Selling Labor Low: Wage Responses to Productivity Shocks in Developing Countries

Seema Jayachandran*

UC Berkeley and UCLA

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Abstract

Productivity risk is pervasive in underdeveloped countries. This paper highlights a way in which underdevelopment exacerbates productivity risk. Productivity shocks cause larger changes in the wage when workers are poorer, less able to migrate, and more credit-constrained because of such workers' inelastic labor supply. This equilibrium wage effect hurts workers. In contrast, it acts as insurance for landowners. Agricultural wage data for 257 districts in India for 1956-87 are used to test the predictions, with rainfall as an instrument for agricultural productivity. In districts with fewer banks or higher migration costs, the wage is much more responsive to fluctuations in productivity.

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I. Introduction

Most of the world's poor work in agriculture, a livelihood prone to large swings in productivity, caused for example by drought. An extensive literature has shown the severe welfare consequences of droughts and other productivity shocks in developing countries. Malnutrition increases, children drop out of school, and farmers sell down their productive assets, depressing their income in future years.[1] These effects occur in response to the sharp drop in earning power that agricultural workers experience during bad crop seasons. For example, in Bangladesh the real agricultural wage fell by 50% during the 1974 drought year, and over a more typical period from 1976 to 1984, the coefficient of variation of the annual real wage was 9% (Ravallion 1987, Osmani 1995).[2] Even extreme famines are generally regarded as due more to income loss than to food scarcity. The first famine report for India concluded that India experiences "rather famines of work than of food," (Srivastava 1968).

This paper highlights and examines empirically a way in which underdevelopment itself exacerbates productivity risk for the poor. Specifically, a productivity shock translates into a larger change in the wage if workers are closer to subsistence, less able to migrate, and more credit constrained because such workers supply labor less elastically. Consider an economy in which individuals are able to save or borrow. 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 and instead borrow or draw upon savings to smooth 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 total factor productivity (TFP), the equilibrium wage is lower in the second economy. The consequence for a worker is that he is exposed to more wage volatility in an economy with a less developed financial sector. Because of this pecuniary externality, a worker who cannot smooth consumption is better off if other workers can.

The labor supply response to a change in the wage has two offsetting effects. If the wage falls, an income effect leads workers to supply more labor and a substitution effect leads them to shift away from labor. When the the income effect is strong and the substitution effect is weak, individuals' labor supply responses will do little to cushion the aggregate impact of a shock. Underdeveloped areas have just this feature. The inability to save or borrow leads to a stronger income effect, as described above. Poverty also heightens the income effect. Being able to consume more is especially valuable to someone near subsistence, so his marginal utility of income is high. Another factor is

[1] See Rosenzweig and Wolpin (1993), Dreze (1995), Jacoby and Skoufias (1997), Jensen (2000), among others.
[2] The coefficient of variation is 9% for either the wage or the wage residual when a linear trend has been removed.

whether workers are able to substitute toward other labor markets. Agricultural shocks are typically local to an area, so labor supply in an area will be more elastic when workers can migrate between areas more easily.

The general equilibrium wage effects caused by inelastic labor supply have important distributional implications. When productivity shocks cause larger fluctuations in the wage, the poor are made worse off because the labor income which they rely upon becomes more volatile. For the land-owning rich, in contrast, wage fluctuations act as insurance. A negative shock to TFP reduces the profits earned from land, but the lower the wage a landowner must pay in lean times, the less profits are hurt. 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. Moreover, since a landowner's profit function is convex in the wage (an input price), increased wage variance raises average profits. Because of these equilibrium wage effects, measures that enable the poor to better respond to risk, such as better access to financial services, may hurt landowners.

To develop these ideas, the paper models an agrarian economy in which individuals vary in the amount of land they own, and the equilibrium wage is determined by individual labor supply and demand decisions. The model demonstrates how the responsiveness of the equilibrium wage to TFP shocks varies with workers' ability to smooth consumption, and how this differentially affects the welfare of wealthier versus poorer individuals.

The paper tests the predictions using data on 257 districts in India from 1956 to 1987. Data on the agricultural wage and crop yield are used to estimate the elasticity of the wage with respect to TFP and then to test whether the wage elasticity is larger in areas that are less developed. To isolate exogenous changes in agricultural productivity, local rainfall is used as an instrumental variable. The results suggest that the wage responds much differently to TFP shocks depending on the availability of smoothing mechanisms. First, the wage is less sensitive to productivity shocks if an area has better opportunities for shifting income intertemporally, that is, if the banking sector is more developed. Second, access to other areas, which enables workers to substitute away from the home labor market, leads to large reductions in wage variability. Compared to the sample mean, a standard deviation increase in railway access reduces the wage elasticity by more than 50%. Third, and perhaps most surprisingly, landlessness among agricultural workers decreases the responsiveness of the wage to TFP. One explanation supported by the data is that the landless migrate in response to negative shocks more readily than landowners who are tied to their land.

Several papers have found that individual labor supply is inelastic in poor countries, sometimes even downward-sloping in the wage.[3] This paper builds on the literature by considering the aggregate effect of such behavior—the fact that when workers "sell labor low," the wage becomes more sensitive to fluctuations in TFP. Figure 1 provides suggestive cross-country evidence consistent with this general equilibrium effect. The figure plots the magnitude of year-to-year fluctuations in the agricultural wage versus gross domestic product, using Occupational Wages of the World data (Freeman and Oostendorp 2000). Poorer countries seem to experience considerably more agricultural wage volatility than richer ones.[4] This paper offers an explanation for this fact based on individual behavior and price theory. While more time-series wage variance is consistent with the wage responding more to productivity shocks in poor countries, the pattern in Figure 1 could just be driven by poor countries having noisier wage data or larger agricultural productivity shocks. Hence, the approach of this paper is to examine not just wage variance but more precisely changes in the wage caused by changes in TFP. Moreover, using a unique panel data set, the paper employs microeconometric techniques that isolate exogenous TFP shocks.

The paper is also related to a large literature on income risk in developing countries. A main focus of previous work is informal village insurance, or the extent to which a community pools idiosyncratic risk.[5] One conclusion in the literature is that closed environments may be advantageous, for example because self-enforcing contracts are more sustainable when the cost of absconding is high. Townsend (1995) finds unusually 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. This paper, in contrast, emphasizes locally aggregate risk—when a village suffers a drought, by and large, all suffer in lockstep—which does not lend itself to village coinsurance. Openness could help alleviate this type of risk. For example, labor force mobility dampens the effects of shocks if workers in low-productivity areas migrate to higher-productivity areas. Moreover, it may be the poor who especially benefit from this type of market integration.

The remainder of the paper is organized as follows. Section II models an agrarian economy subject to productivity shocks, and section III presents the theoretical results. Section IV describes the empirical strategy and data used to test the predictions. The empirical results are presented in

[3]See Rosenzweig (1980), Lamb (1996), and Rose (2001) for evidence on rural India, Sharif (1991) on Bangladesh, and Frankenberg, Smith, and Thomas (2003) on Indonesia. Note that I use *inelastic* to mean that the elasticity is low, not small in magnitude.

[4]The real business cycle literature provides further evidence that the wage is more responsive to shocks in poor countries. 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. The correlation coefficient in the U.S. is about .12 (King and Rebelo 1999).

[5]See, for example, Townsend (1994), Ravallion and Chaudhuri (1997), Deaton (1997), Morduch (2001) and Attanasio and Rios-Rull (2000).

section V. Section VI presents conclusions.

II. Model of an Agrarian Labor Market with Productivity Shocks

This section models a rural agricultural economy subject to 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 wage effects in a setting where workers are reliant on their labor income. Then in section III comparative statics are derived and the model is extended to include migration.

A. Assumptions

The economy (village) has a large number N of agents who live for two periods ($t = 1, 2$). Each agent i is endowed with landholding k_i, and there is no market for land. All agents have the same endowment of time, $\overline{h}$, which they allocate between labor, h_i and leisure, l_i.

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 $k_p = 0$, and the remaining villagers have equally sized plots of land. That is, a proportion $1 - \theta$ of the villagers have $k_r = \frac{K}{(1-\theta)N}$. The subscript p denotes 'poor' and r denotes 'rich'.

Production in period 1 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, including both own and hired labor. Total factor productivity, $\widetilde{A}$, is stochastic with the following distribution:

$$\widetilde{A} = \begin{cases} A_H & \text{with probability } \frac{1}{2} \\ A_L & \text{with probability } \frac{1}{2} \end{cases}$$

with $A_H > A_L$. Let $A \equiv (A_H + A_L)/2$.

In period 2, income is exogenous. An individual earns y_i, the value of which is such that if there is a good shock in period 1, he would want to save in order to optimize the marginal utility of consumption across periods, and conversely if there is a bad shock, he would want to borrow. The purpose of y_i in the model is solely to generate this borrowing and saving behavior.[6]

[6] The value of y_i is assumed to be weakly increasing in landholding to ensure that landowners are always wealthier than the landless. The mathematical appendix shows that for all parameter values, there exist values of y_i such that, in equilibrium, individuals transfer assets from period 1 to period 2 if $\widetilde{A} = A_H$, and from period 2 to period 1 if $\widetilde{A} = A_L$.

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 $\underline{c} \geq 0$. (Parameter restrictions given in the mathematical appendix ensure this is feasible.) 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 U_i.

An individual may borrow or save at an exogenous interest rate $r \geq 0$; the village is a small open economy with respect to the financial market. Agents must have nonnegative 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 $\phi \in (0, r)$, which may depend on landholding, as the *banking cost*.[7]

The labor market clears at the endogenous wage w. At this wage $\sum_i d_i = \sum_i (\overline{h} - l_i)$. Note that agents make their choices after observing the realization of $\widetilde{A}$, and they have rational expectations about other agents' choices. Therefore agents' choices are optimal at the equilibrium wage.

B. Individual Maximization Problem

Gathering all of the assumptions gives the following maximization problem:

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

subject to

$$c_{i2} \leq (1 + (r+\phi)\mathbb{1}(c_{i2} < y_i) + (r-\phi)\mathbb{1}(c_{i2} > y_i)) \left(\widetilde{A} d_i^{\beta} k_i^{1-\beta} - d_i w + w(\overline{h} - l_i) - c_{i1} \right) + y_i$$

An individual has three choice variables in period 1: his leisure l_i, the quantity of labor d_i to use on his land, and consumption c_{i1}. 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

A supplemental appendix available from the author considers the cases where agents do not shift assets between periods in one of the states. The results do not change.

[7]The results hold if the cost of borrowing is allowed to differ from the cost of saving. The formulation with a single parameter simplifies the model. In some of the analysis, ϕ is allowed to differ for landowners versus the landless.

period 2, it enters the maximand as a constant that is set to 0, and 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_i. The effective 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.) The two sources of period-1 income are land profits, which equal output minus the wage bill, and labor income.

C. Labor Demand Solution

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,

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

Land profits are thus

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

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.

D. Labor Supply Solution

The interior solution to the maximization problem gives the following expression for labor supply:[8]

$$h_i^* = \frac{1-\alpha}{1+\alpha b} \left(\frac{\alpha(1-b)}{1-\alpha} \overline{h} - w^{-1} \left(\frac{y - \underline{c}}{1 + (r \pm \phi)} - \underline{c} + (1-\beta) \left(\frac{\widetilde{A}\beta^{\beta}}{w^{\beta}} \right)^{\frac{1}{1-\beta}} k_i \right) \right).$$

Individual labor supply is declining in landownership, as seen from the last term. Leisure is a normal good, and individuals with more land are wealthier. Two other features of labor supply are worth noting. First, since land 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 does not hold in general, e.g., in the extended model with migration or at a corner solution in which landowners

[8]The supplemental appendix considers corner solutions where landowners supply no labor.

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.

E. Definition of Wage Elasticity

Setting aggregate labor supply equal to aggregate labor demand determines the equilibrium wage. Let w_H denote the wage in the state $\widetilde{A} = A_H$ and w_L denote the wage when $\widetilde{A} = A_L$. The primary focus of the results will be the elasticity of the wage with respect to productivity, or wage elasticity.

Definition. *The* wage elasticity *is the arc elasticity of the wage with respect to productivity across the two states of the world:*

$$\nu \equiv \left(\frac{w_H - w_L}{A_H - A_L}\right)\left(\frac{A_H + A_L}{w_H + w_L}\right) \approx \frac{\partial w}{\partial \widetilde{A}}\frac{\widetilde{A}}{w}.$$

Since A_H and A_L are exogenous parameters, comparative statics for ν depend on the quantity $\frac{w_H - w_L}{w_H + w_L}$. Taking derivatives, it follows that for any parameter x, $\frac{\partial \nu}{\partial x} > 0 \Leftrightarrow w_L \frac{\partial w_H}{\partial x} - w_H \frac{\partial w_L}{\partial x} > 0$.

III. Theoretical Results

This section derives the relationships between the wage elasticity and factors such as poverty and the ability to save and borrow. The distributional implications of changes in the wage elasticity are also considered. Subsection III.D extends the model to analyze migration. All proofs are in an appendix available from the journal's website.

A. Effect 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 given levels of A_H and A_L, is a measure of poverty. Poverty, which here is defined as a characteristic of the economy rather than of certain individuals within the economy, will affect how responsive the wage is to changes in TFP because when workers are closer to subsistence, they supply labor less elastically.

Proposition (1). *The wage elasticity is increasing in poverty, where poverty is parameterized by the ratio of the subsistence level to average TFP ($\frac{\underline{c}}{A}$); for fixed A, $\frac{\partial \nu}{\partial \underline{c}} > 0$.*

Poverty affects the first moment of the wage; in a poorer area, more labor is supplied and the wage is lower in both states of the world. Poverty also affects the second moment because the income elasticity of labor supply is more pronounced in the low-productivity state, when consumption is closer to $\underline{c}$. Labor supply therefore is more inelastic in poor places. 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.

Poverty could have other effects on labor supply that are not modeled. For example, a worker's productivity may improve when he is better nourished (Leibenstein 1957, Bliss and Stern 1978, 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.

B. Effect of Borrowing and Saving

I next examine how the ability to smooth consumption intertemporally affects the wage elasticity.

Proposition (2). *The wage elasticity is increasing in banking costs, or $\frac{\partial \nu}{\partial \phi} > 0$.*

Banking costs affect the degree to which individuals save when there is a good shock and borrow when there is a bad shock. 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 his period-1 consumption, which has a decreasing marginal benefit. Raising his period-1 income is more valuable if he can also shift income to period 2, when the marginal utility of consumption is higher. 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. High banking costs therefore imply more inelastic labor supply and, in turn, larger wage responses to TFP shocks.

C. Welfare Implications of Wage Fluctuations—Landless versus Landowners

An important facet of wage fluctuations is that they affect landless and landowning individuals differently, and if a policy affects the wage elasticity, rich and poor people will have different preferences toward it. 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. Profit functions are convex in input prices, so mean-preserving spreads in the wage increase average land profits. Wage variance caused by TFP shocks has an additional special feature: the wage is lower precisely when land is less productive and profits are low. Thus, a higher wage elasticity acts as insurance for a landowner. For these reasons, it is possible that landowners would oppose a reduction in the cost of financial transactions.

Proposition (3)**.**

(i) An increase in the banking fee of the landless can make a landowner better off in expectation. That is, if $\phi = \phi_p$ *for* $k_i = 0$*, then* $\exists$ *parameter values such that* $\frac{\partial EU_r}{\partial \phi_p} > 0$*.*

(ii) An increase in the economy-wide cost of borrowing can make a landowner better off. That is, if all agents face the banking cost ϕ*, then* $\exists$ *parameter values such that* $\frac{\partial U_r}{\partial \phi} > 0$ *in the state* $\widetilde{A} = A_L$*.*

Part (i) considers the welfare implications if landless workers' ability to borrow and save changes.[9] Landless individuals enjoy a direct benefit if their banking cost declines since they are better able to smooth consumption. In addition, 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 him worse off. For a large landowner, smaller wage fluctuations have the adverse effect of making income more volatile. Consider the case of a negative shock to TFP. The shock lowers the productivity of land, and land profits fall. With more elastic labor supply, a landowner must pay a relatively higher wage in this state of the world and his profits fall by more. For a risk averse landowner, this cost outweighs the benefit of elastic labor supply, namely a lower wage in the event of good shocks.

Inelastic labor supply is like insurance for a landowner: it boosts profits in bad times and reduces profits in good times. A market often plays more than one role when other 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.

A reduction in the economy-wide cost of credit can also hurt a landowner, according to part (ii). Here a landowner's own cost of borrowing is lowered as well. In partial equilibrium, lower

[9] In practice, landowners and the landless usually do have different banking costs. The cost of borrowing is lower for landowners because their land can act as collateral.

credit fees are Pareto-improving in this economy: every agent benefits from being better able to smooth consumption. However, the equilibrium wage effect—a lower wage elasticity—further helps the landless, but can hurt landowners. If the effects on the wage are strong enough, on net a landowner is better off with more friction in the credit market, despite his lessened ability to shift income intertemporally.

D. Effects of Migration

This section extends the model to examine the effects of migration costs and also considers how the land distribution can affect the wage through its effects on migration.

An individual has the choice of whether to migrate in period 1 to another labor market that pays a fixed wage W. Individuals have independent migration costs drawn from a uniform distribution, $\widetilde{\Delta}_i \sim U[\Delta_{min}, \Delta_{min} + \psi]$. 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 TFP is high. The condition is given in the mathematical appendix.

An individual's maximand is as was given above in (1). He has an additional choice $Migrate_i \in \{0, 1\}$, and his budget constraint becomes

$$\begin{aligned} c_{i2} \leq & (1 + (r - \phi)\mathbb{1}(c_{i2} > y_i) + (r + \phi)\mathbb{1}(c_{i2} < y_i)) \\ & \Big(\pi_i + w(\overline{h} - l_i) + ((W - w)(\overline{h} - l_i) - \widetilde{\Delta}_i)Migrate_i - c_{i1}\Big) + y_i \end{aligned}$$

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 $\widetilde{\Delta}_i$. The incentive to migrate will be decreasing in the cost $\widetilde{\Delta}_i$. Define Δ_r as the maximum migration cost such that migrating is individually optimal for a landowner, and Δ_p as the maximum migration cost such that migrating is optimal for a landless individual, given the equilibrium wage.

Proposition (4)**.**

(i) The wage elasticity is increasing in migration costs, or $\frac{\partial \nu}{\partial \psi} > 0$.

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

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

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 in the event of $\widetilde{A} = A_L$ which is equivalent to a reduction in the wage elasticity. While only out-migration is modeled, in-migration would also reduce the wage elasticity. Suppose the model were extended to two symmetric economies with uncorrelated productivity shocks and both out- and in-migration were allowed. Then when one village had a better shock than the other, in-migration would increase labor supply in the temporarily higher-TFP village. The influx of labor would reduce the wage associated with a positive TFP shock, so in-migration also would dampen wage fluctuations.

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 the elasticity of the wage with respect to TFP. 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 the wage elasticity 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, and the net effect of landlessness on the wage elasticity could be either negative or positive. Therefore, this result should not be interpreted as general, but instead 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. Taking land from landowners and giving it to a subset of the landless population could have a negative pecuniary effect on those individuals who remain landless.[10]

With endogenous migration in the model, parameters now affect the wage through two channels. As before, there is an effect on the quantity of labor an individual would supply if he stayed in the village (intensive margin). Additionally, there is an an effect on migration (extensive margin). The income gain from migration is proportional to hours worked and to $W - w$, the amount by which the outside wage exceeds the local wage, so migration is affected either by a change in w or a change in the individual's choice of hours to work. Suppose a parameter increases labor supply

[10]This result was shown formally in a previous version of the paper. A related literature discusses indirect effects of agrarian land reform, focusing on provision of public goods such as irrigation (Bardhan, Ghatak, and Karaivanov 2002, Bardhan 1984, Boyce 1987).

along the intensive margin. The wage falls. In response, aggregate migration rises. This generates an offsetting increase in the wage. In addition, the increase in desired hours of work directly makes migration more attractive, and when more migration is induced, this puts further upward pressure on the wage. The comparative statics derived above for ψ and θ in Proposition 4 are net results combining these channels. The earlier results on poverty and banking, on the other hand, need not hold in general with unrestricted levels of migration. In the low productivity state, the migration effect—the fact that out-migration levels rise when banking fees increase, for example—can outweigh the fact that each nonmigrant now supplies more labor. However, as long as migration levels are not too high, Propositions 1 through 3 generalize, which should be intuitive since the extensive-margin effects become small in this case.[11]

IV. Empirical Strategy and Data

A. Empirical Strategy

The theory suggests that certain factors increase the aggregate labor supply elasticity and therefore decrease the sensitivity of the wage to productivity shocks. I examine these predictions 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 log TFP. S_{jt} are characteristics predicted to 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 error term. The coefficient β_1 measures the average elasticity of the wage with respect to productivity (if S_{jt} and X_{jt} are mean 0). With district fixed effects included, deviations from the district's average productivity identify β_1.

Workers in some labor markets are better able to smooth consumption in the face of productivity shocks, for example by adjusting how much they save or dissave or by migrating to work in another area. The availability of these smoothing mechanisms, measured by S_{jt}, should increase the aggregate

[11] The supplemental appendix derives these results. Note that in India, the setting studied below, migration rates are relatively low, suggesting that poverty and banking costs should increase the wage elasticity. Also note that if migration were modeled as providing a fixed income or utility level (instead of a higher wage), then the indirect effects on the wage that occurred due to migration would be second-order, and a parameter could only increase out-migration if it reduced the local wage. All results would then generalize to the migration case.

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. Testing this prediction is the main empirical objective.

The available measure of agricultural productivity is crop yield, the crop volume produced per unit of land. Crop yield depends on TFP but is not equivalent to it, since it also depends on the amounts of labor and other inputs that are used. Thus, with $Yield_{jt}$ standing in for A_{jt}, when the equation,

$$w_{jt} = \beta_1 Yield_{jt} + \beta_2 S_{jt} + \beta_3 S_{jt} * Yield_{jt} + \beta_4 X_{jt} + \beta_5 X_{jt} * Yield_{jt} + \delta_t + \alpha_j + \varepsilon_{jt}, \tag{2}$$

is estimated using ordinary least squares (OLS), the coefficients on $Yield_{jt}$ and its interactions do not isolate effects due to TFP fluctuations. Therefore I use an instrumental variables (IV) approach and instrument for crop yield with rainfall shocks (rainfall in excess of the district's normal rainfall). Rainfall is used as a source of exogenous variation in TFP where the assumption is that rain affects crop yield through its effect on TFP. The first-stage equation relating crop yield to rainfall is

$$\begin{aligned} Yield_{jt} =& \gamma_1 RainShock_{jt} + \gamma_2 S_{jt} + \gamma_3 S_{jt} * RainShock_{jt} + \gamma_4 X_{jt} + \gamma_5 X_{jt} * RainShock_{jt} \\ &+ \eta_t + \lambda_j + u_{jt}, \end{aligned} \tag{3}$$

where η_t and λ_j are year and district fixed effects, and u_{jt} is the error term. In the estimation of equation (2), $RainShock_{jt}$, $S_{jt} * RainShock_{jt}$, and $X_{jt} * RainShock_{jt}$ serve as instruments for the endogenous regressors, $Yield_{jt}$, $S_{jt} * Yield_{jt}$, and $X_{jt} * Yield_{jt}$.

The identification strategy assumes that rainfall affects TFP and does not affect workers' endowment of time or preferences or the shape of the production function. Another important assumption is that S_{jt} measures differences in the labor supply elasticity and not differences in the size of the productivity shock.[12] I interpret banks and roads as smoothing mechanisms, but the measures could be correlated with omitted variables. There are two distinct concerns. First, areas with more banks and roads might be places where geography or irrigation makes agricultural productivity less sensitive to

[12] Also, S_{jt} is interpreted as raising the elasticity of labor supply because of the income effect or substitution toward other labor markets, 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.

weather. This problem could confound the reduced-form relationship between rainfall and the wage. The wage could be less sensitive to rainfall shocks in developed areas simply because fluctuations in rainfall are causing smaller changes in crop yield. However, the relationship I examine—between crop yield and the wage—should not be affected by this type of omitted variable problem. The IV estimator projects $RainShock_{jt}$ and $S_{jt} * RainShock_{jt}$ onto $Yield_{jt}$ and $S_{jt} * Yield_{jt}$, and is not biased by a correlation between $Yield_{jt}$ and $S_{jt} * RainShock_{jt}$. Nevertheless, I probe this concern in subsection IV.E.

The second type of omitted variable problem is if S_{jt} is correlated with an unobserved measure of how large the industrial sector is. If agriculture is a smaller part of the labor market in places with more banks or roads, then fluctuations in agricultural TFP would represent less significant labor demand shocks and therefore would lead to smaller changes in the wage, generating $\beta_3 < 0$. This concern is lessened by the fact that the dependent variable is specifically the *agricultural* wage. Nonetheless, the agricultural labor market could be integrated with a broader low-skill labor market.

If there were policies that led to near–random placement of roads or banks, then one could address the problem by focusing on exogenous variation induced by the policies. Alternatively, if there were sufficient within-district variation over time in S_{jt}, one could include in the estimating equation district dummies interacted with the shock variable to absorb time-invariant omitted characteristics of a district. Unfortunately, in practice, these approaches are infeasible. However, the omitted variable concern can be partially addressed by controlling for the interaction of $Yield_{jt}$ with a measure of how important agricultural productivity is to overall labor productivity, namely the percentage of the total workforce that agricultural workers represent, denoted $\%Agrarian_{jt}$.

In addition, section IV.E presents a set of specification tests that help distinguish between the labor supply interpretation of the results and the omitted variable story. The first test looks at the relationship between crop yield, rainfall, and S_{jt}. Crop yield, which measures output per unit of land, is increasing not only in TFP but also in the quantity of labor used. The basis of the test is that crop yield therefore is increasing in labor supply, and should be more sensitive to rainfall shocks when labor supply is more elastic. In contrast, yield should respond less to rainfall in areas where weather has a smaller impact on agricultural TFP.

The second test uses crop prices as the dependent variable in a model analogous to equation (2). The logic of the test is that a negative shock to agricultural yield induces a negative supply shock in the product market and should drive up crop prices. The price response will be less pronounced in more industrialized areas where local output is a smaller part of the agricultural product market. On the other hand, if S_{jt} is not just proxying for industrialization but is indeed measuring a higher labor supply elasticity, then agricultural output and thus crop prices should be more sensitive to crop yield shocks where S_{jt} is larger because relatively more labor is available in good times and less in bad times. The results of the tests support the conclusion that smoothing mechanisms reduce wage fluctuations because of their effect on labor supply.

B. Data

I estimate equation (2) where the unit of observation is a district in India in a given year. The panel comprises 257 rural districts, defined by 1961 boundaries, observed from 1956 to 1987.[13] The sample covers over 80% 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 sample, 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. Crop yield is calculated as the revenue-weighted average of log(volume of crop produced/area cropped) for the 5 major crops by revenue, where revenue, crop volume, and area cropped are from the World Bank data set. Annual rainfall for a district, measured at the closest point on a 0.5° latitude by 0.5° longitude grid, is from the Center for Climatic Research at the University of Delaware. Four types of district traits are examined: financial services, access to other areas, poverty and landownership. These data are from the World Bank data set, Census of Population (cross-sectional measures from 1981 or 1961, 1971, and 1981 measures, interpolated between years), Agricultural Census, Reserve Bank of India, and National Sample Survey.

V. Empirical Results on the Wage Response to Productivity Shocks

A. Relationship Between the Agricultural Wage and Crop Yield

I estimate the relationship between the log wage and log crop yield, using rainfall shocks as an instrument for log crop yield. The relationship between crop yield and rainfall in the sample suggests that more rain improves agricultural productivity—crop yield increases monotonically with rainfall. India differs from other settings in which either below- or above-normal rainfall might hurt agricultural productivity. The variable, *RainShock*, is constructed accordingly, treating excess rain as a good

[13] Data are available for 271 districts. I exclude from the sample the 14 districts with measured altitude above 600 meters, as rainfall has a weak relationship with crop yield in these districts. The results presented below are similar, with larger standard errors, if these districts are included.

shock and a shortfall as a bad shock.[14] Previous work on India uses similar specifications (Jacoby and Skoufias 1997, Kochar 1997, Rose 2001). The *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, so I impose this restriction to improve power. The results presented are similar but less precise if the fractional deviation from the district's mean annual rainfall is used as the measure of *RainShock*. The distribution of rainfall used to construct the variables is for the period 1956 to 1987.

Column 1 of Table 2 shows the first-stage relationship between log crop yield and rainfall. A rainfall shock causes a 7% change in crop yield.[15] The t-statistic of the estimate is 9.3. Because there may be spatial correlation in rainfall, standard errors allow for clustering within a region-year, where a National Sample Survey region comprises 7 districts on average. The regression includes district and year fixed effects and the interaction of *RainShock* with *%Agrarian*, the proportion of the workforce in agriculture in 1961 (since the interaction of crop yield and *%Agrarian* will be a control variable in the second stage).

Column 2 of Table 2 presents the OLS relationship between the wage and crop yield.[16] The coefficient on log crop yield, which represents the elasticity of the wage with respect to yield, is .035. Higher productivity seems to lead to a higher wage. Yield depends both on TFP and on inputs besides land, so the coefficient lacks a straightforward interpretation, however. Specifically, the coefficient is likely to be smaller than the desired estimand, the elasticity of the wage with respect to TFP, because of the following source of endogeneity. Suppose a labor market experiences a positive shock to labor supply (for example, because of negative demand shocks in other industries). First, the wage will decrease. Second, producers will use more labor, and therefore crop yield (output per unit of land) will increase. This effect generates a negative correlation of the wage and crop yield, biasing the OLS coefficient downward. Column 3 presents the IV estimate of the relationship between the wage and crop yield. Rainfall, as the instrument for crop yield, should be isolating effects due to exogenous changes in TFP. Here, the elasticity of the wage with respect to productivity is .17. The larger IV

[14] The Ministry of Agriculture tracks which areas have below–average rain each rainy season and groups together those with average or above–average rain, suggesting that shortfalls are of greatest concern. Extreme flooding presumably would be an exception. See Das (1995) on rainfall and agricultural productivity in India.

[15] Because of measurement error in *RainShock*, the coefficient is probably an underestimate of the effect of weather on crop yield. Rainfall calculated at one point is used to describe rain for a district's entire area. In smaller districts, where this problem should be less important, the coefficient on rainfall is significantly larger. Also, rainfall for that one point is interpolated from several nearby weather stations. In addition, excess rainfall is a crude approximation of the weather shocks that affect agricultural productivity.

[16] Theoretically, lagged shocks also might affect the wage, for example if successive bad shocks deplete one's buffer stock savings. Empirically, I do not find an effect of lagged shocks.

estimate confirms that productivity fluctuations are not the only source of variation in crop yield in the data. In addition, if crop yield is measured with classical measurement error, the IV estimates may be correcting attenuation bias in the OLS estimate.[17]

As discussed above, one concern is that the agricultural wage might be less sensitive to agricultural productivity where the nonagricultural sector is more important in the local economy. Therefore the regression includes as a control variable $Yield$ interacted with the fraction of the workforce in agriculture. If the agricultural wage measures an overall unskilled wage, it should be more sensitive to crop yield in more agrarian areas, but the interaction coefficient is negative, though small and insignificant. This result suggests that the agrarian labor market may be fairly distinct from the nonagrarian labor market. Another potential explanation is that the control variable is not a good measure of sectoral composition. However, results presented in section IV.E suggest that the variable is in fact a meaningful measure.

Note that all variables interacted with crop yield have been standardized to have a mean of 0 and standard deviation of 1 to ease interpretation. The coefficient on $\%Agrarian * Yield$ implies that for every standard deviation increase in the proportion of workers in agriculture, the wage becomes less sensitive to the weather shock by 0.9 log points. Column 3 is the specification augmented below to test whether banking and other factors affect the wage elasticity.

The estimate of the elasticity of the wage with respect to crop yield allows one to calculate the magnitude of typical wage fluctuations caused by productivity shocks. Crop yield in a district fluctuates considerably year-to-year. Figure 2 depicts the distribution of the residual when log crop yield is regressed on district-specific linear time trends and year effects. The standard deviation of the residual is 21 log points. This variation also captures measurement error in crop yield, so 21 log points is likely an upper bound on the standard deviation of actual TFP shocks. A 21% shock, given the estimated elasticity of .17 (column 3), corresponds to a 3.5% wage fluctuation. A decline in earning power of even this magnitude is likely to be economically important to those who are very poor, and the rarer events when crop yield and the wage fall sharply would have more severe consequences.

B. Banking

Table 3 presents results on the relationship between financial development and the wage elasticity. Proposition 2 suggests that access to banking should reduce the sensitivity of the wage to productivity shocks, or that the coefficient on $Banking * Yield$ should be negative. In columns 1 and 2, banking is

[17] The reason the OLS and IV estimates differ does not seem to be that large deviations from typical rainfall are the identifying variation with the discrete *RainShock* measure. The IV estimate is similar (.14) when the instrument is a continuous measure, namely the fractional deviation from the district's mean rainfall.

measured as per capita deposits and per capita credit. In both cases, banking reduces the responsiveness of the wage to shocks, and the estimates are statistically significant at the 5% and 10% levels, respectively. These results are IV estimates where the variables $RainShock$, $Banking * RainShock$, and $\%Agrarian * RainShock$ are instruments for $Yield$, $Banking * Yield$, and $\%Agrarian * Yield$. Note that for time-invariant measures of $Banking$, the level effect is absorbed by the district fixed effect. The final measure of banking, the number of bank branches per capita, also reduces the magnitude of wage fluctuations (column 3).[18]

The coefficients on the interaction terms are sizable. In column 1, moving from the mean level of bank deposits to one standard deviation below the mean, the wage becomes over 50% more sensitive to crop yield shocks (an increase from 16% to 25%). In fact, one might worry that for large positive values of $Banking$, this implies that the wage is decreasing in $Yield$. $Banking$, however, rarely takes on large positive values. For 95% of the sample, the bank deposit variable is below 1.78, the threshold at which the wage would begin to decrease with $Yield$. Moreover, taking into account estimation error (i.e., using a t-test), one cannot reject that the wage is increasing in $Yield$ up to the 99th percentile of the bank deposit variable.

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 loans from informal lenders or landlords who in turn use the formal banking sector. Banking might also enable entrepreneurs to expand nonagricultural businesses when agricultural productivity is low, creating an alternative use for labor. Analogously, Foster and Rosenzweig (2003) argue that industrial capital migrates to low-wage areas to explain their finding that rural industrialization in India has been more rapid in villages where agricultural productivity has been stagnant.

C. Access to Neighboring Areas

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), the wage should be less responsive to productivity changes, as seen in Proposition 4(i). I use measures of a district's physical connectedness with neighboring areas, which should be associated

[18] Different measures of financial services enable one to test whether certain facets of financial services have a stronger relationship with the wage elasticity than others, and to check whether the results are robust to changing the way financial services are measured. The different measures are positively correlated, so if all of the $Banking * Yield$ variables are included in a single regression, they do not all have negative coefficients. This is also true for the measures of access examined below.

with lower costs of migration, to test this prediction.[19] 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. In areas with lower road density the wage elasticity is higher, consistent with the prediction, although this estimate is imprecise. In columns 2 and 3, the measures of accessibility are the proportion of villages with bus service and with a railway station. Better bus or rail access leads to a significant reduction in the wage elasticity. Finally, the estimate in column 4 suggests 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.

D. Poverty and Landholding

Income effects are likely to be particularly pronounced for the very poor, implying that the aggregate labor supply elasticity may decline as the poverty rate in an area increases. On the other hand, the poor have a greater incentive to out-migrate to higher–wage areas in response to negative shocks. 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 were landless. Anecdotal evidence suggests that there is also a moral hazard cost of being an absentee landlord that deters landowners from migrating (Bardhan 1977). Thus, the presence of poor workers could on net increase or reduce the wage elasticity in the home market.

In addition to the propensity to migrate, there are other reasons not addressed here why the landless might have more elastic labor supply than landowners. One possibility is that malnourishment reduces labor productivity and causes unemployment (Leibenstein 1957, Bliss and Stern 1978, Dasgupta and Ray 1986). If the landless are less healthy than landowners, 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. Smaller wage fluctuations would not be welfare-enhancing for the poor if they were not earning wages in lean times.

[19] The variables might also be measuring how open the goods markets are. However, 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).

1. Labor supply elasticity and migration of the landless versus landowners

Before examining the wage effects of landownership and poverty, I provide evidence on the basic facts that, first, among workers who stay in the home market, labor supply elasticity is increasing in landownership and, second, the landless have a higher propensity to migrate in response to bad shocks. To do so, I use an individual-level data set on rural India, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) study. ICRISAT surveyed 40 households in each of 6 villages between 1975 and 1979 and in the original 6 plus 4 more villages from 1980 to 1984.

Table 5 presents descriptive statistics for the ICRISAT samples used. Data on labor supply are not available for all villages and years, so I use a subsample of 3 villages during 1975-9. The sample consists of adult male household members who are supplying labor in the village, and the unit of observation is an individual-month. Rainfall during 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.[20] 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, data for all 10 villages are available and the sample consists of adult male household members, present or absent. 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 4%.

Table 6 provides evidence that an individual's labor supply elasticity is increasing in landownership. 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 an 8.4% decrease in labor supply. The landless have a significantly lower labor supply elasticity than landowners; they reduce labor supply by only 3.7% in response to the same shock. The landless also work more hours overall. Column 2 separately estimates the labor supply and labor supply elasticity for the 4 landholding categories. While the estimates are imprecise, the pattern of coefficients shows that, in general, the poorer the stratum, the more hours worked and the less elastic the labor supply. The regressions include village, year, and month fixed effects and control for the number of working male adults in the

[20]Since the panel is short, the *RainShock* variable is not measured relative to 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 a full set of village dummy variables interacted with *RainShock* is included.)

household 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 have a lower labor supply elasticity. The fact that they work more hours than landowners suggests they also would have more to gain by migrating to a higher-wage market. Indeed, consistent with Proposition 4(ii), I find that the landless are more likely to out-migrate for work in response to bad shocks. Column 3 of Table 6 compares the propensity to temporarily migrate among landowners and the landless. Results for a probit model are shown; unreported OLS results are similar. The behavior of landowners is unaffected by the rain shock, while a negative shock significantly increases a landless individual's likelihood of migrating. A one-standard-deviation negative shock increases his probability of migrating by 25%. Column 4 shows 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.[21] This also suggests that 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.

Empirically, landless individuals have offsetting effects on the wage elasticity. Within the home market, they supply labor more inelastically which should contribute to a larger decline in the wage when TFP suffers a negative shock, but they are also more likely to migrate to other areas which should mitigate the local impact of a bad shock. I now turn to estimating in the main agricultural wage data set the net impact that poor or landless individuals have on the wage elasticity.

2. Poverty, landholding patterns, and wage responses

Table 7 examines how the wage elasticity varies with income and land ownership. First, I use two poverty measures constructed from expenditure data in the 1987-8 National Sample Survey: average per capita expenditure and the fraction of households below a poverty line of 14,000 rupees per year in expenditures, approximately the World Bank poverty line (columns 1-2).[22] The theoretical prediction (Proposition 1) is that poorer places, where average TFP is lower, should experience large wage adjustments to TFP shocks since workers supply labor inelastically in order to maintain their near-subsistence income levels. Empirically, the interaction between per capita expenditure and $Yield$

[21] 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.

[22] NSS data are not available at the district level for earlier years.

is negative but insignificant, consistent with but not strong evidence of a greater wage elasticity in poorer areas. The poverty head count ratio does not have a statistically significant impact on the wage elasticity.

Columns 3 and 4 examine two measures of landholding patterns. The first is the proportion of agricultural workers who are landless.[23] The wage is significantly less responsive to productivity shocks when the fraction landless is higher. A plausible explanation in light of the ICRISAT evidence is that labor migration in response to shocks—which acts to dampen wage fluctuations—is increasing in the fraction landless. There may also be other explanations for the result. One possibility is that malnourishment causes the landless to supply less labor in the event of bad shocks, although I find the opposite result along the hours margin in the ICRISAT sample. It is worth noting that unlike bank or road density, the proportion landless is *negatively* correlated with most measures of economic development, so the negative coefficient on $\%Landless * Yield$ is unlikely to be driven by an omitted measure of economic development.

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. Greater land inequality among the landed does not have a significant impact on the wage elasticity.

E. Specification Tests Using Crop Yield and Crop Prices

One concern with the estimates in Tables 3, 4 and 7 is that factors like bank or road density might be measuring an omitted variable, either insensitivity of agricultural productivity to weather or lack of importance of agricultural productivity in the labor market. That is, the concern is that the estimates may not be identifying varying labor supply responses to a given TFP shock, but instead differences in the intensity of the TFP shock. To allay these concerns, I present two specification tests that help distinguish between the labor supply explanation that I have put forth and the omitted variable explanation.

The first test examines whether crop yield is more or less sensitive to $RainShock$ in areas where S is higher, that is, where banks, roads, and landlessness are more prevalent. This relationship is simply the first stage for $Yield$ for the IV estimates presented above (equation (3)). The fact that $Yield$ is

[23] 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 among all agricultural workers is the approximate measure of landlessness in the agricultural workforce. The ideal workforce measure would be potential workers including out-migrants and excluding in-migrants. This is unlikely to be a problem in practice since the workforce measure is decennial while the weather and wage data are annual.

increasing both in productivity and in the quantity of available labor makes the first stage useful as a specification test. Suppose the omitted variable explanation is correct. Then, in a place where S is higher, the productivity shock associated with $RainShock$ would be less intense and the coefficient on $S * RainShock$ should be *negative.* In contrast, if labor supply is more elastic when S is high, then in the event of a good shock, more labor is available. The labor used per area and, in turn, the output per area, or crop yield, should be higher as S increases, and the coefficient on $S * RainShock$ should be *positive.* A negative coefficient on $S * RainShock$ would suggest that an omitted variable drives the wage elasticity results presented above, while a positive coefficient supports the interpretation that banks, roads, and landlessness reduce the wage elasticity because they raise the labor supply elasticity.

Table 8 presents the results of this test. The dependent variable is crop yield and the independent variables include $RainShock$, $S * RainShock$, and $\%Agrarian * RainShock$ (the instruments in the IV estimates presented above), as well as the main effect of S and district and year fixed effects. In columns 1–3, the measures of S are bank deposits, road density and the percent landless. The estimated coefficients for the interaction effects with bank deposits is statistically significantly positive, positive for road density, and negative but essentially zero for percent landless. These estimates largely support the labor supply elasticity explanation of the main results.[24]

The second test uses an index of crop prices as the dependent variable in a model otherwise identical to that described by equation (2). (The data appendix further describes the crop price variable.) A positive shock to agricultural productivity should induce a positive supply shock in the product market, and crop prices should decline (negative main effect on $Yield$). The interaction term, $S * Yield$, then provides a distinguishing test. Suppose banks, roads, or landlessness are measuring more industrialized areas. In places with higher S, the price effect should be smaller because in nonagrarian areas, locally produced goods will constitute a smaller portion of total supply in the agricultural product market. The interaction coefficient for $S * Yield$ should be *positive.* In contrast, if S is affecting the labor supply elasticity, a higher value of S implies more labor is available in the event of a positive TFP shock. Agricultural output and crop prices should be more responsive to the shock, or the interaction coefficient should be *negative.*

The results of this test are given in Table 8, columns 4-7. With log crop price as the dependent

[24] A related test uses the area cropped as the dependent variable. Farmers choose whether to farm marginal land and when TFP is high, the area planted should increase. $RainShock$ should and does lead to an increase in 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 S indicates that relatively more labor is supplied during high-TFP years, then with complementary labor and land, area cropped will increase more if S is larger. In results not reported, I find positive and significant interaction effects for bank deposits, road density and percent landless, in support of the labor supply channel.

variable, the main effect of log crop yield is negative, as expected; a boost to supply in the product market leads to lower crop prices. Next consider the interactions of crop yield and S. If S were a proxy for industrialization, one would expect these coefficients to be positive. The interaction coefficient for $\%Landless$ is negative and significant at the 5% level, and the coefficients for bank and road density are negative and positive, respectively, but imprecise in both cases.

Also notable is that the coefficient on $\%Agrarian * Yield$ is negative, large, and statistically significant (see column 4). In more agrarian areas as measured by $\%Agrarian$, where local output is presumably more important in the product market, crop prices are more responsive to local productivity, as one would expect. The strong predictive power of the fraction of the workforce in agriculture suggests that this variable is a good measure of how agrarian an area is. Therefore, in the wage regressions presented above, the inclusion of $\%Agrarian * Yield$ as a control variable should be reducing the likelihood of omitted variable bias. The fact that in the wage regressions the coefficient on $\%Agrarian * Yield$ is small and insignificant seems to indicate that the agricultural and nonagricultural labor markets are distinct.

In sum, the results of the two tests suggest that banking, transportation, and landlessness are measuring differences in the elasticity of labor supply rather than omitted variables and that wage fluctuations are more pronounced in underdeveloped areas because workers have more limited means of responding to risk.

VI. Conclusion

Productivity risk is endemic in underdeveloped areas. Agricultural production is sensitive to drought, floods, pestilence, price fluctuations, and other events. This paper has shown theoretically and empirically that several fundamental characteristics of impoverished areas conspire to exacerbate this risk for workers.

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 the wage moves in response to productivity shocks. Higher costs of migrating, borrowing, and saving also amplify wage fluctuations. Empirically, a better developed banking system and better access to other areas are important in explaining the sensitivity of the wage to TFP shocks. For example, in the sample of 257 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 50% more sensitive to weather-cum-productivity shocks.

The distribution of wealth is important both in explaining the responsive of the wage to productivity changes and in understanding its welfare consequences. The prevalence of landlessness among agricultural workers was found to reduce the elasticity of the wage with respect to productivity. Individual-level data supported the explanation that the landless have a particularly high propensity to out-migrate when local agricultural conditions are unfavorable. In addition, wage fluctuations have different welfare implications for rich and poor. Volatile wages hurt the poor since their main asset is their labor. For the rich who are net buyers of labor, a greater wage elasticity can be beneficial. This implies that improvements in the banking sector—or other policies that affect how labor responds to shocks—have redistributional as well as level effects on welfare.

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.[25] Second, land redistribution from the rich to the poor could have counterintuitive effects. If land redistribution decreases 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, the different preferences of the rich and poor toward institutions that enable consumption smoothing may have important political economy implications. At first blush, improving financial services would seem to benefit all individuals in an economy subject to productivity risk and income volatility, since everyone benefits from being better able 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 landowners since they then have to pay workers a higher wage in bad times. These considerations may affect political support for policies such as improved banking that are in the interest of the poor and that promote economic growth.

[25] The paper has focused on "distress sales" of labor, but similar price effects are likely to occur in other markets. For example, Jodha (1975) reports that during the 1963–4 drought in Rajasthan, India, households sold down assets such as camels, sheep, and bullock carts and the prices of these goods fell sharply, in part because of the supply glut.

Data Appendix

Agricultural wage

The agricultural wage data are from the World Bank India Agricultural and Climate data set. The data set covers 271 districts, defined by 1961 boundaries, in 13 states (Haryana, Punjab, Uttar Pradesh, Gujarat, Rajasthan, Bihar, Orissa, West Bengal, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Madhya Pradesh). Changes in district boundaries have been accounted for by consolidating new districts into their parent districts. I restrict the sample to the 257 districts whose measured altitude is less than 600 meters.

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 annual *Agricultural Wages in India* publication. The Directorate suggests that states use public servants such as patwaris (revenue officials), primary school teachers, or panchayat (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.

Crop yield

Data on the volume produced and the area cropped, by crop, are from the World Bank data set. I construct the variable log yield as the weighted average of log(volume of crop produced/area cropped) for the 5 major crops by revenue which are rice, wheat, sugar, jowar (sorghum), and groundnut. 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.

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 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.

Fraction of Workforce in Agriculture

The fraction of the working population in agriculture is from the Indian District Data, 1961–1991 compiled by Reeve Vanneman and Douglas Barnes. The original source is the decennial Census of India. Data are linearly extrapolated between Census years.

Crop price

Data on crop prices, by crop, are from the World Bank data set. I construct the variable log crop price as the weighted average of the log price for the 5 major crops by revenue which are rice, wheat, sugar, jowar (sorghum), and groundnut. The weights are the district-average revenue share of the crop, and the price for each crop has been normalized to mean 1 for comparability across crops.

Banking

Average deposits and credit per capita are from the Indian district data set. Data on 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.

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.

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. The villages in the labor supply sample are Aurepalle, Shirapur, and Kanzara, and the villages in the migration sample are Aurepalle, Dokur, Shirapur, Kalman, Kanzara, Kinkheda, Boriya Becharji, Rampura, Rampura Kalan, and Papda.

Landless households are defined as those with less than 0.2 hectares (ha) 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 than 0.2 ha were divided into three equally-sized strata, and 10 households were sampled per stratum per village. In the median village, small landowners are those with ¡3 ha and medium landowners are those with ¡6 ha.

Mathematical Appendix[26]

Solution of the Model

The Lagrangian of the model presented in Section II of the paper is

$$\begin{aligned}\mathcal{L} &= U(c_1, c_2, l) + \mu_1\left[\overline{h} - l\right] + \mu_2\left[l - 0\right] + \mu_3\left[c_1 - \underline{c}\right] + \mu_4\left[c_2 - \underline{c}\right] \\ &\quad +\lambda\left[\left(1 + \mathbf{1}_{c_2<y}(r+\phi) + \mathbf{1}_{c_2>y}(r-\phi)\right)\left(\pi + w\left(\overline{h} - l\right) - c_1\right) + y - c_2\right]\end{aligned}$$

which gives the following first order conditions

$$\begin{aligned}\text{(i)}\quad \frac{\partial\mathcal{L}}{\partial c_1} &= \frac{1}{c_1 - \underline{c}} - \lambda\left(1 + \mathbf{1}_{c_2<y}(r+\phi) + \mathbf{1}_{c_2>y}(r-\phi)\right) + \mu_3 = 0 \\ \text{(ii)}\quad \frac{\partial\mathcal{L}}{\partial c_2} &= \frac{b}{c_2 - \underline{c}} - \lambda + \mu_4 = 0 \\ \text{(iii)}\quad \frac{\partial\mathcal{L}}{\partial l} &= \frac{1-\alpha}{\alpha l} - \lambda\left(1 + \mathbf{1}_{c_2<y}(r+\phi) + \mathbf{1}_{c_2>y}(r-\phi)\right)w - \mu_1 + \mu_2 = 0\end{aligned}$$

with

$$\begin{aligned}\lambda\left[\left(1 + \mathbf{1}_{c_2<y}(r+\phi) + \mathbf{1}_{c_2>y}(r-\phi)\right)\left(\pi + w\left(\overline{h} - l\right) - c_1\right) + y - c_2\right] &= 0 \quad \text{(iv)} \\ \mu_1\left[\overline{h} - l\right] &= 0 \quad \text{(v)} \\ \mu_2 l &= 0 \quad \text{(vi)} \\ \mu_3\left[c_1 - \underline{c}\right] &= 0 \quad \text{(vii)} \\ \mu_4\left[c_2 - \underline{c}\right] &= 0 \quad \text{(viii)}\end{aligned}$$

and $\lambda, \mu_1, \mu_2, \mu_3, \mu_4 \geq 0$. For $\mu_2 = \mu_3 = \mu_4 = 0$ and $\lambda > 0$ and $l < \overline{h}$ at the optimum, we get the following interior solution

$$\begin{aligned}(L)\qquad l &= \frac{1-\alpha}{1+\alpha b}\left[\overline{h} + w^{-1}\left(\pi + \frac{y - \underline{c}}{1 + \mathbf{1}_{c_2<y}(r+\phi) + \mathbf{1}_{c_2>y}(r-\phi)} - \underline{c}\right)\right] \\ (C1)\qquad c_1 - \underline{c} &= \frac{\alpha}{1+\alpha b}\left[\pi + w\overline{h} + \frac{y - \underline{c}}{1 + \mathbf{1}_{c_2<y}(r+\phi) + \mathbf{1}_{c_2>y}(r-\phi)} - \underline{c}\right] \\ (C2)\qquad c_2 - \underline{c} &= \frac{\alpha b}{1+\alpha b}\left[\left(\pi + w\overline{h} - \underline{c}\right)\left(1 + \mathbf{1}_{c_2<y}(r+\phi) + \mathbf{1}_{c_2>y}(r-\phi)\right) + y - \underline{c}\right]\end{aligned}$$

A requirement for the solution to be valid is that the subsistence level of consumption is reached in each period. From (L) to $(C2)$, this is equivalent to requiring

$$w_j(A_j)\,\overline{h} + \pi_i(A_j) + \frac{y_i - \underline{c}}{1 + \mathbf{1}_{c_{2,i}<y_i}(r+\phi) + \mathbf{1}_{c_{2,i}>y_i}(r-\phi)} - \underline{c} > 0 \quad \text{for } i \in \{p, r\}.$$

where landless agents are denoted by $i = p$ and landowners by $i = r$. Since $\pi_p(A_j) = 0$ for $j \in \{H, L\}$, if $y_r \geq y_p$, a sufficient condition for subsistence consumption to be reached is

$$\frac{y_p - \underline{c}}{1 + \mathbf{1}_{c_{2,p}<y_p}(r+\phi) + \mathbf{1}_{c_{2,p}>y_p}(r-\phi)} - \underline{c} > 0 \tag{4}$$

[26] A supplemental appendix with additional derivations and proofs is available from the author upon request.

which covers even the limit case where $w_j \longrightarrow 0^+$.

Labor Market Equilibrium

We are interested in analyzing an economy that exhibits *aggregate* borrowing (savings) in the face of a bad (good) shock. We require

$$(1-\theta)\left(c_{2,r}\left(A_j\right)-y_r\right)+\theta\left(c_{2,p}\left(A_j\right)-y_p\right) \equiv (1-\theta)\, c_{2,r}\left(A_j\right)+\theta c_{2,p}\left(A_j\right)-y$$

to be negative (positive) for $j=L$ ($j=H$) where $y=(1-\theta)\, y_r+\theta y_p$ is the economy-wide, period-2, windfall income:

$$(1-\theta)\left(c_{2,r}\left(A_L\right)-\underline{c}-y_r\right)+\theta\left(c_{2,p}\left(A_L\right)-\underline{c}-y_p\right)<\underline{c} \tag{5}$$

$$(1-\theta)\left(c_{2,r}\left(A_H\right)-\underline{c}-y_r\right)+\theta\left(c_{2,p}\left(A_H\right)-\underline{c}-y_p\right)>\underline{c} \tag{6}$$

Recall that labor demand is $d_i\left(A_j\right)=k_i\left(\frac{A_j\beta}{w}\right)^{\frac{1}{1-\beta}}$, and the village has total land K and landowners have equally sized plots of land, $k_r=\frac{K}{(1-\theta)N}$. Therefore, total labor demand in this economy, at a wage rate w, is given by

$$L_d\left(A_j\right)=(1-\theta)\, N d_r=K\left(\frac{A_j\beta}{w_j}\right)^{\frac{1}{1-\beta}} : j \in \{L,H\}$$

For the labor market equilibrium $L_d\left(A_j\right)=\sum_i\left(\overline{h}-l_i\left(A_j\right)\right)$ we have

$$\begin{aligned}
K\left(\frac{A_j\beta}{w_j}\right)^{\frac{1}{1-\beta}} &= \theta N\left[\overline{h}-l_p\left(A_j\right)\right]+(1-\theta)\, N\left[\overline{h}-l_r\left(A_j\right)\right] \Longrightarrow \\
K\left(\frac{A_j\beta}{w_j^{\beta}}\right)^{\frac{1}{1-\beta}} &= w_j H-N\left[\theta w_j l_p\left(A_j\right)+(1-\theta)\, w_j l_r\left(A_j\right)\right] \\
&= \left(\frac{\alpha+\alpha b}{1+\alpha b}\right) w_j H \\
&\quad -\left(\frac{1-\alpha}{1+\alpha b}\right) N\left[(1-\theta)\, \pi_r\left(A_j\right)+\frac{y-\underline{c}}{1+\mathbf{1}_{j=H}(r-\phi)+\mathbf{1}_{j=L}(r+\phi)}-\underline{c}\right]
\end{aligned}$$

Since the landowners' individual profits are given by

$$\pi_r\left(A_j\right)=A_j(1-\beta)\, k_r\left(\frac{A_j\beta}{w_j}\right)^{\frac{\beta}{1-\beta}}, \tag{7}$$

we can rewrite the above equation, using the fact that $K\left(\frac{A_j\beta}{w_j^{\beta}}\right)^{\frac{1}{1-\beta}}=(1-\theta)\left(\frac{\beta}{1-\beta}\right) N\pi_r\left(A_j\right)$, as follows

$$(1-\theta)\left(\frac{\beta}{1-\beta}+\frac{1-\alpha}{1+\alpha b}\right)\pi_{r,j}=\left(\frac{\alpha+\alpha b}{1+\alpha b}\right) w_j\overline{h}-\left(\frac{1-\alpha}{1+\alpha b}\right)\left(\frac{y-\underline{c}}{1+r-\mathbf{1}_{j=H}\phi+\mathbf{1}_{j=L}\phi}-\underline{c}\right) \tag{8}$$

Also note that

$$\frac{\partial\pi_r\left(A_j\right)}{\partial w_j}=-\frac{\beta}{1-\beta}\frac{\pi_r\left(A_j\right)}{w_j}<0 : j\in\{L,H\} \tag{9}$$

Note that from $(C2)$, in the bad state $j=L$, the required condition (A.2) is equivalent to the following

$$\begin{aligned}
\alpha b \left((1-\theta) \left(\pi_{r,L} + w_L \overline{h} - \underline{c} \right) + \theta \left(w_L \overline{h} - \underline{c} \right) \right) (1+r+\phi) < y + 2\alpha b \underline{c} &\iff \\
\left(w_L \overline{h} + (1-\theta)\, \pi_{r,L} \right) (1+r+\phi) < \tfrac{y}{\alpha b} + (2+r+\phi)\, \underline{c} &\overset{(A.5)}{\iff} \\
\left(1 + \tfrac{\beta}{1-\beta} \right) w_L \overline{h}\, (1+r+\phi) < \left(\tfrac{\beta}{1-\beta} + \tfrac{1-\alpha}{1+\alpha b} \right) \left(\tfrac{y}{\alpha b} + (2+r+\phi)\, \underline{c} \right) &\iff \\
w_L < \frac{\left(\frac{\beta}{1-\beta} + \frac{1-\alpha}{1+\alpha b} \right) \left(\frac{y}{\alpha b} + (2+r+\phi) \underline{c} \right)}{\left(1 + \frac{\beta}{1-\beta} \right) (1+r+\phi) \overline{h}} &
\end{aligned} \tag{A.5$'$}$$

whereas, in the good state $j = H$, (A.3) becomes

$$\begin{aligned}
\left(w_H \overline{h} + (1-\theta)\, \pi_{r,H} \right) (1+r-\phi) &< \frac{y}{\alpha b} + (2+r-\phi)\, \underline{c} \overset{(A.5)}{\iff} \\
\left(1 + \frac{\beta}{1-\beta} \right) w_H \overline{h}\, (1+r-\phi) &< \left(\frac{\beta}{1-\beta} + \frac{1-\alpha}{1+\alpha b} \right) \left(\frac{y}{\alpha b} + (2+r-\phi)\, \underline{c} \right) \iff \\
w_H &< \frac{\left(\frac{\beta}{1-\beta} + \frac{1-\alpha}{1+\alpha b} \right) \left(\frac{y}{\alpha b} + (2+r-\phi)\, \underline{c} \right)}{\left(1 + \frac{\beta}{1-\beta} \right) (1+r-\phi)\, \overline{h}}
\end{aligned} \tag{A.6$'$}$$

In general, we would have y_i be increasing in the landholdings k_i for $i \in \{p, r\}$, or $y_r > y_p$. Yet, if $y_r = y_p = y$, a sufficient condition for the required macroeconomic behavior of aggregate savings/borrowing is for the landowners (landless) to be borrowing (saving) during a bad (good) productivity shock.

Proposition 1

The wage elasticity is increasing in poverty, where poverty is parameterized by the ratio of the subsistence level to average TFP ($\frac{\underline{c}}{A}$); for fixed A, $\frac{\partial \nu}{\partial \underline{c}} > 0$.

This is equivalent to $w_L \frac{\partial w_H}{\partial \underline{c}} - w_H \frac{\partial w_L}{\partial \underline{c}} > 0$ for fixed A_H, A_L. Taking derivatives of (A.5) with respect to $\underline{c}$ we get, respectively, for $j = H$

$$\left[\left(\frac{\alpha + \alpha b}{1 + \alpha b} \right) \overline{h} - (1-\theta) \left(\frac{\beta}{1-\beta} + \frac{1-\alpha}{1+\alpha b} \right) \frac{\partial \pi_{r,H}}{\partial w_H} \right] \frac{\partial w_H}{\partial \underline{c}} = - \left(\frac{1-\alpha}{1+\alpha b} \right) \left(1 + \frac{1}{1+r-\phi} \right)$$

and for $j = L$

$$\left[\left(\frac{\alpha + \alpha b}{1 + \alpha b} \right) \overline{h} - (1-\theta) \left(\frac{\beta}{1-\beta} + \frac{1-\alpha}{1+\alpha b} \right) \frac{\partial \pi_{r,L}}{\partial w_L} \right] \frac{\partial w_L}{\partial \underline{c}} = - \left(\frac{1-\alpha}{1+\alpha b} \right) \left(1 + \frac{1}{1+r+\phi} \right)$$

From (A.6), it is now immediate that $\frac{\partial w_H}{\partial \underline{c}}, \frac{\partial w_L}{\partial \underline{c}} < 0$.

Subtracting the labor market equilibrium equation (A.5) for each state of the world $j \in \{H, L\}$, we get

$$\begin{aligned}
(1-\theta) \left(\tfrac{\beta}{1-\beta} + \tfrac{1-\alpha}{1+\alpha b} \right) (\pi_{r,H} - \pi_{r,L}) &= \\
\left(\tfrac{\alpha+\alpha b}{1+\alpha b} \right) \overline{h}\, (w_H - w_L) - \left(\tfrac{1-\alpha}{1+\alpha b} \right) \left(\tfrac{y-\underline{c}}{1+r-\phi} - \tfrac{y-\underline{c}}{1+r+\phi} \right) & \\
= \left(\tfrac{\alpha+\alpha b}{1+\alpha b} \right) \overline{h}\, (w_H - w_L) - \left(\tfrac{1-\alpha}{1+\alpha b} \right) \tfrac{2\phi (y-\underline{c})}{(1+r-\phi)(1+r+\phi)} &
\end{aligned}$$

Using (A.4), though, we get

$$
\begin{aligned}
\pi_{r,H}-\pi_{r,L} &= (1-\beta)\,\beta^{\frac{\beta}{1-\beta}}k_r\left(A_H\left(\frac{A_H}{w_H}\right)^{\frac{\beta}{1-\beta}}-A_L\left(\frac{A_L}{w_L}\right)^{\frac{\beta}{1-\beta}}\right)\\
&> (1-\beta)\left(A_L\beta^{\beta}\right)^{\frac{1}{1-\beta}}k_r\left(w_H{}^{-\frac{\beta}{1-\beta}}-w_L^{-\frac{\beta}{1-\beta}}\right)\\
&= -(1-\beta)\left(\frac{A_L\beta^{\beta}}{w_H^{\beta}w_L^{\beta}}\right)^{\frac{1}{1-\beta}}k_r\left(w_H{}^{\frac{\beta}{1-\beta}}-w_L^{\frac{\beta}{1-\beta}}\right)
\end{aligned}
$$

Thus,

$$
\begin{aligned}
&\left(\tfrac{\alpha+\alpha b}{1+\alpha b}\right)\overline{h}\,(w_H-w_L)+(1-\theta)\left(\tfrac{\beta}{1-\beta}+\tfrac{1-\alpha}{1+\alpha b}\right)(1-\beta)\left(\tfrac{A_L\beta^{\beta}}{w_H^{\beta}w_L^{\beta}}\right)^{\frac{1}{1-\beta}}k_r\left(w_H{}^{\frac{\beta}{1-\beta}}-w_L^{\frac{\beta}{1-\beta}}\right)\\
&\quad> \left(\tfrac{\alpha+\alpha b}{1+\alpha b}\right)\overline{h}\,(w_H-w_L)-(1-\theta)\left(\tfrac{\beta}{1-\beta}+\tfrac{1-\alpha}{1+\alpha b}\right)(\pi_{r,H}-\pi_{r,L})\\
&\quad= \left(\tfrac{1-\alpha}{1+\alpha b}\right)\tfrac{2\phi(y-\underline{c})}{(1+r-\phi)(1+r+\phi)}>0
\end{aligned}
$$

which establishes

$$
w_H > w_L \tag{A.10}
$$

Constructing the expression to be signed, we have

$$
\begin{aligned}
w_L\frac{\partial w_H}{\partial \underline{c}}-w_H\frac{\partial w_L}{\partial \underline{c}} &= w_Lw_H\left(w_H^{-1}\frac{\partial w_H}{\partial \underline{c}}-w_L^{-1}\frac{\partial w_L}{\partial \underline{c}}\right)\\
&= w_Lw_H\left(\frac{1-\alpha}{1+\alpha b}\right)\left(\begin{array}{c}\frac{1+\frac{1}{1+r+\phi}}{\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)w_L\overline{h}-(1-\theta)\left(\frac{\beta}{1-\beta}+\frac{1-\alpha}{1+\alpha b}\right)w_L\frac{\partial \pi_{r,L}}{\partial w_L}}\\ -\frac{1+\frac{1}{1+r-\phi}}{\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)w_H\overline{h}-(1-\theta)\left(\frac{\beta}{1-\beta}+\frac{1-\alpha}{1+\alpha b}\right)w_H\frac{\partial \pi_{r,H}}{\partial w_H}}\end{array}\right)
\end{aligned}
$$

Hence, the sign of the quantity $w_L\frac{\partial w_H}{\partial \underline{c}}-w_H\frac{\partial w_L}{\partial \underline{c}}$ is the same as the sign of the following quantity

$$
\begin{aligned}
&\left(1+\frac{1}{1+r+\phi}\right)\left(\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)w_H\overline{h}-(1-\theta)\left(\frac{\beta}{1-\beta}+\frac{1-\alpha}{1+\alpha b}\right)w_H\frac{\partial \pi_{r,H}}{\partial w_H}\right)\\
&-\left(1+\frac{1}{1+r-\phi}\right)\left(\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)w_L\overline{h}-(1-\theta)\left(\frac{\beta}{1-\beta}+\frac{1-\alpha}{1+\alpha b}\right)w_L\frac{\partial \pi_{r,L}}{\partial w_L}\right)\\
=\;&\left(1+\frac{1}{1+r+\phi}\right)\left(\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)w_H\overline{h}+(1-\theta)\left(\frac{\beta}{1-\beta}\right)\left(\frac{\beta}{1-\beta}+\frac{1-\alpha}{1+\alpha b}\right)\pi_{r,H}\right)\\
&-\left(1+\frac{1}{1+r-\phi}\right)\left(\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)w_L\overline{h}+(1-\theta)\left(\frac{\beta}{1-\beta}\right)\left(\frac{\beta}{1-\beta}+\frac{1-\alpha}{1+\alpha b}\right)\pi_{r,L}\right)\\
=\;&\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)\overline{h}\left(w_H-w_L-\frac{(1+r)(w_H-w_L)-\phi(w_H+w_L)}{(1+r+\phi)(1+r-\phi)}\right)\\
&+\left(\frac{\beta(1-\theta)}{1-\beta}\right)\left(\frac{\beta}{1-\beta}+\frac{1-\alpha}{1+\alpha b}\right)\left(\pi_{r,H}-\pi_{r,L}-\frac{(1+r)(\pi_{r,H}-\pi_{r,L})-\phi(\pi_{r,H}+\pi_{r,L})}{(1+r+\phi)(1+r-\phi)}\right).
\end{aligned}
$$

This is positive for $\pi_{r,H}>\pi_{r,L}$ since $r>\phi>0$. ■

Proposition 2

The wage elasticity is increasing in banking costs, or $\frac{\partial \nu}{\partial \phi} > 0$.

This is equivalent to $w_L \frac{\partial w_H}{\partial \phi} - w_H \frac{\partial w_L}{\partial \phi} > 0$. Differentiate the labor market equilibrium equation (A.5) with respect to ϕ. For $j = H$, we get

$$\begin{gathered}(1-\theta)\left(\tfrac{\beta}{1-\beta}+\tfrac{1-\alpha}{1+\alpha b}\right)\tfrac{\partial \pi_{r,H}}{\partial w_H}\tfrac{\partial w_H}{\partial \phi}=\left(\tfrac{\alpha+\alpha b}{1+\alpha b}\right)\overline{h}\tfrac{\partial w_H}{\partial \phi}-\left(\tfrac{1-\alpha}{1+\alpha b}\right)\tfrac{y-\underline{c}}{(1+r-\phi)^2}\implies \\ \left[\left(\tfrac{\alpha+\alpha b}{1+\alpha b}\right)\overline{h}-(1-\theta)\left(\tfrac{\beta}{1-\beta}+\tfrac{1-\alpha}{1+\alpha b}\right)\tfrac{\partial \pi_{r,H}}{\partial w_H}\right]\tfrac{\partial w_H}{\partial \phi}=\left(\tfrac{1-\alpha}{1+\alpha b}\right)\tfrac{y-\underline{c}}{(1+r-\phi)^2}\end{gathered}$$

For $j = L$,

$$\left[\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)\overline{h}-(1-\theta)\left(\frac{\beta}{1-\beta}+\frac{1-\alpha}{1+\alpha b}\right)\frac{\partial \pi_{r,L}}{\partial w_L}\right]\frac{\partial w_L}{\partial \phi}=-\left(\frac{1-\alpha}{1+\alpha b}\right)\frac{y-\underline{c}}{(1+r+\phi)^2}$$

Since $y > \underline{c}$ and (A.6), we get $\frac{\partial w_H}{\partial \phi} > 0$ and $\frac{\partial w_L}{\partial \phi} < 0$. The result is immediate. ■

Proposition 3(i)

An increase in the banking fee of the landless can make a landowner better off in expectation. That is, if $\phi = \phi_p$ *for* $k_i = 0$, *then* $\exists$ *parameter values such that* $\frac{\partial EU_r}{\partial \phi_p} > 0$.

For any state $j \in \{H, L\}$, the optimality conditions now give

$$\frac{c_{2,r}-\underline{c}}{c_{1,r}-\underline{c}} = b\left(1+\mathbf{1}_{j=L}(r+\phi)+\mathbf{1}_{j=H}(r-\phi)\right) \qquad wl_r = \left(\frac{1-\alpha}{\alpha}\right)(c_{1,r}-\underline{c})$$

The equilibrium utility of a landowner is given by

$$\begin{aligned} U_r(c_{1,r},l_r,c_{2,r}) &= \log(c_{1,r}-\underline{c})+\left(\frac{1-\alpha}{\alpha}\right)\log\left(\left(\frac{1-\alpha}{\alpha w_j}\right)(c_{1,r}-\underline{c})\right) \\ &\quad +b\log\left(b\left(1+\mathbf{1}_{j=L}(r+\phi_r)+\mathbf{1}_{j=H}(r-\phi_r)\right)(c_{1,r}-\underline{c})\right) \\ &= \frac{1+\alpha b}{\alpha}\log(c_{1,r}-\underline{c})+\frac{1-\alpha}{\alpha}\log\left(\frac{1-\alpha}{\alpha w_j}\right) \\ &\quad +b\log\left(b\left(1+\mathbf{1}_{j=L}(r+\phi_r)+\mathbf{1}_{j=H}(r-\phi_r)\right)\right) \end{aligned}$$

A change in the banking costs for the landless ϕ_p, affects the utility of the landowners only through its affect on the equilibrium wage w_j. Using $(C1)$ and the optimality conditions, we have

$$\begin{aligned} \frac{\partial}{\partial \phi_p}U(c_{1,r},l_r,c_{2,r}) &= \left(\frac{1+\alpha b}{\alpha}\right)(c_{1,r}-\underline{c})^{-1}\frac{\partial}{\partial \phi_p}c_{1,r}-\left(\frac{1-\alpha}{\alpha}\right)w_j^{-1}\frac{\partial w_j}{\partial \phi_p} \\ &= \left(\frac{1-\alpha}{\alpha}\right)w_j^{-1}l_r^{-1}\left(\frac{\partial \pi_r(A_j)}{\partial w_j}\frac{\partial w_j}{\partial \phi_p}+h\frac{\partial w_j}{\partial \phi_p}\right)-\left(\frac{1-\alpha}{\alpha}\right)w_j^{-1}\frac{\partial w_j}{\partial \phi_p} \\ &= \left(\frac{1-\alpha}{\alpha}\right)w_j^{-1}l_r^{-1}\left(\overline{h}-\left(\frac{\beta}{1-\beta}\right)\frac{\pi_r(A_j)}{w_j}-l_r\right)\frac{\partial w_j}{\partial \phi_p} \end{aligned}$$

The labor market equilibrium equation (A.5) now becomes

$$(1-\theta)\left(\tfrac{\beta}{1-\beta}+\tfrac{1-\alpha}{1+\alpha b}\right)\pi_r \tag{A.11}$$
$$=\left(\tfrac{\alpha+\alpha b}{1+\alpha b}\right)w_j\overline{h}-\left(\tfrac{1-\alpha}{1+\alpha b}\right)\left(\left(\begin{array}{c}\frac{\theta(y-\underline{c})}{1+\mathbf{1}_{j=H}(r-\phi_p)+\mathbf{1}_{j=L}(r+\phi_p)}\\+\frac{(1-\theta)(y-\underline{c})}{1+\mathbf{1}_{j=H}(r-\phi_r)+\mathbf{1}_{j=L}(r+\phi_r)}\end{array}\right)-\underline{c}\right)$$

To obtain the effect of a change in ϕ_p on the wage w_j, differentiate (A.8) with respect to ϕ_p. For $j=H$,

$$(1-\theta)\left(\tfrac{\beta}{1-\beta}+\tfrac{1-\alpha}{1+\alpha b}\right)\tfrac{\partial\pi_r}{\partial w_H}\tfrac{\partial w_H}{\partial\phi_p}=\left(\tfrac{\alpha+\alpha b}{1+\alpha b}\right)h\tfrac{\partial w_H}{\partial\phi_p}-\theta\left(\tfrac{1-\alpha}{1+\alpha b}\right)\tfrac{y-\underline{c}}{(1+r-\phi_p)^2}\Longrightarrow$$
$$\left[\left(\tfrac{\alpha+\alpha b}{1+\alpha b}\right)h+(1-\theta)\left(\tfrac{\beta}{1-\beta}+\tfrac{1-\alpha}{1+\alpha b}\right)\left(\tfrac{\beta}{1-\beta}\right)\tfrac{\pi_{r,H}}{w_H}\right]\tfrac{\partial w_H}{\partial\phi_p}=\theta\left(\tfrac{1-\alpha}{1+\alpha b}\right)\tfrac{y-\underline{c}}{(1+r-\phi_p)^2} \tag{A.12}$$

and for $j=L$,

$$(1-\theta)\left(\tfrac{\beta}{1-\beta}+\tfrac{1-\alpha}{1+\alpha b}\right)\tfrac{\partial\pi_{r,L}}{\partial w_L}\tfrac{\partial w_L}{\partial\phi_p}=\left(\tfrac{\alpha+\alpha b}{1+\alpha b}\right)h\tfrac{\partial w_L}{\partial\phi_p}+\theta\left(\tfrac{1-\alpha}{1+\alpha b}\right)\tfrac{y-\underline{c}}{(1+r+\phi_p)^2}\Longrightarrow$$
$$\left[\left(\tfrac{\alpha+\alpha b}{1+\alpha b}\right)h+(1-\theta)\left(\tfrac{\beta}{1-\beta}+\tfrac{1-\alpha}{1+\alpha b}\right)\left(\tfrac{\beta}{1-\beta}\right)\tfrac{\pi_{r,L}}{w_L}\right]\tfrac{\partial w_L}{\partial\phi_p}=-\theta\left(\tfrac{1-\alpha}{1+\alpha b}\right)\tfrac{y-\underline{c}}{(1+r+\phi_p)^2}$$

Clearly, $\frac{\partial w_H}{\partial\phi_p}>0$ and $\frac{\partial w_L}{\partial\phi_p}<0$.

For the ex-ante expected utility of a member of the land-owning class, we have

$$\begin{aligned}\mathbf{E}_{\widetilde{A}}\left[\frac{\partial}{\partial\phi_p}U(c_{1,r},l_r,c_{2,r})\right] &= \left(\frac{1-\alpha}{2\alpha}\right)\left[w_H^{-1}l_{r,H}^{-1}\left(\overline{h}-\left(\frac{\beta}{1-\beta}\right)\frac{\pi_{r,H}}{w_H}-l_{r,H}\right)\frac{\partial w_H}{\partial\phi_p}\right.\\ &\quad\left.+w_L^{-1}l_{r,L}^{-1}\left(\overline{h}-\left(\frac{\beta}{1-\beta}\right)\frac{\pi_{r,L}}{w_L}-l_{r,L}\right)\frac{\partial w_L}{\partial\phi_p}\right]\end{aligned} \tag{A.13}$$

From (L), it is straightforward to check the following

$$w_j\left(\overline{h}-l_i(A_j)\right)=\frac{\alpha+\alpha b}{1+\alpha b}w_j\overline{h}-\frac{1-\alpha}{1+\alpha b}\left(\pi_i(A_j)+\frac{y_i-\underline{c}}{1+\mathbf{1}_{j=L}(r+\phi_i)+\mathbf{1}_{j=H}(r-\phi_i)}-\underline{c}\right) \tag{A.14}$$

which, using the labor market equilibrium equation (A.8), becomes

$$w_j\left(\overline{h}-l_r(A_j)\right)= \tag{A.15}$$
$$\left((1-\theta)\tfrac{\beta}{1-\beta}-\theta\tfrac{1-\alpha}{1+\alpha b}\right)\pi_r(A_j)-\theta\left(\tfrac{1-\alpha}{1+\alpha b}\right)\left(\tfrac{y-\underline{c}}{1+\mathbf{1}_{j=H}(r-\phi_r)+\mathbf{1}_{j=L}(r+\phi_r)}-\tfrac{y-\underline{c}}{1+\mathbf{1}_{j=H}(r-\phi_p)+\mathbf{1}_{j=L}(r+\phi_p)}\right)$$

For $j=L$, (A.12) implies that $\phi_r\leq\phi_p$ suffices for the second term on the right hand side of (A.10) to be positive[27]For the first term on the right hand side of (A.10), notice that (A.8), for $j=H$, implies that the

[27]More precisely, (A.12) implies that the term multiplying $\frac{\partial w_L}{\partial\phi_p}$ in (A.10) is negative (recall that $\frac{\partial w_L}{\partial\phi_p}<0$).

positive quantity $\frac{\pi_{r,H}}{w_H}$ is bounded above:

$$\begin{aligned}
\frac{\pi_{r,H}}{w_H} &= (1-\theta)^{-1}\left(\frac{\beta}{1-\beta}+\frac{1-\alpha}{1+\alpha b}\right)^{-1} \times \\
&\left[\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)\overline{h} - w_H^{-1}\left(\frac{1-\alpha}{1+\alpha b}\right)\left(\left(\frac{\theta\left(y-\underline{c}\right)}{1+r-\phi_p}+\frac{(1-\theta)\left(y_r-\underline{c}\right)}{1+r-\phi_r}\right)-\underline{c}\right)\right] \\
&< (1-\theta)^{-1}\left(\frac{\beta}{1-\beta}+\frac{1-\alpha}{1+\alpha b}\right)^{-1}\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)\overline{h}
\end{aligned}$$

By (A.4), the quantity $\frac{\pi_{r,H}}{w_H}$ is proportional to $\frac{A_H}{w_H}$. For a sufficiently large productivity shock, $A_H \longrightarrow \infty$, $\frac{\pi_{r,H}}{w_H}$ remaining bounded from above requires that $\frac{A_H}{w_H}$ remain bounded above; hence, it must be that $w_H \longrightarrow \infty$. Notice also from (A.9) that $\frac{\partial w_H}{\partial \phi_p}$ is bounded above whereas, by (L), $l_{r,H}$ tends to a finite limit. Therefore, for $A_H \longrightarrow \infty$, the first term on the right hand side of (A.10) vanishes. ■

Proposition 3(ii)

An increase in the economy-wide cost of borrowing can make a landowner better off. That is, if all agents face the banking cost ϕ, then $\exists$ parameter values such that $\frac{\partial U_r}{\partial \phi} > 0$ in the state $\widetilde{A} = A_L$.

For $j = L$, the optimality conditions become

$$\frac{c_2-\underline{c}}{c_1-\underline{c}} = b\left(1+r+\phi\right) \qquad wl = \left(\frac{1-\alpha}{\alpha}\right)\left(c_1-\underline{c}\right)$$

The equilibrium utility of a member of the land-owning class is given by

$$\begin{aligned}
U\left(c_{1,r}, l_r, c_{2,r}\right) &= \log\left(c_{1,r}-\underline{c}\right) + b\log\left(b\left(1+r+\phi\right)\left(c_{1,r}-\underline{c}\right)\right) + \frac{1-\alpha}{\alpha}\log\left(\left(\frac{1-\alpha}{\alpha w_L}\right)\left(c_{1,r}-\underline{c}\right)\right) \\
&= \left(\frac{1+\alpha b}{\alpha}\right)\log\left(c_{1,r}-\underline{c}\right) + \left(\frac{1-\alpha}{\alpha}\right)\log\left(\frac{1-\alpha}{\alpha w_L}\right) + b\log\left(b\left(1+r+\phi\right)\right)
\end{aligned}$$

It suffices to show that there is a range of the parameters of the model such that $\frac{\partial}{\partial \phi}U\left(c_{1,r}, l_r, c_{2,r}\right) > 0$. We have

$$\begin{aligned}
\frac{\partial}{\partial \phi}U\left(c_{1,r}, l_r, c_{2,r}\right) &= \left(\frac{1+\alpha b}{\alpha}\right)\left(c_{1,r}-\underline{c}\right)^{-1}\frac{\partial}{\partial \phi}c_{1,r} - \left(\frac{1-\alpha}{\alpha}\right)w_L^{-1}\frac{\partial w_L}{\partial \phi} + \frac{b}{1+r+\phi} \\
&= \left(\frac{1-\alpha}{\alpha w_L l_r}\right)\left(\frac{\partial \pi_{r,L}}{\partial w_L}\frac{\partial w_L}{\partial \phi} + \overline{h}\frac{\partial w_L}{\partial \phi} - \frac{y-\underline{c}}{\left(1+r+\phi\right)^2}\right) \\
&\quad - \left(\frac{1-\alpha}{\alpha}\right)w_L^{-1}\frac{\partial w_L}{\partial \phi} + \frac{b}{1+r+\phi} \\
&= \left(\frac{1-\alpha}{\alpha}\right)w_L^{-1}\left[l_r^{-1}\left(\overline{h} - \left(\frac{\beta}{1-\beta}\right)\frac{\pi_{r,L}}{w_L}\right) - 1\right]\frac{\partial w_L}{\partial \phi} \\
&\quad - \left(\frac{1-\alpha}{\alpha}\right)w_L^{-1}l_r^{-1}\frac{y-\underline{c}}{\left(1+r+\phi\right)^2} + \frac{b}{1+r+\phi}
\end{aligned}$$

where the last equality uses (A.6). In the proof to Proposition 1 we showed, however, that

$$\begin{aligned}\frac{y-\underline{c}}{(1+r+\phi)^2} &= \left[-\left(\frac{\alpha+\alpha b}{1-\alpha}\right)\overline{h}+(1-\theta)\left(\left(\frac{\beta}{1-\beta}\right)\left(\frac{1+\alpha b}{1-\alpha}\right)+1\right)\frac{\partial \pi_{r,L}}{\partial w_L}\right]\frac{\partial w_L}{\partial \phi}\\ &= \left[-\left(\frac{\alpha+\alpha b}{1-\alpha}\right)\overline{h}-(1-\theta)\left(\left(\frac{\beta}{1-\beta}\right)\left(\frac{1+\alpha b}{1-\alpha}\right)+1\right)\left(\frac{\beta}{1-\beta}\right)\frac{\pi_{r,L}}{w_L}\right]\frac{\partial w_L}{\partial \phi}\end{aligned}$$

Thus

$$\begin{aligned}&\frac{\partial}{\partial \phi}U\left(c_{1,r},l_r,c_{2,r}\right)=\\ &\frac{b}{1+r+\phi}+\left(\frac{1-\alpha}{\alpha}\right)w_L^{-1}l_r^{-1}\left[\begin{pmatrix}\overline{h}-\left(\frac{\beta}{1-\beta}\right)\frac{\pi_{r,L}}{w_L}+\left(\frac{\alpha+\alpha b}{1-\alpha}\right)\overline{h}\\ +(1-\theta)\left(\left(\frac{\beta}{1-\beta}\right)\left(\frac{1+\alpha b}{1-\alpha}\right)+1\right)\left(\frac{\beta}{1-\beta}\right)\frac{\pi_{r,L}}{w_L}\end{pmatrix}-l_r\right]\frac{\partial w_L}{\partial \phi}\\ &=\frac{b}{1+r+\phi}+\left(\frac{1-\alpha}{\alpha}\right)w_L^{-1}l_r^{-1}\times\\ &\left[\left(\frac{1+\alpha b}{1-\alpha}\right)\overline{h}+\left((1-\theta)\left(\frac{\beta}{1-\beta}\right)\left(\frac{1+\alpha b}{1-\alpha}\right)-\theta\right)\left(\frac{\beta}{1-\beta}\right)\frac{\pi_{r,L}}{w_L}-l_r\right]\frac{\partial w_L}{\partial \phi}\end{aligned}$$

Recall, however, that $\frac{\partial w_L}{\partial \phi}<0$.[28] Hence, for $\frac{\partial}{\partial \phi}U\left(c_{1,r},l_r,c_{2,r}\right)>0$, the following condition suffices

$$\left(\frac{1+\alpha b}{1-\alpha}\right)\overline{h}+\left((1-\theta)\left(\frac{\beta}{1-\beta}\right)\left(\frac{1+\alpha b}{1-\alpha}\right)-\theta\right)\left(\frac{\beta}{1-\beta}\right)\frac{\pi_{r,L}}{w_L}<l_r$$

or, equivalently,

$$\begin{aligned}&\left(\frac{1+\alpha b}{1-\alpha}\right)w_L\overline{h}+\left((1-\theta)\left(\frac{\beta}{1-\beta}\right)\left(\frac{1+\alpha b}{1-\alpha}\right)-\theta\right)\left(\frac{\beta}{1-\beta}\right)\pi_{r,L}\\ <\;& w_L l_r\\ =\;& \frac{1-\alpha}{1+\alpha b}\left(w_L\overline{h}+\pi_{r,L}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)\end{aligned}$$

where the equality follows from (L). Hence, the sufficiency condition is equivalent to the following

$$\begin{aligned}\left(\frac{1+\alpha b}{1-\alpha}-\frac{1-\alpha}{1+\alpha b}\right)w_L\overline{h} \;<\;& \left(\frac{1-\alpha}{1+\alpha b}-\left((1-\theta)\left(\frac{\beta}{1-\beta}\right)\left(\frac{1+\alpha b}{1-\alpha}\right)-\theta\right)\left(\frac{\beta}{1-\beta}\right)\right)\pi_{r,L}\\ &+\left(\frac{1-\alpha}{1+\alpha b}\right)\left(\frac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)\end{aligned} \tag{A.16}$$

Notice now that, since $b\in(0,1)$, we have

$$\frac{1+\alpha b}{1-\alpha}-\frac{1-\alpha}{1+\alpha b}=\frac{(1+\alpha b)^2-(1-\alpha)^2}{(1+\alpha b)(1-\alpha)}=-\frac{\alpha^2\left(1-b^2\right)+2\alpha(1-b)}{(1+\alpha b)(1-\alpha)}<0$$

[28] See the proof to Proposition 2.

which means that the left-hand side of (A.13) is negative. Moreover,

$$\frac{1-\alpha}{1+\alpha b} - \left((1-\theta)\left(\frac{\beta}{1-\beta}\right)\left(\frac{1+\alpha b}{1-\alpha}\right) - \theta\right)\left(\frac{\beta}{1-\beta}\right)$$

is a non-negative quantity if

$$\begin{aligned}
(1-\theta)\left(\frac{\beta}{1-\beta}\right)\left(\frac{1+\alpha b}{1-\alpha}\right) &\leq \theta \Longleftrightarrow \\
\left(\frac{\beta}{1-\beta}\right)\left(\frac{1+\alpha b}{1-\alpha}\right) &< \left(1+\left(\frac{\beta}{1-\beta}\right)\left(\frac{1+\alpha b}{1-\alpha}\right)\right)\theta \Longleftrightarrow \\
\theta &> \frac{\left(\frac{\beta}{1-\beta}\right)\left(\frac{1+\alpha b}{1-\alpha}\right)}{1+\left(\frac{\beta}{1-\beta}\right)\left(\frac{1+\alpha b}{1-\alpha}\right)} \in (0,1)
\end{aligned}$$

Therefore, for large enough θ, there exists a non-empty set of values for the parameters of the model such that all terms on the right-hand side of (A.13) are positive.

Recall now (A.4) and (A.6): when w_L is falling, $\pi_{r,L}$ is rising with $\lim_{w_L \longrightarrow 0} \pi_{r,L} = +\infty$. Hence, a sufficiently low equilibrium wage w_L guarantees that (A.13) holds for the aforementioned range of parameters. The following claim guarantees that a falling equilibrium wage is not inconsistent with large values for the parameter θ. This completes the proof. ■

Solution with Migration

The subsequent analysis allows migration to take place in the low-TFP state ($j = L$). We continue to assume that, in this state, agents borrow against their period-2 income (or are, at most, indifferent between borrowing or not). Notice first that one would never choose to migrate and *not* work. If $l_i = \overline{h}$, one is better off not incurring the costs of migration. Thus, we restrict attention to the interior solutions ($l_i < \overline{h}$).

The solution to the individual problem when migration is individually optimal is

$$\begin{aligned}
(ML) \qquad l^M &= \frac{1-\alpha}{1+\alpha b}\left[\overline{h} + W^{-1}\left(\pi - \widetilde{\Delta} + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}\right)\right] \\
(MC1) \quad c_1^M - \underline{c} &= \frac{\alpha}{1+\alpha b}\left[\pi - \widetilde{\Delta} + W\overline{h} + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}\right] \\
(MC2) \quad c_2^M - \underline{c} &= \frac{\alpha b}{1+\alpha b}\left[\left(\pi - \widetilde{\Delta} + W\overline{h} - \underline{c}\right)(1+r+\phi) + y - \underline{c}\right]
\end{aligned}$$

Let the equilibrium be such that a fraction $\lambda_i \in (0,1)$ of the members of group $i \in \{p, r\}$ choose to migrate. Let it also be that everyone in the economy is working ($l_i, l_i^M < h : i \in \{p, r\}$). The solution is given by (L), ($C1$) and ($C2$) for those members of the ith group who do not migrate and by (ML), ($MC1$) and ($MC2$) for those who do. The domestic labor market equilibrium is given by

$$\begin{aligned}
K\left(\frac{A_L\beta}{w_L}\right)^{\frac{1}{1-\beta}} &= \left(1-\lambda_p\right)\theta N\left[\overline{h}-l_{p,L}\right]+\left(1-\lambda_r\right)\left(1-\theta\right)N\left[\overline{h}-l_{r,L}\right] \Longrightarrow \\
K\left(\frac{A_L\beta}{w_L^{\beta}}\right)^{\frac{1}{1-\beta}} &= \left(1-\lambda_p\right)\theta\left[w_LH-w_LNl_{p,L}\right]+\left(1-\lambda_r\right)\left(1-\theta\right)\left[w_LH-w_LNl_{r,L}\right] \\
&= \left[1-\lambda_r-\theta\left(\lambda_p-\lambda_r\right)\right]\left[\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)w_LH-\left(\frac{1-\alpha}{1+\alpha b}\right)N\left(\frac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)\right] \\
&\quad -\left(1-\lambda_r\right)\left(1-\theta\right)N\left(\frac{1-\alpha}{1+\alpha b}\right)\pi_{r,L}
\end{aligned}$$

Using (A.4), the labor market equilibrium equation simplifies to the following

$$\begin{aligned}
&\left(1-\theta\right)\left[\frac{1-\beta}{\beta}+\left(\frac{1-\alpha}{1+\alpha b}\right)\left(1-\lambda_r\right)\right]\pi_{r,L} \\
=\ &\left[1-\lambda_r-\theta\left(\lambda_p-\lambda_r\right)\right]\left[\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)w_L\overline{h}-\left(\frac{1-\alpha}{1+\alpha b}\right)\left(\frac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)\right] \qquad \text{(A.17)}
\end{aligned}$$

Applying (A.11) for $y_i = y : i \in \{p, r\}$,(A.14) can be equivalently written as

$$\left(1-\theta\right)\left[\frac{1-\beta}{\beta}+\left(\frac{1-\alpha}{1+\alpha b}\right)\left(1-\lambda_r\right)\right]\pi_{r,L}=\left[1-\lambda_r-\theta\left(\lambda_p-\lambda_r\right)\right]w_L\left(\overline{h}-l_{p,L}\right) \qquad \text{(A.18)}$$

In equilibrium, the fraction λ_i who migrate from the ith group is determined endogenously: there must exist a draw of the random migration costs $\widetilde{\Delta}$ that makes an agent indifferent between migrating and not. Let Δ_i be this cut-off value for group $i \in \{p, r\}$; given that migration costs are uniformly distributed within $[\Delta_{\min}, \Delta_{\max}]$ we have:

$$\lambda_i = \frac{\Delta_i - \Delta_{\min}}{\Delta_{\max} - \Delta_{\min}} \qquad i \in \{p, r\}$$

Note that everyone in group i with migration costs below the threshold Δ_i would choose to migrate, in equilibrium, whereas everyone with costs above Δ_i would stay home. The condition determining the cut-off migration costs for group $i \in \{p, r\}$ is given by

$$
\begin{aligned}
& U\left(l_i^M, c_{1,i}^M, c_{2,i}^M; \Delta_i, M=1\right) = U\left(l_i, c_{1,i}, c_{2,i}; \Delta_i, M=0\right) \\
\iff & \log\left(\frac{\alpha}{1+\alpha b}\left[\pi - \Delta_i + W\overline{h} + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}\right]\right) \\
& + \left(\frac{1-\alpha}{\alpha}\right)\log\left(\frac{1-\alpha}{1+\alpha b}\left[\overline{h} + W^{-1}\left(\pi - \Delta_i + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}\right)\right]\right) \\
& + b\log\left(\frac{\alpha b}{1+\alpha b}\left[\left(\pi - \Delta_i + W\overline{h} - \underline{c}\right)(1+r+\phi) + y - \underline{c}\right]\right) \\
= & \log\left(\frac{\alpha}{1+\alpha b}\left[\pi + w_L\overline{h} + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}\right]\right) \\
& + \left(\frac{1-\alpha}{\alpha}\right)\log\left(\frac{1-\alpha}{1+\alpha b}\left[\overline{h} + w_L^{-1}\left(\pi + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}\right)\right]\right) \\
& + b\log\frac{\alpha b}{1+\alpha b}\left[\left(\pi + w_L\overline{h} - \underline{c}\right)(1+r+\phi) + y - \underline{c}\right] \\
\iff & \left(\frac{W\overline{h} + \pi_i - \Delta_i + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}{w_L\overline{h} + \pi_i + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}\right)^{\frac{1+\alpha b}{\alpha}} = \left(\frac{W}{w_L}\right)^{\frac{1-\alpha}{\alpha}}
\end{aligned} \tag{A.19}
$$

Notice a direct implication given that (A.16) holds for both $i = r$ and $i = p$:

$$
\frac{W\overline{h} + \pi_r - \Delta_r + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}{w_L\overline{h} + \pi_r + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}} = \frac{W\overline{h} - \Delta_p + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}{w_L\overline{h} + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}} \tag{A.20}
$$

Since a sine qua non for any migration in group $i \in \{p, r\}$ to take place is $W > w_L$, we get moreover

$$
\log\left(\frac{W\overline{h} + \pi_i - \Delta_i + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}{w_L\overline{h} + \pi_i + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}\right) = \left(\frac{1-\alpha}{\alpha+\alpha b}\right)\log\left(\frac{W}{w_L}\right) > 0
$$

or

$$
\left(W - w_L\right)\overline{h} > \Delta_i \qquad i \in \{p, r\} \tag{A.21}
$$

Proposition 4(i)

The wage elasticity is increasing in migration costs, or $\frac{\partial \nu}{\partial \psi} > 0$.

This is equivalent to $w_L \frac{\partial w_H}{\partial \Delta_{max}} - w_H \frac{\partial w_L}{\partial \Delta_{max}} > 0$ where $\Delta_{max} \equiv \Delta_{min} + \psi$. Consider first differentiating the labor market equilibrium equation (A.14) with respect to $\Delta_{\max}$:

$$
\begin{aligned}
& (1-\theta)\left(\frac{1-\beta}{\beta} + \left(\frac{1-\alpha}{1+\alpha b}\right)(1-\lambda_r)\right)\frac{\partial \pi_{r,L}}{\partial w_L}\frac{\partial w_L}{\partial \Delta_{\max}} - (1-\theta)\left(\frac{1-\alpha}{1+\alpha b}\right)\pi_{r,L}\frac{\partial \lambda_r}{\partial \Delta_{\max}} \\
= & \left[1 - \lambda_r - \theta\left(\lambda_p - \lambda_r\right)\right]\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)\overline{h}\frac{\partial w_L}{\partial \Delta_{\max}} \\
& - \left((1-\theta)\frac{\partial \lambda_r}{\partial \Delta_{\max}} + \theta\frac{\partial \lambda_p}{\partial \Delta_{\max}}\right)\left(\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)w_L\overline{h} - \left(\frac{1-\alpha}{1+\alpha b}\right)\left(\frac{y-\underline{c}}{1+r+\phi} - \underline{c}\right)\right)
\end{aligned}
$$

or, using (A.6),

$$\left[\begin{array}{c}[1-\lambda_r-\theta(\lambda_p-\lambda_r)]\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)\overline{h}\\ +(1-\theta)\left(\frac{1-\beta}{\beta}+\left(\frac{1-\alpha}{1+\alpha b}\right)(1-\lambda_r)\right)\left(\frac{\beta}{1-\beta}\right)w_L^{-1}\pi_{r,L}\end{array}\right]\frac{\partial w_L}{\partial\Delta_{\max}}$$
$$= (1-\theta)\left(\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)w_L\overline{h}-\left(\frac{1-\alpha}{1+\alpha b}\right)\left(\pi_{r,L}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)\right)\frac{\partial\lambda_r}{\partial\Delta_{\max}}$$
$$+\theta\left(\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)w_L\overline{h}-\left(\frac{1-\alpha}{1+\alpha b}\right)\left(\frac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)\right)\frac{\partial\lambda_p}{\partial\Delta_{\max}}$$

which, by (A.7), can be also written as follows

$$\left[\begin{array}{c}[1-\lambda_r-\theta(\lambda_p-\lambda_r)]\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)\overline{h}\\ +(1-\theta)\left(\frac{1-\beta}{\beta}+\left(\frac{1-\alpha}{1+\alpha b}\right)(1-\lambda_r)\right)\left(\frac{\beta}{1-\beta}\right)w_L^{-1}\pi_{r,L}\end{array}\right]\frac{\partial w_L}{\partial\Delta_{\max}}$$
$$= (1-\theta)w_L\left(\overline{h}-l_{r,L}\right)\frac{\partial\lambda_r}{\partial\Delta_{\max}}+\theta w_L\left(\overline{h}-l_{p,L}\right)\frac{\partial\lambda_p}{\partial\Delta_{\max}} \tag{A.22}$$

The rate of change of λ_i with respect to $\Delta_{\max}$ is given by

$$\frac{\partial\lambda_i}{\partial\Delta_{\max}} = -(\Delta_{\max}-\Delta_{\min})^{-2}\left(\Delta_i-\Delta_{\min}-\frac{\partial\Delta_i}{\partial\Delta_{\max}}(\Delta_{\max}-\Delta_{\min})\right)$$
$$= -\frac{\Delta_i-\Delta_{\min}}{(\Delta_{\max}-\Delta_{\min})^2}+(\Delta_{\max}-\Delta_{\min})^{-1}\frac{\partial\Delta_i}{\partial\Delta_{\max}}$$

Step I: It is instructive for the exposition of the proof to ignore for the moment the effects of a change in $\Delta_{\max}$ on λ_i that occur in response to the change in w_L and focus on the direct effect:

$$\frac{\partial\lambda_i'}{\partial\Delta_{\max}} = -\frac{\Delta_i-\Delta_{\min}}{(\Delta_{\max}-\Delta_{\min})^2}$$

Notice first that, from (A.15), we get

$$(1-\lambda_r)(1-\theta)\left(\frac{1-\alpha}{1+\alpha b}\right)\pi_{r,L} = [1-\lambda_r-\theta(\lambda_p-\lambda_r)]w_L\left(\overline{h}-l_{p,L}\right)-\left(\frac{1-\beta}{\beta}\right)(1-\theta)\pi_{r,L}$$
$$< (1-\lambda_r)w_L\left(\overline{h}-l_{p,L}\right) \implies$$
$$(1-\theta)\left(\frac{1-\alpha}{1+\alpha b}\right)\pi_{r,L} < w_L\left(\overline{h}-l_{p,L}\right)$$

where the first inequality follows from $\lambda_p > \lambda_r$.[29] The part of the right hand side of (A.19) which represents

[29] The result that $\lambda_p > \lambda_r$ is an immediate corollary of Proposition 4(ii).

the direct effects can now be written as follows

$$\begin{aligned}
& (1-\theta)\, w_L \left(\overline{h}-l_{r,L}\right) \frac{\partial \lambda_r'}{\partial \Delta_{\max}} + \theta w_L \left(\overline{h}-l_{p,L}\right) \frac{\partial \lambda_p'}{\partial \Delta_{\max}} \\
= \; & -\left(\Delta_{\max}-\Delta_{\min}\right)^{-2} \left[(1-\theta)\, w_L \left(\overline{h}-l_{r,L}\right)\left(\Delta_r-\Delta_{\min}\right) + \theta w_L \left(\overline{h}-l_{p,L}\right)\left(\Delta_p-\Delta_{\min}\right)\right] \\
< \; & -\left(\Delta_{\max}-\Delta_{\min}\right)^{-2} \left[(1-\theta)\, w_L \left(\overline{h}-l_{r,L}\right) + \theta w_L \left(\overline{h}-l_{p,L}\right)\right]\left(\Delta_r-\Delta_{\min}\right) \\
< \; & -\left(\Delta_{\max}-\Delta_{\min}\right)^{-2} w_L \left(\overline{h}-l_{r,L}\right)\left(\Delta_r-\Delta_{\min}\right) \\
< \; & 0
\end{aligned}$$

where the first inequality follows from $\Delta_p > \Delta_r$ (Proposition 4(ii))which is proved below) and the second one from $l_p < l_r$.[30] In other words, the part of the right hand side of (A.19) which represents the direct effects is *negative*.

Step II: The part of the right hand side of (A.19) representing the indirect effects is given by

$$\left(\Delta_{\max}-\Delta_{\min}\right)^{-1} \left[(1-\theta)\, w_L \left(\overline{h}-l_{r,L}\right) \frac{\partial \Delta_r}{\partial \Delta_{\max}} + \theta w_L \left(\overline{h}-l_{p,L}\right) \frac{\partial \Delta_p}{\partial \Delta_{\max}}\right]$$

Consider now the condition determining the cut-off migration costs for group $i \in \{p, r\}$. Differentiating with respect to $\Delta_{\max}$ gives

$$\begin{aligned}
& \tfrac{\partial}{\partial \Delta_{\max}} \left[U\left(l_i^M, c_{1,i}^M, c_{2,i}^M; \Delta_i, M=1\right) - U\left(l_i, c_{1,i}, c_{2,i}; \Delta_i, M=0\right)\right] \\
& = \left(W\overline{h} + \pi_i - \Delta_i + \tfrac{y-\underline{c}}{1+r+\phi} - \underline{c}\right)^{-1} \left(\tfrac{\partial \pi_i}{\partial w_L}\tfrac{\partial w_L}{\partial \Delta_{\max}} - \tfrac{\partial \Delta_i}{\partial \Delta_{\max}}\right) \\
& \quad - \left(w_L\overline{h} + \pi_i + \tfrac{y-\underline{c}}{1+r+\phi} - \underline{c}\right)^{-1} \left(\tfrac{\partial \pi_i}{\partial w_L}\tfrac{\partial w_L}{\partial \Delta_{\max}} + \tfrac{\partial w_L}{\partial \Delta_{\max}}\overline{h}\right) \\
& \quad + \left(\tfrac{1-\alpha}{\alpha}\right)\left(W\overline{h} + \pi_i - \Delta_i + \tfrac{y-\underline{c}}{1+r+\phi} - \underline{c}\right)^{-1} \left(\tfrac{\partial \pi_i}{\partial w_L}\tfrac{\partial w_L}{\partial \Delta_{\max}} - \tfrac{\partial \Delta_i}{\partial \Delta_{\max}}\right) \\
& \quad - \left(\tfrac{1-\alpha}{\alpha}\right)\left(w_L\overline{h} + \pi_i + \tfrac{y-\underline{c}}{1+r+\phi} - \underline{c}\right)^{-1} \left(\tfrac{\partial \pi_i}{\partial w_L}\tfrac{\partial w_L}{\partial \Delta_{\max}} - \left(\pi_i + \tfrac{y-\underline{c}}{1+r+\phi} - \underline{c}\right) w_L^{-1}\tfrac{\partial w_L}{\partial \Delta_{\max}}\right) \\
& \quad + b\left(W\overline{h} + \pi_i - \Delta_i + \tfrac{y-\underline{c}}{1+r+\phi} - \underline{c}\right)^{-1} \left(\tfrac{\partial \pi_i}{\partial w_L}\tfrac{\partial w_L}{\partial \Delta_{\max}} - \tfrac{\partial \Delta_i}{\partial \Delta_{\max}}\right) \\
& \quad - b\left(w_L\overline{h} + \pi_i + \tfrac{y-\underline{c}}{1+r+\phi} - \underline{c}\right)^{-1} \left(\tfrac{\partial \pi_i}{\partial w_L}\tfrac{\partial w_L}{\partial \Delta_{\max}} + \tfrac{\partial w_L}{\partial \Delta_{\max}}\overline{h}\right)
\end{aligned}$$

Since we ought to have

$$\frac{\partial}{\partial \Delta_{\max}} U\left(l_i^M, c_{1,i}^M, c_{2,i}^M; \Delta_i, M=1\right) = \frac{\partial}{\partial \Delta_{\max}} U\left(l_i, c_{1,i}, c_{2,i}; \Delta_i, M=0\right)$$

[30] Notice that, for any realization of the migration costs Δ, (ML) establishes that $l_p < l_r$ since $\pi_p = 0 < \pi_r$.

we get

$$\left(\frac{1}{W\overline{h}+\pi_i-\Delta_i+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}-\frac{1}{w_L\overline{h}+\pi_i+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\left(\frac{1+\alpha b}{\alpha}\right)\frac{\partial\pi_i}{\partial w_L}\frac{\partial w_L}{\partial\Delta_{\max}}$$
$$-\left(\frac{1}{w_L\overline{h}+\pi_i+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\left[(1+b)\,\overline{h}-\left(\frac{1-\alpha}{\alpha}\right)\left(\pi_i+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)w_L^{-1}\right]\frac{\partial w_L}{\partial\Delta_{\max}}$$
$$=\left(\frac{1}{W\overline{h}+\pi_i-\Delta_i+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\left(\frac{1+\alpha b}{\alpha}\right)\frac{\partial\Delta_i}{\partial\Delta_{\max}}$$

or

$$-\left(\left(W-w_L\right)\overline{h}-\Delta_i\right)\tfrac{\partial\pi_i}{\partial w_L}\tfrac{\partial w_L}{\partial\Delta_{\max}}$$
$$-\left(W\overline{h}+\pi_i-\Delta_i+\tfrac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)w_L^{-1}\left(\left(\tfrac{\alpha+\alpha b}{1+\alpha b}\right)w_L\overline{h}-\left(\tfrac{1-\alpha}{1+\alpha b}\right)\left(\pi_i+\tfrac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)\right)\tfrac{\partial w_L}{\partial\Delta_{\max}}$$
$$=\left(w_L\overline{h}+\pi_i+\tfrac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)\tfrac{\partial\Delta_i}{\partial\Delta_{\max}}$$

Now, (A.11) and (A.6) allow us to rewrite the equality above as follows

$$\left(\left(W-w_L\right)\overline{h}-\Delta_i\right)\left(\frac{\beta}{1-\beta}\right)\frac{\pi_i}{w_L}\frac{\partial w_L}{\partial\Delta_{\max}}$$
$$-\left(W\overline{h}+\pi_i-\Delta_i+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)\left(\overline{h}-l_i\right)\frac{\partial w_L}{\partial\Delta_{\max}}$$
$$=\left(w_L\overline{h}+\pi_i+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)\frac{\partial\Delta_i}{\partial\Delta_{\max}}$$

Therefore, the part of the right hand side of (A.19) representing the indirect effects can be written as $(\Delta_{\max}-\Delta_{\min})^{-1}$ multiplying the following quantity

$$(1-\theta)\,w_L\left(\overline{h}-l_{r,L}\right)\frac{\partial\Delta_r}{\partial\Delta_{\max}}+\theta w_L\left(\overline{h}-l_{p,L}\right)\frac{\partial\Delta_p}{\partial\Delta_{\max}}$$
$$=(1-\theta)\,w_L\left(\overline{h}-l_{r,L}\right)\left[\begin{array}{c}\left(\frac{(W-w_L)\overline{h}-\Delta_r}{w_L\overline{h}+\pi_r+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\left(\frac{\beta}{1-\beta}\right)\frac{\pi_{r,L}}{w_L}\\-\left(\frac{W\overline{h}+\pi_r-\Delta_r+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}{w_L\overline{h}+\pi_r+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\left(\overline{h}-l_{r,L}\right)\end{array}\right]\frac{\partial w_L}{\partial\Delta_{\max}}$$
$$-\theta w_L\left(\overline{h}-l_{p,L}\right)\left[\left(\frac{W\overline{h}-\Delta_p+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}{w_L\overline{h}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\left(\overline{h}-l_{p,L}\right)\right]\frac{\partial w_L}{\partial\Delta_{\max}}$$

or, equivalently, as $\left[w_L\left(\Delta_{\max}-\Delta_{\min}\right)\right]^{-1}\partial w_L/\partial\Delta_{\max}$ multiplying the following quantity

$$\Upsilon\equiv(1-\theta)\,w_L\left(\overline{h}-l_{r,L}\right)\left(\begin{array}{c}\left(\frac{(W-w_L)\overline{h}-\Delta_r}{w_L\overline{h}+\pi_{r,L}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\left(\frac{\beta}{1-\beta}\right)\pi_{r,L}\\-\left(\frac{W\overline{h}+\pi_{r,L}-\Delta_r+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}{w_L\overline{h}+\pi_{r,L}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)w_L\left(\overline{h}-l_{r,L}\right)\end{array}\right)$$
$$-\theta\left(\frac{W\overline{h}-\Delta_p+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}{w_L\overline{h}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)w_L^2\left(\overline{h}-l_{p,L}\right)^2$$

But

$$(W - w_L)\,\overline{h} - \Delta_i = \left(W\overline{h} + \pi_i - \Delta_i + \frac{y - \underline{c}}{1 + r + \phi} - \underline{c} \right) - \left(w_L \overline{h} + \pi_i + \frac{y - \underline{c}}{1 + r + \phi} - \underline{c} \right) \tag{A.23}$$

for $i \in \{p, r\}$. Hence, using also (A.17), we get

$$\frac{(W - w_L)\,\overline{h} - \Delta_i}{w_L \overline{h} + \pi_i + \frac{y - \underline{c}}{1+r+\phi} - \underline{c}} = \frac{W\overline{h} + \pi_r - \Delta_r + \frac{y - \underline{c}}{1+r+\phi} - \underline{c}}{w_L \overline{h} + \pi_r + \frac{y - \underline{c}}{1+r+\phi} - \underline{c}} - 1 = \frac{W\overline{h} - \Delta_p + \frac{y - \underline{c}}{1+r+\phi} - \underline{c}}{w_L \overline{h} + \frac{y - \underline{c}}{1+r+\phi} - \underline{c}} - 1 \tag{A.24}$$

Thus, we have

$$\begin{aligned} \Upsilon \;=\; & (1-\theta)\, w_L \left(\overline{h} - l_{r,L}\right) \left(\frac{W\overline{h} - \Delta_p + \frac{y - \underline{c}}{1+r+\phi} - \underline{c}}{w_L \overline{h} + \frac{y - \underline{c}}{1+r+\phi} - \underline{c}} \right) \left(\left(\frac{\beta}{1-\beta} \right) \pi_{r,L} - w_L \left(\overline{h} - l_{r,L}\right) \right) \\ & - w_L \left(\overline{h} - l_{r,L}\right) (1-\theta) \left(\frac{\beta}{1-\beta} \right) \pi_{r,L} - \theta \left(\frac{W\overline{h} - \Delta_p + \frac{y - \underline{c}}{1+r+\phi} - \underline{c}}{w_L \overline{h} + \frac{y - \underline{c}}{1+r+\phi} - \underline{c}} \right) w_L^2 \left(\overline{h} - l_{p,L}\right)^2 \end{aligned}$$

A fundamental property of Cobb-Douglas production is that aggregate profits must be equal to aggregate labor income from domestic production:[31]

$$(1-\theta) \left(\frac{1-\beta}{\beta} \right) \pi_{r,L} = (1-\theta)(1-\lambda_r)\, w_L \left(\overline{h} - l_{r,L}\right) + \theta (1-\lambda_p)\, w_L \left(\overline{h} - l_{p,L}\right)$$

Hence, Υ simplifies to the following

$$\begin{aligned} \Upsilon \;=\; & w_L \left(\overline{h} - l_{r,L}\right) \left(\frac{W\overline{h} - \Delta_p + \frac{y - \underline{c}}{1+r+\phi} - \underline{c}}{w_L \overline{h} + \frac{y - \underline{c}}{1+r+\phi} - \underline{c}} \right) \left[-\lambda_r (1-\theta)\, w_L \left(\overline{h} - l_{r,L}\right) + \theta (1-\lambda_p)\, w_L \left(\overline{h} - l_{p,L}\right) \right] \\ & - (1-\theta) \left(\frac{\beta}{1-\beta} \right) \pi_{r,L} w_L \left(\overline{h} - l_{r,L}\right) - \theta \left(\frac{W\overline{h} - \Delta_p + \frac{y - \underline{c}}{1+r+\phi} - \underline{c}}{w_L \overline{h} + \frac{y - \underline{c}}{1+r+\phi} - \underline{c}} \right) w_L^2 \left(\overline{h} - l_{p,L}\right)^2 \end{aligned}$$

Since we are assuming an interior solution ($l_{i,L} < \overline{h}$ for $i \in \{p, r\}$), the last two terms in Υ are negative. (The subscript L denotes the state $\widetilde{A} = A_L$.) For the first term, notice that

$$\begin{aligned} & -\lambda_r (1-\theta)\, w_L \left(\overline{h} - l_{r,L}\right) + \theta (1-\lambda_p)\, w_L \left(\overline{h} - l_{p,L}\right) \\ < \; & -\lambda_r (1-\theta)\, w_L \left(\overline{h} - l_{r,L}\right) + \theta (1-\lambda_r)\, w_L \left(\overline{h} - l_{p,L}\right) \\ = \; & -\theta \lambda_r w_L \left[l_{r,L} - l_{p,L} \right] - \lambda_r w_L \left(\overline{h} - l_{r,L}\right) + \theta w_L \left(\overline{h} - l_{p,L}\right) \end{aligned}$$

where the inequality follows from $\lambda_p > \lambda_r$, $\theta \in (0, 1)$ and our assumption of an interior solution for $i = p$.

[31] This property is just a restatement of the labor market equilibrium equation (A.14).

Consequently,

$$\begin{aligned}
\Upsilon &< -\lambda_r w_L^2 \left(\overline{h} - l_{r,L}\right) \left(\frac{W\overline{h} - \Delta_p + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}{w_L\overline{h} + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}\right) \left[\theta\left(l_{r,L} - l_{p,L}\right) + \overline{h} - l_{r,L}\right] \\
&\quad +\theta \left(\frac{W\overline{h} - \Delta_p + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}{w_L\overline{h} + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}\right) w_L^2 \left(\overline{h} - l_{r,L}\right)\left(\overline{h} - l_{p,L}\right) \\
&\quad - (1-\theta)\left(\frac{\beta}{1-\beta}\right)\pi_{r,L} w_L \left(\overline{h} - l_{r,L}\right) - \theta \left(\frac{W\overline{h} - \Delta_p + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}{w_L\overline{h} + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}\right) w_L^2 \left(\overline{h} - l_{p,L}\right)^2 \\
&< -\lambda_r w_L^2 \left(\overline{h} - l_{r,L}\right) \left(\frac{W\overline{h} - \Delta_p + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}{w_L\overline{h} + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}\right) \left[\theta\left(l_{r,L} - l_{p,L}\right) + \overline{h} - l_{r,L}\right] \\
&\quad +\theta \left(\frac{W\overline{h} - \Delta_p + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}{w_L\overline{h} + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}\right) w_L^2 \left(\overline{h} - l_{p,L}\right)^2 \\
&\quad - (1-\theta)\left(\frac{\beta}{1-\beta}\right)\pi_{r,L} w_L \left(\overline{h} - l_{r,L}\right) - \theta \left(\frac{W\overline{h} - \Delta_p + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}{w_L\overline{h} + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}\right) w_L^2 \left(\overline{h} - l_{p,L}\right)^2 \\
&= -\lambda_r w_L^2 \left(\overline{h} - l_{r,L}\right) \left(\frac{W\overline{h} - \Delta_p + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}{w_L\overline{h} + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}}\right) \left[\theta\left(l_{r,L} - l_{p,L}\right) + \overline{h} - l_{r,L}\right] \\
&\quad - (1-\theta)\left(\frac{\beta}{1-\beta}\right)\pi_{r,L} w_L \left(\overline{h} - l_{r,L}\right) \\
&< 0
\end{aligned}$$

where the second inequality uses the fact that $l_r > l_p$.

Step III: Consider (A.19) again and move the part of its right-hand side representing the indirect effects on the λ_i's to the left-hand side. What will remain now on the right consists only of the quantity giving the direct effects while the left-hand side will become

$$\left[\begin{array}{c}
\left[1 - \lambda_r - \theta\left(\lambda_p - \lambda_r\right)\right]\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)\overline{h} \\
+(1-\theta)\left(\frac{1-\beta}{\beta} + \left(\frac{1-\alpha}{1+\alpha b}\right)(1-\lambda_r)\right)\left(\frac{\beta}{1-\beta}\right) w_L^{-1}\pi_{r,L} \\
-\left[w_L\left(\Delta_{\max} - \Delta_{\min}\right)\right]^{-1}\Upsilon
\end{array}\right]\frac{\partial w_L}{\partial \Delta_{\max}}$$

By Step I, the right-hand side is now negative; on the left, the quantity in the brackets multiplying $\partial w_L/\partial\Delta_{\max}$ is positive. Hence, $\partial w_L/\partial\Delta_{\max} < 0$. ■

Notice that both the direct and indirect effects seem to operate here in a similar manner in the sense that we end up with a relation of the form

$$Z\frac{\partial w_L}{\partial \Delta_{\max}} = G : Z > 0, G < 0$$

The quantity G is the same in both cases. The quantity Z, however, gets larger when one includes the indirect effects. In other words, taking into account the offsetting indirect effects results in $\frac{\partial w_L}{\partial \Delta_{\max}}$ remaining negative but becoming smaller in magnitude.

Proposition 4(ii)

The landless have a higher propensity to move than landowners, or $\Delta_p > \Delta_r$.

In equation (A.16), define

$$X = W\overline{h} + \frac{y-\underline{c}}{1+r+\phi} - \underline{c} \quad \text{and} \quad x = w_L\overline{h} + \frac{y-\underline{c}}{1+r+\phi} - \underline{c}$$

to get

$$\begin{aligned} \frac{X+\pi_r-\Delta_r}{x+\pi_r} = \frac{X-\Delta_p}{x} \quad &\Longrightarrow \quad x\left(\pi_r-\Delta_r\right) = X\pi_r - \Delta_p\left(x+\pi_r\right) \quad \Longrightarrow \\ \left(X-x-\Delta_p\right)\pi_r = x\left(\Delta_p-\Delta_r\right) \quad &\Longrightarrow \quad \Delta_p-\Delta_r = \frac{\left(W-w_L\right)\overline{h}-\Delta_p}{w_L\overline{h}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\pi_r > 0 \end{aligned}$$

where the inequality results from applying (A.18) to the landless group. Thus $\Delta_p > \Delta_r$. ■

By definition, $\Delta_r < \Delta_p$ is equivalent to $\lambda_r < \lambda_p$. Since $\theta, \lambda_i \in (0,1)$ for $i \in \{p, r\}$, it follows that

$$1-\lambda_r-\theta\left(\lambda_p-\lambda_r\right) > (1-\theta)\left(\lambda_p-\lambda_r\right) > 0$$

This, in turn, suffices for (A.14) to establish that

$$w_L\overline{h} > \left(\frac{1-\alpha}{\alpha+\alpha b}\right)\left(\frac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)$$

Proposition 4(iii)

The wage elasticity is decreasing in the proportion of individuals who are landless, or $\frac{\partial\nu}{\partial\theta} < 0$.
Differentiating the domestic labor-market equilibrium equation (A.14) with respect to θ, we get[32]

$$\begin{aligned} & (1-\theta)\left[\left(\frac{1-\beta}{\beta}+\left(\frac{1-\alpha}{1+\alpha b}\right)(1-\lambda_r)\right)\frac{\partial\pi_{r,L}}{\partial w_L}\frac{\partial w_L}{\partial\theta} - \left(\frac{1-\alpha}{1+\alpha b}\right)\pi_{r,L}\frac{\partial\lambda_r}{\partial\theta}\right] \\ = \quad & \left[1-\lambda_r-\theta\left(\lambda_p-\lambda_r\right)\right]\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)\overline{h}\frac{\partial w_L}{\partial\theta} \\ & -\left(\lambda_p-\lambda_r+(1-\theta)\frac{\partial\lambda_r}{\partial\theta}+\theta\frac{\partial\lambda_p}{\partial\theta}\right)\left(\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)w_L\overline{h}-\left(\frac{1-\alpha}{1+\alpha b}\right)\left(\frac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)\right) \end{aligned}$$

[32]Note that aggregate profits

$$(1-\theta)\,\pi_{r,L} = (1-\theta)\,k_r\left(\frac{\beta^\beta A_L}{w_j^\beta}\right)^{\frac{1}{1-\beta}} = \frac{K}{N}\left(\frac{\beta^\beta A_L}{w_j^\beta}\right)^{\frac{1}{1-\beta}}$$

are independent of θ for $j \in \{H, L\}$.

or, using (A.6) and (A.11),

$$\begin{aligned}
&\left[\begin{array}{c} \left[1-\lambda_r-\theta\left(\lambda_p-\lambda_r\right)\right]\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)\overline{h} \\ +\left(1-\theta\right)\left(\frac{1-\beta}{\beta}+\left(\frac{1-\alpha}{1+\alpha b}\right)\left(1-\lambda_r\right)\right)\left(\frac{\beta}{1-\beta}\right)w_L^{-1}\pi_{r,L} \end{array}\right]\frac{\partial w_L}{\partial\theta} \\
= \;& \left(\lambda_p-\lambda_r\right)\left(\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)w_L\overline{h}-\left(\frac{1-\alpha}{1+\alpha b}\right)\left(\frac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)\right) \\
& +\left(1-\theta\right)\left(\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)w_L\overline{h}-\left(\frac{1-\alpha}{1+\alpha b}\right)\left(\pi_{r,L}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)\right)\frac{\partial\lambda_r}{\partial\theta} \\
& +\theta\left(\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)w_L\overline{h}-\left(\frac{1-\alpha}{1+\alpha b}\right)\left(\frac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)\right)\frac{\partial\lambda_p}{\partial\theta} \\
= \;& \left(\lambda_p-\lambda_r\right)w_L\left(\overline{h}-l_{p,L}\right)+\left(1-\theta\right)w_L\left(\overline{h}-l_{r,L}\right)\frac{\partial\lambda_r}{\partial\theta}+\theta w_L\left(\overline{h}-l_{p,L}\right)\frac{\partial\lambda_p}{\partial\theta}
\end{aligned} \tag{A.25}$$

From the utility-cutoff equation we have

$$\begin{aligned}
&\tfrac{\partial}{\partial\theta}\left[U\left(l_i^M,c_{1,i}^M,c_{2,i}^M;\Delta_i,M=1\right)-U\left(l_i,c_{1,i},c_{2,i};\Delta_i,M=0\right)\right] \\
&=\left(W\overline{h}+\pi_i-\Delta_i+\tfrac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)^{-1}\left(\tfrac{\partial\pi_i}{\partial w_L}\tfrac{\partial w_L}{\partial\theta}+\tfrac{\partial\pi_i}{\partial\theta}-\tfrac{\partial\Delta_i}{\partial\theta}\right) \\
&-\left(w_L\overline{h}+\pi_i+\tfrac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)^{-1}\left(\tfrac{\partial\pi_i}{\partial w_L}\tfrac{\partial w_L}{\partial\theta}+\tfrac{\partial\pi_i}{\partial\theta}+\tfrac{\partial w_L}{\partial\theta}\overline{h}\right) \\
&+\left(\tfrac{1-\alpha}{\alpha}\right)\left(W\overline{h}+\pi_i-\Delta_i+\tfrac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)^{-1}\left(\tfrac{\partial\pi_i}{\partial w_L}\tfrac{\partial w_L}{\partial\theta}+\tfrac{\partial\pi_i}{\partial\theta}-\tfrac{\partial\Delta_i}{\partial\theta}\right) \\
&-\left(\tfrac{1-\alpha}{\alpha}\right)\left(w_L\overline{h}+\pi_i+\tfrac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)^{-1}\left(\tfrac{\partial\pi_i}{\partial w_L}\tfrac{\partial w_L}{\partial\theta}+\tfrac{\partial\pi_i}{\partial\theta}-\left(\pi_i+\tfrac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)w_L^{-1}\tfrac{\partial w_L}{\partial\theta}\right) \\
&+b\left(W\overline{h}+\pi_i-\Delta_i+\tfrac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)^{-1}\left(\tfrac{\partial\pi_i}{\partial w_L}\tfrac{\partial w_L}{\partial\theta}+\tfrac{\partial\pi_i}{\partial\theta}-\tfrac{\partial\Delta_i}{\partial\theta}\right) \\
&-b\left(w_L\overline{h}+\pi_i+\tfrac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)^{-1}\left(\tfrac{\partial\pi_i}{\partial w_L}\tfrac{\partial w_L}{\partial\theta}+\tfrac{\partial\pi_i}{\partial\theta}+\tfrac{\partial w_L}{\partial\theta}\overline{h}\right)
\end{aligned}$$

and, by definition of the cutoff migration cost Δ_i, we ought to have

$$\frac{\partial}{\partial\theta}\left[U\left(l_i^M,c_{1,i}^M,c_{2,i}^M;\left(\Delta_i,M=1\right)\right)-U\left(l_i,c_{1,i},c_{2,i};\left(\Delta_i,M=0\right)\right)\right]=0$$

Consequently,

$$\begin{aligned}
&-\left(\left(W-w_L\right)\overline{h}-\Delta_i\right)\left(\tfrac{\partial\pi_i}{\partial w_L}\tfrac{\partial w_L}{\partial\theta}+\tfrac{\partial\pi_{i,L}}{\partial\theta}\right) \\
&-\left(W\overline{h}+\pi_i-\Delta_i+\tfrac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)w_L^{-1}\left(\left(\tfrac{\alpha+\alpha b}{1+\alpha b}\right)w_L\overline{h}-\left(\tfrac{1-\alpha}{1+\alpha b}\right)\left(\pi_i+\tfrac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)\right)\tfrac{\partial w_L}{\partial\theta} \\
&=\left(w_L\overline{h}+\pi_i+\tfrac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)\tfrac{\partial\Delta_i}{\partial\theta}
\end{aligned}$$

or, using (A.11),

$$\begin{aligned}
&-\left(\left(W-w_L\right)\overline{h}-\Delta_i\right)\left(\tfrac{\partial\pi_i}{\partial w_L}\tfrac{\partial w_L}{\partial\theta}+\tfrac{\partial\pi_i}{\partial\theta}\right)-\left(W\overline{h}+\pi_i-\Delta_i+\tfrac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)\left(\overline{h}-l_i\right)\tfrac{\partial w_L}{\partial\theta} \\
&=\left(w_L\overline{h}+\pi_i+\tfrac{y-\underline{c}}{1+r+\phi}-\underline{c}\right)\tfrac{\partial\Delta_i}{\partial\theta}
\end{aligned}$$

Notice now that, given the equilibrium wage w_L, we have

$$\frac{\partial}{\partial\theta}\left[\pi_{r,L}\right]=\frac{\partial}{\partial\theta}\left[\frac{K}{(1-\theta)N}\left(\frac{1-\beta}{\beta}\right)\left(\frac{A_L\beta}{w_L^{\beta}}\right)^{\frac{1}{1-\beta}}\right]=\frac{\pi_{r,L}}{(1-\theta)}$$

Also, recall that

$$\frac{\partial\lambda_i}{\partial\theta}=\left(\Delta_{\max}-\Delta_{\min}\right)^{-1}\frac{\partial\Delta_i}{\partial\theta}\quad\text{for } i\in\{p,r\}$$

Therefore, the last two terms on the right hand side of (A.22) are given by

$$\begin{aligned}
&(1-\theta)\,w_L\left(\overline{h}-l_{r,L}\right)\frac{\partial\lambda_r}{\partial\theta}+\theta w_L\left(\overline{h}-l_{p,L}\right)\frac{\partial\lambda_p}{\partial\theta}\\
=\;&\left(\Delta_{\max}-\Delta_{\min}\right)^{-1}\left((1-\theta)\,w_L\left(\overline{h}-l_{r,L}\right)\frac{\partial\Delta_r}{\partial\theta}+\theta w_L\left(\overline{h}-l_{p,L}\right)\frac{\partial\Delta_p}{\partial\theta}\right)
\end{aligned}$$

which is equal to $-\left(\Delta_{\max}-\Delta_{\min}\right)^{-1}$ multiplying the following quantity

$$\begin{aligned}
&(1-\theta)\,w_L\left(\overline{h}-l_{r,L}\right)\left(\begin{array}{c}\left(\frac{(W-w_L)\overline{h}-\Delta_r}{w_L\overline{h}+\pi_{r,L}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\left(\frac{\partial\pi_{i,L}}{\partial w_L}\frac{\partial w_L}{\partial\theta}+\frac{\partial\pi_r(\sigma_L)}{\partial\theta}\right)\\+\left(\frac{W\overline{h}+\pi_{r,L}-\Delta_r+\frac{y-\underline{c}}{1+\phi}-\underline{c}}{w_L\overline{h}+\pi_{r,L}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\left(\overline{h}-l_{r,L}\right)\frac{\partial w_L}{\partial\theta}\end{array}\right)\\
&+\theta w_L\left(\overline{h}-l_{p,L}\right)\left(\frac{W\overline{h}-\Delta_p+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}{w_L\overline{h}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\left(\overline{h}-l_{p,L}\right)\frac{\partial w_L}{\partial\theta}\\
=\;&\left[\begin{array}{c}(1-\theta)\,w_L\left(\overline{h}-l_{r,L}\right)\\\left(\left(\frac{W\overline{h}+\pi_{r,L}-\Delta_r+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}{w_L\overline{h}+\pi_{r,L}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\left(\overline{h}-l_{r,L}\right)-\left(\frac{(W-w_L)\overline{h}-\Delta_r}{w_L\overline{h}+\pi_{r,L}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\left(\frac{\beta}{1-\beta}\right)w_L^{-1}\pi_{r,L}\right)\\+\theta\left(\frac{W\overline{h}-\Delta_p+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}{w_L\overline{h}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)w_L\left(\overline{h}-l_{p,L}\right)^2\end{array}\right]\frac{\partial w_L}{\partial\theta}\\
&+w_L\left(\overline{h}-l_{r,L}\right)\left(\frac{(W-w_L)\,\overline{h}-\Delta_r}{w_L\overline{h}+\pi_{r,L}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\pi_{r,L}\\
=\;&-w_L^{-1}\Upsilon\frac{\partial w_L}{\partial\theta}+w_L\left(\overline{h}-l_{r,L}\right)\left(\frac{(W-w_L)\,\overline{h}-\Delta_r}{w_L\overline{h}+\pi_{r,L}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\pi_{r,L}
\end{aligned}$$

Hence, (A.22) can be written as follows

$$\begin{aligned}
&\left[\begin{array}{c}\left[1-\lambda_r-\theta\left(\lambda_p-\lambda_r\right)\right]\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)\overline{h}\\+(1-\theta)\left(\left(\frac{1-\beta}{\beta}\right)+\left(\frac{1-\alpha}{1+\alpha b}\right)(1-\lambda_r)\right)\left(\frac{\beta}{1-\beta}\right)w_L^{-1}\pi_{r,L}\end{array}\right]\frac{\partial w_L}{\partial\theta}\\
=\;&\left[w_L\left(\Delta_{\max}-\Delta_{\min}\right)\right]^{-1}\Upsilon\frac{\partial w_L}{\partial\theta}+\left(\lambda_p-\lambda_r\right)w_L\left(\overline{h}-l_{p,L}\right)\\
&-\left(\Delta_{\max}-\Delta_{\min}\right)^{-1}w_L\left(\overline{h}-l_{r,L}\right)\left(\frac{(W-w_L)\,\overline{h}-\Delta_r}{w_L\overline{h}+\pi_{r,L}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\pi_{r,L}
\end{aligned}$$

or

$$\begin{bmatrix} [1-\lambda_r-\theta(\lambda_p-\lambda_r)]\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)\overline{h} \\ +(1-\theta)\left(\left(\frac{1-\beta}{\beta}\right)+\left(\frac{1-\alpha}{1+\alpha b}\right)(1-\lambda_r)\right)\left(\frac{\beta}{1-\beta}\right)w_L^{-1}\pi_{r,L} \\ -\left[w_L\left(\Delta_{\max}-\Delta_{\min}\right)\right]^{-1}\Upsilon \end{bmatrix}\frac{\partial w_L}{\partial\theta}$$

$$= \quad (\lambda_p-\lambda_r)\,w_L\left(\overline{h}-l_{p,L}\right)-\left(\Delta_{\max}-\Delta_{\min}\right)^{-1}w_L\left(\overline{h}-l_{r,L}\right)\left(\frac{(W-w_L)\,\overline{h}-\Delta_r}{w_L\overline{h}+\pi_{r,L}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\pi_{r,L}$$

Consider now the right-hand side of the above equality

$$\begin{aligned} &(\lambda_p-\lambda_r)\,w_L\left(\overline{h}-l_{p,L}\right)-\left(\Delta_{\max}-\Delta_{\min}\right)^{-1}w_L\left(\overline{h}-l_{r,L}\right)\left(\frac{(W-w_L)\,\overline{h}-\Delta_r}{w_L\overline{h}+\pi_{r,L}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\pi_{r,L} \\ = \quad &\left(\Delta_{\max}-\Delta_{\min}\right)^{-1}\left[(\Delta_p-\Delta_r)\,w_L\left(\overline{h}-l_{p,L}\right)-w_L\left(\overline{h}-l_{r,L}\right)\left(\frac{(W-w_L)\,\overline{h}-\Delta_r}{w_L\overline{h}+\pi_{r,L}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\pi_{r,L}\right] \end{aligned}$$

Recall that in the proof to Proposition 4(ii), we derived the following relation

$$\Delta_p-\Delta_r=\left(\frac{(W-w_L)\,\overline{h}-\Delta_p}{w_L\overline{h}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\pi_r \tag{A.26}$$

Thus, the above quantity simplifies to the following

$$\begin{aligned} &\left(\Delta_{\max}-\Delta_{\min}\right)^{-1}\begin{bmatrix} w_L\left(\overline{h}-l_{p,L}\right)\left(\frac{(W-w_L)\overline{h}-\Delta_p}{w_L\overline{h}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right) \\ -w_L\left(\overline{h}-l_{r,L}\right)\left(\frac{(W-w_L)\overline{h}-\Delta_r}{w_L\overline{h}+\pi_{r,L}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\end{bmatrix}\pi_{r,L} \\ \overset{(A.17)}{=} &\left(\Delta_{\max}-\Delta_{\min}\right)^{-1}w_L\left(l_{r,L}-l_{p,L}\right)\left(\frac{(W-w_L)\,\overline{h}-\Delta_p}{w_L\overline{h}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\pi_{r,L} \end{aligned}$$

Finally, we can now write (A.22) as follows

$$\begin{aligned} &\begin{bmatrix} [1-\lambda_r-\theta(\lambda_p-\lambda_r)]\left(\frac{\alpha+\alpha b}{1+\alpha b}\right)\overline{h} \\ +(1-\theta)\left(\left(\frac{1-\beta}{\beta}\right)+\left(\frac{1-\alpha}{1+\alpha b}\right)(1-\lambda_r)\right)\left(\frac{\beta}{1-\beta}\right)w_L^{-1}\pi_{r,L} \\ -\left[w_L\left(\Delta_{\max}-\Delta_{\min}\right)\right]^{-1}\Upsilon \end{bmatrix}\frac{\partial w_L}{\partial\theta} \\ = \quad &\left(\Delta_{\max}-\Delta_{\min}\right)^{-1}w_L\left(l_{r,L}-l_{p,L}\right)\left(\frac{(W-w_L)\,\overline{h}-\Delta_p}{w_L\overline{h}+\frac{y-\underline{c}}{1+r+\phi}-\underline{c}}\right)\pi_{r,L} \end{aligned}$$

Since both the right-hand side as well as the bracketed term on the left-hand side (multiplying $\frac{\partial w_L}{\partial\theta}$) are positive, $\frac{\partial w_L}{\partial\theta}>0$. ■

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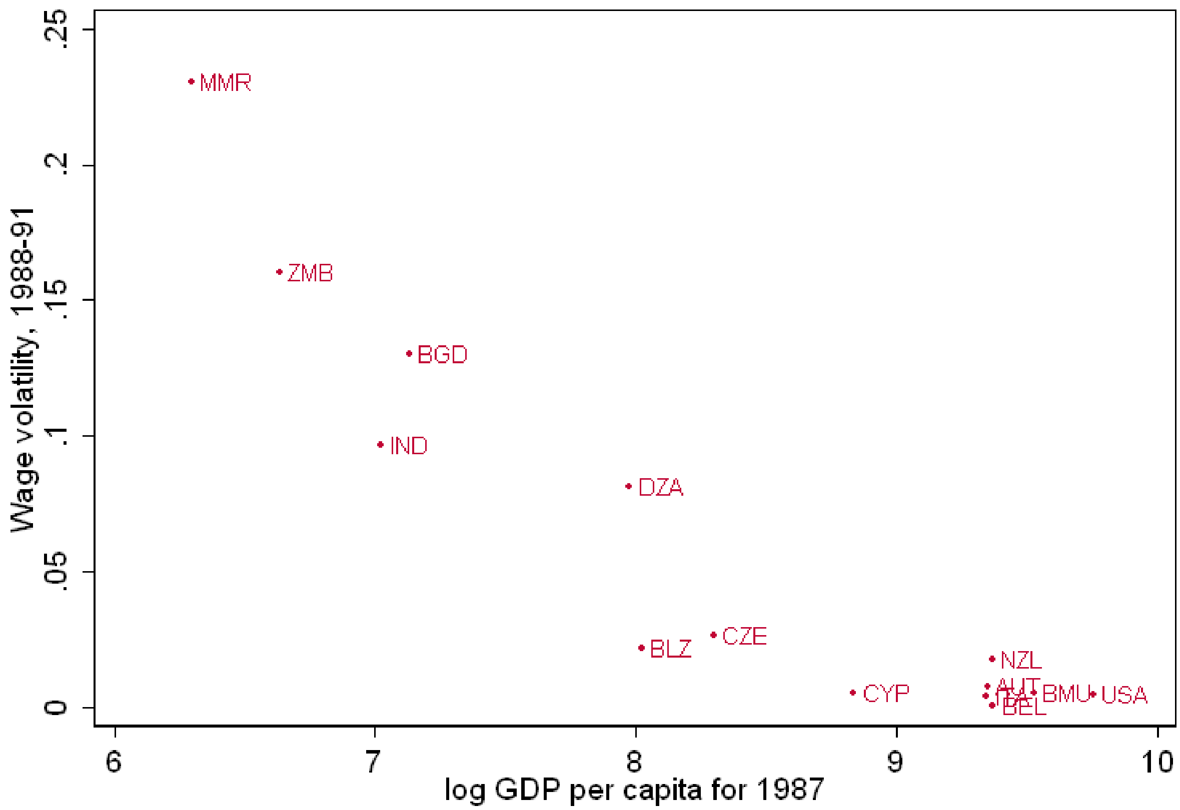
Figure 1: Agricultural Wage Volatility Versus Gross Domestic Product



Notes

1. Wage volatility is calculated from Occupational Wages around the World (OWW) data (Freeman and Oostendorp 2000). It is the standard deviation of log average monthly real wages for a male field crop farm worker, first removing a country-specific linear trend. The log of annual real gross domestic product (GDP) per capita (in 1996 US dollars) is from the Penn World Tables.

2. The sample consists of all countries for which farm-worker wage data are available for each of 1988 to 1991. (AUT=Austria, BGD=Bangladesh, BEL=Belgium, BMU=Bermuda, BLZ=Belize, CZE=Czechoslovakia, CYP=Cyprus, DZA=Algeria, IND=India, ITA=Italy, MMR=Myanmar, NZL=New Zealand, USA=United States, ZMB= Zambia.) The OWW data set covers 1981-99; the 1988-91 period yields the largest balanced panel with at least 4 years per country. The patterns are similar using other subsamples.

Figure 2: Variability of Crop Yield

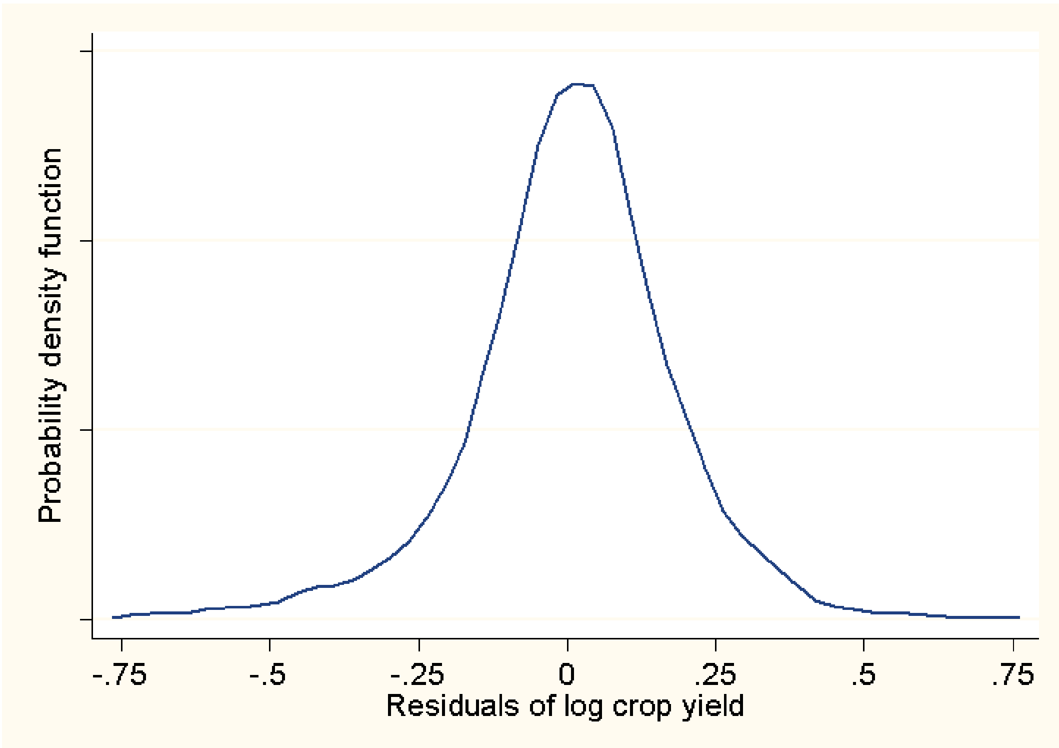


Table 1

Summary Statistics[a]

	Mean	Std deviation	N	Source
Agricultural variables				
Log agricultural wage	1.22	0.82	8222	World Bank
Log crop yield	-0.06	0.29	8222	World Bank
Log crop price index	-0.22	0.64	8222	World Bank
Rainfall				
Proportional deviation from mean district rainfall	0.00	0.28	8222	University of Delaware
Annual rainfall (millimeters)	1057	551	8222	University of Delaware
Banking				
Per capita deposits in 1981 (rupees 1000s/person)	0.25	0.26	7678	Census of India
Per capita credit in 1981 (rupees 1000s/person)	0.17	0.21	7614	Census of India
Bank branches/1000 people	0.04	0.05	8080	Reserve Bank of India
Access to other areas				
Road density (km/km^2)	1.93	2.08	7965	World Bank
Proportion of villages with bus service in 1981	0.33	0.25	7838	Census of India
Proportion of villages with railway in 1981	0.02	0.02	7838	Census of India
Closeness to city (km^{-1})	0.012	0.013	8222	Census of India
Poverty (among agricultural households)				
Per capita expenditure (rupees/year) in 1987	33739	89244	8126	National Sample Survey
Proportion poor (expenditures $<$ 14000 rupees/year)	0.51	0.16	8126	National Sample Survey
Land ownership				
Proportion of agricultural workers who are landless	0.28	0.16	8222	Census of India 1961/71/81
Gini of land ownership (excluding landless) in 1981	0.53	0.05	7711	Agricultural Census 1981
Other variables				
Area of district (km^2)	4633	2370	8222	World Bank
Proportion of workforce in agriculture in 1961	0.80	0.09	8222	Census of India

[a]The data appendix describes how variables are defined and constructed.

Table 2

Relationship Between Agricultural Wage and Crop Yield, Instrumented with Rainfall[a]

Model:	OLS (1st stage)	OLS	IV
Dependent variable:	Log crop yield	Log agricultural wage	Log agricultural wage
	(1)	(2)	(3)
RainShock	.070 ***		
	(.007)		
RainShock * % of workforce in agric.	.003		
	(.005)		
Log crop yield		.035 ***	.167 **
		(.012)	(.084)
Log crop yield * % of workforce in agric.			-.009
			(.039)
N	8222	8222	8222
Instruments			RainShock, RainShock * % in agric.
District and year fixed effects?	Yes	Yes	Yes

[a]Each observation is a district-year. Standard errors, in parentheses below the coefficients, allow for clustering within a region-year. *** indicates p<.01, ** indicates p<.05, * indicates p<.10. 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. Log crop yield is the weighted average log(volume of crop produced/area cropped) for the 5 major crops by revenue. Percent of workforce in agriculture has been transformed to be mean 0, standard deviation 1. See the data appendix for data sources and further detail.

Table 3

Banking and the Elasticity of the Wage[a]

Dependent variable: Log agricultural wage, 1956-1987			
	Measure of Banking		
	Bank deposits per capita	Bank credit per capita	Bank branches per capita
	(1)	(2)	(3)
Log crop yield	.162 **	.158 *	.138 *
	(.083)	(.083)	(.082)
Banking			-.049 **
			(.021)
Log crop yield * Banking	-.091 **	-.075 *	-.033 *
	(.036)	(.044)	(.019)
N	7678	7614	8080
District and year FE?	Yes	Yes	Yes
Instruments = RainShock, RainShock * Banking, RainShock * % of workforce in agriculture			

[a]Standard errors, which are in parentheses below the coefficients, allow for clustering within region-years. *** indicates p<.01, ** indicates p<.05, * indicates p<.10. Variables interacted with log crop yield have been transformed to be mean 0, standard deviation 1. All regressions include as an endogenous control variable the % of workforce in agriculture in 1961 interacted with log crop yield. The district fixed effect absorbs the level effect of time-invariant measures of banking. See the data appendix for data sources and further detail.

Table 4

Access to Neighboring Areas and the Elasticity of the Wage[a]

Dependent variable: Log agricultural wage, 1956-1987				
	Measure of Access to Neighboring Areas			
	Road density (km/km^2)	Bus service (% of villages)	Railway (% of villages)	Closeness to city (km^{-1})
	(1)	(2)	(3)	(4)
Log crop yield	.133 *	.147 *	.162 **	.171 **
	(.080)	(.076)	(.082)	(.084)
Access	-.026			
	(.020)			
Log crop yield * Access	-.111	-.095 **	-.098 *	-.050
	(.083)	(.046)	(.051)	(.039)
N	7965	7838	7838	8222
District and year FE?	Yes	Yes	Yes	Yes
Instruments = RainShock, RainShock * Access, RainShock * % of workforce in agriculture				

[a]Standard errors, in parentheses below the coefficients, allow for clustering within region-years. *** 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 an endogenous control variable the % of workforce in agriculture interacted with log crop yield. The district fixed effect absorbs the level effect of time-invariant measures of access. See the data appendix for data sources and further detail.

Table 5

ICRISAT Summary Statistics[a]

Sample for analysis of labor supply (3 villages, 1975-1979)

Variable	Mean	Std. Dev
Monsoon rainfall (July and August) in meters	0.34	0.16
Proportion who are landless	0.15	0.35
Proportion who are small landowners	0.16	0.37
Proportion who are medium landowners	0.29	0.45
Proportion who are large landowners	0.40	0.49
Log hours worked in agriculture/day	1.80	0.46
Male adults per household	1.91	1.28

Sample for analysis of migration (10 villages, 1975-1984)

Variable	Mean	Std. Dev
Monsoon rainfall (July and August) in meters	0.36	0.24
Proportion who are landless	0.22	0.41
Proportion who are small landowners	0.21	0.41
Proportion who are medium landowners	0.24	0.43
Proportion who are large landowners	0.32	0.47
Individual has temporarily migrated for work	0.04	0.19
Male adults per household	2.13	1.16

[a]The sample for the labor supply estimates are adult family males who supply labor in the home village (N=2603 person-months), and for the migration estimates, all adult males (N=1784 person-months). 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 6

Labor Supply Elasticity and Migration by Land Ownership[a]

	Dependent variable			
	Log hours worked in agriculture/day (OLS)		Has migrated temporarily for work (Probit)	
	(1)	(2)	(3)	(4)
RainShock	.527 ***	.620 ***	.007	-.002
	(.149)	(.237)	(.009)	(.011)
Landless	.306 ***	.397 ***	.037 **	.029 *
	(.106)	(.131)	(.028)	(.027)
Small landholding		.291 ***		-.019 *
		(.102)		(.008)
Medium landholding		.095		.011
		(.101)		(.013)
RainShock * Landless	-.295	-.369	-.046 **	-.027
	(.223)	(.288)	(.020)	(.018)
RainShock * Small Land		-.382		.049 *
		(.243)		(.025)
RainShock * Medium Land		-.048		.005
		(.239)		(.013)
N	2603	2603	1784	1784
Village, year, and month FE?	Yes	Yes	Yes	Yes

[a]Standard errors are in parentheses below the coefficients and are adjusted for clustering within a household. *** indicates p<.01, ** indicates p<.05, * indicates p<.10. Each 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 terciles of the village's land distribution. Number of working male adults in the household and its interaction with RainShock are included as controls. The reported probit coefficients are marginal effects. Source: ICRISAT.

Table 7

Poverty, Land Inequality, and the Elasticity of the Wage[a]

Dependent variable: Log agricultural wage, 1956-1987

	Measure of poverty		Measure of land inequality	
	Average expenditure	Poverty head count	% landless	Gini coefficient
	(1)	(2)	(3)	(4)
Log crop yield	.183 **	.181 **	.121	.186 **
	(.090)	(.091)	(.084)	(.091)
District trait			-.059 **	
			(.026)	
Log crop yield * District trait	-.034	-.002	-.157 ***	-.005
	(.028)	(.045)	(.056)	(.048)
N	7934	7934	8222	7711
District and year FE?	Y	Y	Y	Y

Instruments = RainShock, RainShock * District trait, RainShock * % of workforce in agriculture

[a]Standard errors, in parentheses below the coefficients, allow for clustering within region-years. *** indicates p<.01, ** indicates p<.05, * indicates p<.10. Variables interacted with log crop yield have been transformed to be mean 0, standard deviation 1. All regressions include as an endogenous control variable the % of workforce in agriculture interacted with log crop yield. Gini coefficient for land ownership is calculated excluding the landless. See the data appendix for sources and further detail.

Table 8

Specification Tests Based on Crop Yield and Crop Prices[a]

	Dependent var. = Log crop yield			Dependent var. = Log crop prices			
	District Trait			District Trait			
	Bank deposits	Road density	% Landless	None	Bank deposits	Road density	% Landless
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
RainShock	.0699 ***	.0719 ***	.0677 ***				
	(.0076)	(.0076)	(.0074)				
District Trait		-.0111	-.0942 ***			-.001	.155 **
		(.0074)	(.0175)			(.005)	(.071)
RainShock * District Trait	.0131 *	.0054	-.0003				
	(.0075)	(.0048)	(.0060)				
Log crop yield				-.136 *	-.136 *	-.146 **	-.090
				(.077)	(.078)	(.074)	(.085)
Log crop yield * % in agric.				-.118 ***	-.124 ***	-.112 ***	.026
				(.044)	(.044)	(.042)	(.028)
Log crop yield * District Trait					-.028	.012	-.097 **
					(.039)	(.032)	(.045)
N	7678	7965	8222	8222	7678	7965	8222
Instruments	n/a	n/a	n/a	RainShock, RainShock * District trait, RainShock * % in agric.			
District and year FE?	Yes	Yes	Yes	Yes	Yes	Yes	Yes

[a] Standard errors, in parentheses below the coefficients, allow for clustering within region-years. *** indicates p<.01, ** indicates p<.05, * indicates p<.10. Variables interacted with RainShock in columns 1-2 and with Log crop yield in columns 5-6 have been transformed to be mean 0, standard deviation 1. The district fixed effect absorbs the level effect of time-invariant district traits. Columns 1-3 include the interaction between RainShock and the fraction of the workforce in agriculture in 1961. See the data appendix for sources and further detail.