K^{-1}$. Combined with $\left.\frac{\partial k_i}{\partial \theta}\right|_{K(1-\theta)^{-1}} = K(1-\theta)^{-2}$, this gives $\frac{\partial \Delta_r}{\partial \theta} = -(\Delta_p - \Delta_r)(1-\theta)^{-1}$. Third,

$$\frac{\partial \Delta_p}{\partial w} - \frac{\partial \Delta_r}{\partial w} = (1-\beta)\widetilde{A}^{\frac{1}{1-\beta}}\beta^{\frac{\beta}{1-\beta}}k_i\frac{\partial}{\partial w}\left(W^{1-\alpha}w^{-(1-\alpha)-\frac{\beta}{1-\beta}} - w^{-\frac{\beta}{1-\beta}}\right)$$
$$= -\left(\frac{\widetilde{A}}{w}\right)^{\frac{1}{1-\beta}}\beta^{\frac{\beta}{1-\beta}}k_i\left(\beta\left(\left(\frac{W}{w}\right)^{1-\alpha} - 1\right) + (1-\alpha)(1-\beta)\left(\frac{W}{w}\right)^{1-\alpha}\right) \leq 0 \quad \text{(A.2)}$$

since W must exceed w if any migration occurs, and if no migration occurs, $\frac{\partial \Delta_p}{\partial w} = \frac{\partial \Delta_r}{\partial w} = 0$.

The next step is to calculate $\frac{dg_3}{d\theta}$ and $\frac{dg_3}{dw}$. Since

$$\frac{dD}{d\theta} = -(\Delta_p - \Delta_r) - (1-\theta)\frac{\partial \Delta_r}{\partial \theta} = -(\Delta_p - \Delta_r) + (\Delta_p - \Delta_r) = 0,$$

and

$$\frac{dN}{d\theta} = -(1-\alpha)(1-\beta)\frac{\partial \Delta_r}{\partial \theta} = \frac{(1-\alpha)(1-\beta)}{1-\theta}(\Delta_p - \Delta_r) > 0,$$

$$\frac{dg_3}{d\theta} = -x_4(1-\beta)\left(\frac{N}{D}\right)^{-\beta} D^{-2}\left(\frac{dN}{d\theta}D - \frac{dD}{d\theta}N\right) < 0.$$

To find the sign of

$$\frac{dg_3}{dw} = 1 - x_4(1-\beta)\left(\frac{N}{D}\right)^{-\beta} D^{-2}\left(\frac{dN}{dw}D - \frac{dD}{dw}N\right),$$

note first that

$$\frac{dN}{dw} = -(1-\alpha)(1-\beta)\frac{\partial \Delta_r}{\partial w} \qquad \text{and} \qquad \frac{dD}{dw} = -\theta\frac{\partial \Delta_p}{\partial w} - (1-\theta)\frac{\partial \Delta_r}{\partial w}$$

Therefore, defining $x_5 \equiv (1-\alpha)(1-\beta)(\Delta_{min} + \psi - \Delta_r) > 0$,

$$\begin{aligned}\frac{dN}{dw}D - \frac{dD}{dw}N &= \frac{\partial \Delta_r}{\partial w}(-x_5 + \theta(1-\alpha)(1-\beta)(\Delta_p - \Delta_r)) + \frac{\partial \Delta_p}{\partial w}\theta(x_5 + \beta\psi) + \frac{\partial \Delta_r}{\partial w}(1-\theta)(x_5 + \beta\psi) \\ &= \theta x_5\left(\frac{\partial \Delta_p}{\partial w} - \frac{\partial \Delta_r}{\partial w}\right) + (1-\theta)\beta\psi\frac{\partial \Delta_r}{\partial w} + \theta\frac{\partial \Delta_p}{\partial w} + \theta(1-\alpha)(1-\beta)(\Delta_p - \Delta_r)\frac{\partial \Delta_r}{\partial w} < 0,\end{aligned}$$

using the fact that Δ_r and Δ_p are decreasing in w, the fact that $\frac{\partial \Delta_p}{\partial w} - \frac{\partial \Delta_r}{\partial w} \leq 0$ from (A.2), and the result of Proposition 2(ii) that $\Delta_p \geq \Delta_r$. Therefore $\frac{dg_3}{dw} > 0$, so $\frac{dw}{d\theta} > 0$ in the state $\widetilde{\sigma} = -\sigma$. ■

Proof of Corollary 2.1

This follows from the fact that indirect utility is strictly increasing in the wage for a landless individual (see proof of Lemma 1), and Proposition 2(iii) which shows that in all states of the world, the wage is weakly increasing in θ.

Proof of Proposition 3

Step 1: *Solve for the equilibrium.*

Define $\widehat{R} = R \pm \phi$. For $\widehat{R} > 0$, the solution to the maximization problem given in (3.5) is

$$c_{i1} = \frac{w\overline{h} + \pi_i + \frac{y_{i2}}{\widehat{R}}}{1+b+\gamma} \qquad\qquad c_{i2} = b\widehat{R}c_{i1}$$

$$h_i = \overline{h} - \frac{\gamma c_{i1}}{w} = \frac{1}{1+b+\gamma}\left((1+b)\overline{h} - \frac{\gamma(\pi_i + \frac{y_{i2}}{\widehat{R}})}{w}\right)$$

where $\gamma \equiv \frac{1-\alpha}{\alpha}$. Aggregating the expressions for labor demand and profits given in (2.2) and (2.3), this gives a market-clearing condition

$$g_4 \equiv \left(1 + \frac{1-\beta}{\beta}\left(\frac{\gamma}{1+b+\gamma}\right)\right)\left(\frac{\beta\widetilde{A}}{w}\right)^{\frac{1}{1-\beta}} K - \frac{1+b}{1+b+\gamma}\overline{h} + \frac{\gamma}{1+b+\gamma} Y_{i2}\widehat{R}^{-1}w^{-1} = 0$$

where Y_{i2} is the aggregate value of y_{i2}. For $\widehat{R} \leq 0$ (which is possible in the case when, absent banking costs, individuals would save), no intertemporal transfers occur; the period 1 outcomes are as in the autarkic case solved in section 3.3, and $c_{i2} = y_{i2}$.

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 $\widehat{R} = R - \phi$,

$$\frac{dg_4}{d\phi} = \frac{\gamma}{1+b+\gamma} Y_{i2} w^{-1}(R-\phi)^{-2} > 0$$

$$\frac{dg_4}{dw} = -\left(\frac{1}{1-\beta} + \frac{1}{\beta}\left(\frac{\gamma}{1+b+\gamma}\right)\right)\left(\frac{\beta\widetilde{A}}{w}\right)^{\frac{1}{1-\beta}} w^{-1}K - \frac{\gamma}{1+b+\gamma} Y_{i2} w^{-2}(R-\phi)^{-1} < 0$$

Therefore by the implicit value theorem $\frac{dw}{d\phi} > 0$ (or $\frac{dw}{d\phi} = 0$ at the corner solution). Similarly, when individuals are borrowing and $\widehat{R} = R + \phi$, it can be shown that $\frac{dg_4}{d\phi} < 0$ and $\frac{dg_4}{dw} < 0$ and therefore $\frac{dw}{d\phi} < 0$. In other words, an increase in ϕ increases the wage when individuals are saving and lowers the wage when individuals are borrowing.

Step 3: *Show that there is a range of values of* y_{i2} *such that agents save if* $\widetilde{\sigma} = \sigma$ *and borrow if* $\widetilde{\sigma} = -\sigma$*. It then follows that for* y_{i2} *in this range, an increase in* ϕ *increases wage volatility.* If c_{i2} is increasing in $\widetilde{A}$, then with fixed y_{i2}, the incentive to save is increasing in $\widetilde{A}$. Then y_{i2} can be restricted to a range such that workers save if $\widetilde{\sigma} = \sigma$ and borrow if $\widetilde{\sigma} = -\sigma$ since an individual saves if $y_{i2} = 0$ and borrows as $y_{i2} \to \infty$, and the incentive to borrow increases with y_{i2}.

Using the solutions above, c_{i2} is increasing in $\widetilde{A}$ if total income, defined as $\hat{y}_i \equiv w\overline{h} + \widetilde{A}(1-\beta)\left(\frac{\widetilde{A}\beta}{w}\right)^{\frac{\beta}{1-\beta}} k_i$, is increasing in $\widetilde{A}$. Defining $x_6 \equiv \left(\frac{1}{1-\beta} + \frac{1}{\beta}\left(\frac{\gamma}{1+b+\gamma}\right)\right)\left(\frac{\beta\widetilde{A}}{w}\right)^{\frac{1}{1-\beta}} K > 0$, note that

$$\frac{\partial w}{\partial \widetilde{A}} = -\frac{\frac{dg_4}{d\widetilde{A}}}{\frac{dg_4}{dw}} = \frac{\widetilde{A}^{-1}x_6}{w^{-1}x_6 + \frac{\gamma}{1+b+\gamma}Y_{i2}w^{-2}(R-\phi)^{-1}} < \frac{w}{\widetilde{A}} < \frac{w}{\beta\widetilde{A}}.$$

It then follows that

$$\frac{d\hat{y}_i}{d\widetilde{A}} = \frac{\partial \hat{y}_i}{\partial \widetilde{A}} + \frac{\partial \hat{y}_i}{\partial w}\frac{\partial w}{\partial \widetilde{A}} = \left(\frac{\beta\widetilde{A}}{w}\right)^{\frac{\beta}{1-\beta}} + \left(\overline{h} - \left(\frac{\beta\widetilde{A}}{w}\right)^{\frac{1}{1-\beta}}\right)\frac{\partial w}{\partial \widetilde{A}} > 0. \blacksquare$$

Proof of Proposition 4(i)

In the limit as $\theta \to 1$, the problem can be solved with 1 large landowner ($i = r$) who supplies no labor. The landowner borrows in bad states if $y_{r2} > b(R + \phi_r)\pi_-$ and saves in good states if $y_{r2} < b(R - \phi_r)\pi_+$. Let ϕ_r be sufficiently large such that neither of these inequalities holds. Then, denoting the landowner's profits when $\widetilde{\sigma} = \pm\sigma$ as $\pi_\pm$, his expected period-1 utility, up to a constant, is $EV_r = \frac{1}{2}(\log \pi_+ + \log \pi_-)$.

Let period-2 income for a landless worker, y_{p2}, which is also the aggregate value since the landless have mass 1, be such that he borrows in the event of a bad shock and saves in the event of a good shock. Let $w_{\pm}$ indicate the wage when $\widetilde{\sigma} = \pm\sigma$ and define $x_7 \equiv \frac{\gamma y_{p2}}{1+b+\gamma}$.

$$\frac{\partial w_{\pm}}{\partial \phi_p} = \pm \frac{x_7 (R \mp \phi_p)^{-2}}{x_7 (R \mp \phi_p)^{-1} w_{\pm}^{-1} + \left(\frac{\beta A_{\pm}}{w_{\pm}}\right)^{\frac{1}{1-\beta}} \left(\frac{1}{1-\beta}\right) k_r} = \pm \frac{x_7 (R \mp \phi_p)^{-2} w_{\pm}}{x_7 (R \mp \phi_p)^{-1} + \beta (1-\beta)^{-2} \pi_{\pm}}$$

and

$$\begin{aligned}\frac{\partial EV_r}{\partial \phi_p} =& \frac{1}{2}\left(\frac{\partial \pi_+}{\partial \phi_p}\frac{1}{\pi_+} + \frac{\partial \pi_-}{\partial \phi_p}\frac{1}{\pi_-}\right) = \frac{\beta}{2(1-\beta)}\left(\frac{\partial w_-}{\partial \phi_p}\frac{1}{w_-} + \frac{\partial w_+}{\partial \phi_p}\frac{1}{w_+}\right) \\ =& \frac{\beta x_7}{2(1-\beta)}\left(\frac{(R+\phi_p)^{-2}}{x_7(R+\phi_p)^{-1} + \beta(1-\beta)^{-2}\pi_-} - \frac{(R-\phi_p)^{-2}}{x_7(R-\phi_p)^{-1} + \beta(1-\beta)^{-2}\pi_+}\right).\end{aligned}$$

Since $\pi_+ > \pi_-$, and π_- is increasing in ϕ_p while π_+ is decreasing in ϕ_p, for sufficiently small ϕ_p, $\frac{\partial EV_r}{\partial \phi_p} > 0$. ■

Proof of Proposition 4(ii)

In the limit as $\theta \to 1$, the problem can be solved with 1 large landowner ($i = r$) who supplies no labor. Let period-2 income equal bR times the expected income in autarky. The expected wage income for a worker is $\beta \left(\frac{\alpha \bar{h}}{K}\right)^{\beta} AK$. Thus let $y_{p2} = \frac{\beta}{1-\beta} y_{r2} = bR\beta \left(\frac{\alpha \bar{h}}{K}\right)^{\beta} AK$. The conditions for saving in good times and borrowing in bad times are that y_{i2} is less than $b(R-\phi)$ times period-1 income when $\widetilde{\sigma} = \sigma$, and that y_{i2} is greater than $b(R+\phi)$ times period-1 income when $\widetilde{\sigma} = -\sigma$. Assume that σ is sufficiently large that these conditions hold.

$$\begin{aligned}EV_r = \frac{1}{2}&\left((1+b)\log\left(\pi_+ + y_{r2}(R-\phi)^{-1}\right) + b\log(R-\phi) + \right.\\ &\left.(1+b)\log\left(\pi_- + y_{r2}(R+\phi)^{-1}\right) + b\log(R+\phi) + 2b\log b - 2(1+b)\log(1+b)\right).\end{aligned}$$

Then

$$\frac{\partial EV_r}{\partial \phi} = \frac{1}{2}\left((1+b)\frac{\frac{\partial \pi_+}{\partial \phi} + y_{r2}(R-\phi)^{-2}}{\pi_+ + y_{r2}(R-\phi)^{-1}} - \frac{b}{R-\phi} + (1+b)\frac{\frac{\partial \pi_-}{\partial \phi} - y_{r2}(R+\phi)^{-2}}{\pi_- + y_{r2}(R+\phi)^{-1}} + \frac{b}{R+\phi}\right).$$

As $b \to 0$, $\frac{\partial EV_r}{\partial \phi} \to \frac{1}{2}\left(\frac{\partial \pi_+}{\partial \phi}\frac{1}{\pi_+} + \frac{\partial \pi_-}{\partial \phi}\frac{1}{\pi_-}\right)$. As shown in the proof to Proposition 4(i), for small ϕ, this expression is positive.

A.2 Other Derivations

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 $\widetilde{\Delta}_i$ when $Gain_i = 0$ and $w = w_{aut}(1+\sigma)$, and also $k_i = 0$ (since, from Proposition 2(ii), the constraint for the landless is the one that binds). This gives

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

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 data set 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 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 because of the high intensity of field work during these months. Missing data prevented their using a single agricultural occupation throughout the series, so their measure uses the wage for a male ploughman if available, then for a male field laborer, and then for other male agricultural labor.

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. Data on 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. The measures are constructed from expenditure data for households whose head of household works in agriculture.

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 size 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 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(yield) as the weighted average of ln(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(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 Small Landholding (ha)	Maximum Size of 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	0.00	0.28	8670	University of Delaware
Annual rainfall (millimeters)	1053	543	8670	University of Delaware
Banking				
Bank branches in 1981 (per 1000 people)	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
Access to other areas				
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
Closeness to city (km^{-1})	0.012	0.013	8670	Census of India
Human capital				
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
Poverty (among agricultural households)				
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
Land ownership				
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
Geographic and other control variables				
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
Population density ($population/km^2$)	289	178	8670	Census of India 1961/71/81
Agricultural measures used in specification checks				
Ln(crop yield)	0.05	0.40	8670	World Bank
Ln(area cropped)	0.42	0.68	8670	World Bank

Notes: The agricultural wage data is an annual series for 1956-1987 for 271 districts in India for a male ploughman or other comparable male farmworker. 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(crop 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. See the data appendix for further details.

Table 2
Relationship Between Rainfall Shock and the Agricultural Wage

Dependent variable: log(ag wage), 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 ***	.0100 ***	.0223 ***	.0146
	(.0037)	(.0037)	(.0083)	(.0091)
Altitude * RainShock		-.0059		-.0120
		(.0037)		(.0080)
Latitude * RainShock		.0091 **		.0178 **
		(.0036)		(.0083)
Longitude * RainShock		-.0089 **		-.0196 **
		(.0040)		(.0089)
% Irrigated		.0448 ***		.0446 ***
		(.0069)		(.0069)
% Irrigated * RainShock		-.0045		-.0096
		(.0037)		(.0085)
% Agricultural * RainShock		.0001		.0015
		(.0037)		(.0078)
Population Density		.0088		.0102
		(.0066)		(.0067)
Population Density * RainShock		.0086 **		.0286 ***
		(.0041)		(.0099)
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. For time-invariant variables interacted with RainShock, the district fixed effect absorbs the level effect. Sources: Wages, altitude, latitude, longitude, and % of cropped land that is irrigated are from the World Bank; rainfall is from the University of Delaware Center for Climactic Research; % of the workforce in agriculture and population density are from the Census (as compiled in the Indian District dataset, University of Maryland).

Table 3
Banking & Wage Volatility

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

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

	Measure of Banking			
	Bank branches per capita	Bank deposits per capita	Bank credit per capita	% of villages with rural bank branch
	(1)	(2)	(3)	(4)
RainShock	.0096 **	.0097 **	.0099 ***	.0093 **
	(.0038)	(.0038)	(.0038)	(.0038)
Banking				-.0152 ***
				(.0035)
Banking * RainShock	**-.0084** *	**-.0132** ***	**-.0088** **	**.0006**
	(.0047)	**(.0042)**	**(.0038)**	**(.0041)**
N	8094	8094	8030	8126
R^2	.95	.95	.95	.95
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 population density; and the interaction between RainShock and each of latitude, longitude, altitude, % of cultivated land that is irrigated, population density, and % of workforce in agriculture. The district fixed effect absorbs the level effect of time-invariant measures of banking. 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 wage), 1956-1987

	Measure of Accessibility			
	Road density (km/km^2)	Bus service (% of villages)	Railway (% villages)	Closeness to city (km^{-1})
	(1)	(2)	(3)	(4)
RainShock	.0089 **	.0095 **	.0095 **	.0100 ***
	(.0037)	(.0038)	(.0038)	(.0037)
Accessibility	-.0277 ***			
	(.0034)			
Accessibility * RainShock	**-.0114** ***	**-.0134** **	**-.0043**	**-.0083** **
	(.0033)	**(.0052)**	**(.0037)**	**(.0034)**
N	8399	8254	8254	8670
R^2	.95	.95	.95	.95
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 population density; and the interaction between RainShock and each of latitude, longitude, altitude, % of cultivated land that is irrigated, population density, and % of workforce in agriculture. The district fixed effect absorbs the level effect of time-invariant measures of accessibility. Sources for accessibility measures: column 1, World Bank; columns 2-3, 1981 Census; column 4, closeness to city =1/(distance to nearest city with 1981 Census population above 500,000).

Table 5
Human Capital & Wage Volatility

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

	Measure of Human Capital			
	Literacy	Primary School (% of villages)	Middle School (% of villages)	High School (% of villages)
	(1)	(2)	(3)	(4)
RainShock	.0092 **	.0096 **	.0129 ***	.0082 **
	(.0037)	(.0038)	(.0040)	(.0042)
Human Capital	-.0883 ***			
	(.0083)			
Human Capital * RainShock	**-.0112 ***	**-.0164 ***	**-.0091 ***	**-.0132 ***
	(.0039)	**(.0041)**	**(.0049)**	**(.0044)**
N	8400	8254	7678	6878
R^2	.95	.95	.95	.95
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 population density; and the interaction between RainShock and each of latitude, longitude, altitude, % of cultivated land that is irrigated, population density, and % of workforce in agriculture. The district fixed effect absorbs the level effect of time-invariant measures of human capital. 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

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

	(1)	(2)	(3)	(4)
Bank Deposits * RainShock	-.0125 ***	-.0100 **		-.0107 **
	(.0042)	(.0044)		(.0044)
Road Density * RainShock	-.0114 ***		-.0090 ***	-.0096 ***
	(.0033)		(.0035)	(.0035)
Literacy * RainShock		-.0089 **	-.0083 **	-.0055
		(.0042)	(.0040)	(.0044)
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

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

	(1)	(2)	(3)	(4)
Bank Deposits * RainShock	-.0238 ***	-.0171 *		-.0198 **
	(.0084)	(.0089)		(.0090)
Road Density * RainShock	-.0175 **		-.0126 *	-.0150 **
	(.0073)		(.0075)	(.0076)
Literacy * RainShock		-.0155 *	-.0160 *	-.0088
		(.0091)	(.0087)	(.0095)
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, using 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 population density; and the interaction between RainShock and each of latitude, longitude, altitude, % of cultivated land that is irrigated, population density, and % of workforce in agriculture. Main effects for RainShock and time-varying district traits are in all regressions.

Table 7
Specification Test Based on Crop Yield and Area Cropped

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

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

	District Trait			
	None	Bank deposits per capita	Road density	Literacy
	(1)	(2)	(3)	(4)
RainShock	.0566 ***	.0570 ***	.0603 ***	.0602 ***
	(.0045)	(.0047)	(.0045)	(.0045)
District Trait			.0045	.0314 ***
			(.0041)	(.0102)
District Trait * RainShock		**.0098** *	**.0004**	**.0180** ***
		(.0052)	**(.0041)**	**(.0047)**
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

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

	District Trait			
	None	Bank deposits per capita	Road density	Literacy
	(1)	(2)	(3)	(4)
RainShock	.0273 ***	.0289 ***	.0287 ***	.0289 ***
	(.0025)	(.0027)	(.0025)	(.0025)
District Trait			-.0063 ***	.0003
			(.0023)	(.0057)
District Trait * RainShock		**.0049** *	**.0045** **	**.0082** ***
		(.0029)	**(.0023)**	**(.0026)**
N	8670	8094	8399	8400
R^2	.41	.40	.40	.40
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 population density; and the interaction between RainShock and each of latitude, longitude, altitude, % of cultivated land that is irrigated, population density, and % of workforce in agriculture. The district fixed effect absorbs the level effect of time-invariant district traits. 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. Source for crop yield and area cropped: World Bank.

Table 8a
ICRISAT Summary Statistics

Sample for analysis of labor supply

Villages: Aurepalle, Shirapur, and Kanzara

Years: 1975-1979

Variable	Mean	Std. Dev	N
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
Adults per household	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 Kalan, and Papda

Years: 1975-1984

Variable	Mean	Std. Dev	N
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
Adults per household	3.48	2.08	3676
Male	0.53	0.50	3676
Male has temporarily migrated for work	0.037	0.19	1933
Male adults per household	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 ***	.430 ***	.508 ***	.570 **
	(.092)	(.153)	(.148)	(.239)
Landless	.291 ***	.418 ***	.326 ***	.401 ***
	(.058)	(.074)	(.109)	(.132)
Small landholding		.295 ***		.256 **
		(.059)		(.103)
Medium landholding		.155 **		.069
		(.070)		(.101)
Landless * RainShock	-.309 **	-.365 **	-.283	-.334
	(.123)	(.176)	(.227)	(.289)
Small Land * RainShock		-.253		-.318
		(.156)		(.247)
Medium Land * RainShock		-.077		-.007
		(.162)		(.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 are 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 interaction with RainShock are included as controls. In columns 3-4, number of working males in the household and its interaction with RainShock are included. Source: ICRISAT (years=1975-1979, villages = Aurepalle, Shirapur, and Kanzara).

Table 8c
Migration by Land Ownership

Dependent variable: Has migrated temporarily for work

	All adults				Adult males			
Model	Probit	OLS	Probit	OLS	Probit	OLS	Probit	OLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RainShock	.005	.006	.002	-.008	.009	.008	.001	-.024
	(.006)	(.014)	(.006)	(.020)	(.011)	(.026)	(.014)	(.038)
Landless	.025	.018	.019	.016	.044	.037 *	.035	.032
	(.016)	(.011)	(.015)	(.013)	(.032)	(.022)	(.031)	(.024)
Small landholding			-.015 ***	-.016 *			-.027 ***	-.028
			(.006)	(.009)			(.010)	(.018)
Medium landholding			.007	.006			.014	.009
			(.008)	(.012)			(.017)	(.023)
Landless * RainShock	-.028 **	-.035 *	-.020 *	-.023	-.060 **	-.080 **	-.039	-.050
	(.014)	(.020)	(.012)	(.024)	(.026)	(.038)	(.024)	(.045)
Small Land * RainShock			.033 **	.017			.062 *	(.034)
			(.017)	(.027)			(.033)	(.054)
Medium Land * Rainshock			-.001	.026			.003	(.067)
			(.008)	(.029)			(.017)	(.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 18-60 year olds. RainShock = rainfall in meters for July and August. Small, medium, and large landholdings are the bottom, middle, and top third of the village-specific land distribution. In columns 1-4, the number of working adults in the household and a dummy for male, and each interacted with RainShock are included as controls. In columns 5-8, number of working males in the household and its interaction with RainShock are included. Source: ICRISAT (years=1975-1984, villages = Aurepalle, Dokur, Shirapur, Kalman, Kanzara, Kinkheda, Boriya Becharji, Rampura, Rampura Kalan, and Papda).

Table 9
Poverty, Land Ownership, & Wage Volatility

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

	Measure of poverty			Measure of land inequality	
	Per capita expenditure	Poverty head count	Gini coefficient of per capita expenditure	% of agricultural workers who are landless	Gini coefficient of land ownership (excluding landless)
	(1)	(2)	(3)	(4)	(5)
RainShock	.0103 ***	.0105 ***	.0103 ***	.0088 **	.0110 ***
	(.0038)	(.0038)	(.0038)	(.0037)	(.0038)
District Trait				-.0846 ***	
				(.0100)	
District Trait * RainShock	**-.0063 ***	**.0025**	**-.0046**	**-.0119 *****	**.0008**
	(.0034)	**(.0043)**	**(.0034)**	**(.0039)**	**(.0035)**
N	8350	8350	8350	8670	8127
R^2	0.95	0.95	0.95	0.95	0.95
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 population density; and the interaction between RainShock and each of latitude, longitude, altitude, % of cultivated land that is irrigated, population density, and % of workforce in agriculture. The district fixed effect absorbs the level effect of time-invariant district traits. Poverty head count is the % of households with per capital expenditure below 14000 rupees/year. % of agricultural workers who are landless = laborers/(laborers + 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: Agricultural 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 wage), 1956-1987

	District Trait = Banking				District Trait = Accessibility			
	Bank branches per capita	Bank deposits per capita	Bank credit per capital	Rural bank branch (% of villages)	Road density (km/km^2)	Bus service (% of villages)	Railway (% villages)	Closeness to city
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RainShock	.0125	.0125	.0136	.0105	.0136	.0138	.0132	.0144
	(.0095)	(.0095)	(.0096)	(.0095)	(.0092)	(.0093)	(.0093)	(.0091)
District Trait				-.0154 ***	-.0266 ***			
				(.0035)	(.0033)			
District Trait * RainShock	**-.0205 ****	**-.0232 *****	**-.0164 ****	**-.0018**	**-.0165 ****	**-.0297 *****	**-.0190 ****	**-.0193 ****
	(.0101)	**(.0083)**	**(.0073)**	**(.0095)**	**(.0073)**	**(.0107)**	**(.0085)**	**(.0076)**
N	8094	8094	8030	8126	8399	8254	8254	8670

	District Trait = Human Capital				District 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 agric. workers who are landless	Gini coefficient of land ownership
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
RainShock	.0131	.0140	.0241 **	.0096	.0166 *	.0172 *	.0168 *	.0109	.0183 *
	(.0092)	(.0093)	(.0097)	(.0100)	(.0093)	(.0093)	(.0093)	(.0091)	(.0095)
District Trait	-.0871 ***							-.0849 ***	
	(.0084)							(.0100)	
District Trait * RainShock	**-.0209 ****	**-.0339 *****	**-.0329 *****	**-.0484 *****	**-.0126**	**.0075**	**-.0101**	**-.0289 *****	**-.0013**
	(.0085)	**(.0088)**	**(.0108)**	**(.0106)**	**(.0095)**	**(.0098)**	**(.0085)**	**(.0094)**	**(.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 as control variables % of cultivated land that is irrigated and population density; and the interaction between RainShock and each of latitude, longitude, altitude, % of cultivated land that is irrigated, population density, and % of workforce in agriculture. The district fixed effect absorbs the level effect of time-invariant measures of district traits. 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	.1264 ***	.1290 ***	.1348 ***	.1328 ***
	(.0110)	(.0117)	(.0112)	(.0112)
District Trait			.0029	.0348 ***
			(.0041)	(.0102)
District Trait * RainShock		**.0226 ****	**-.0076**	**.0449 *****
		(.0102)	**(.0088)**	**(.0103)**
N	8670	8094	8399	8400
R^2	.34	.34	.34	.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	.0682 ***	.0721 ***	.0699 ***	.0700 ***
	(.0062)	(.0066)	(.0062)	(.0062)
District Trait			-.0071 ***	.0019
			(.0023)	(.0057)
District Trait * RainShock		**.0127 ****	**.0029**	**.0178 *****
		(.0058)	**(.0049)**	**(.0058)**
N	8670	8094	8399	8400
R^2	.41	.41	.41	.41
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 population density; and the interaction between RainShock and each of latitude, longitude, altitude, % of cultivated land that is irrigated, population density, and % of workforce in agriculture. The district fixed effect absorbs the level effect of time-invariant district traits. 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. Source for crop yield and area cropped: World Bank.