

Agricultural Development, Industrialization and Rural Inequality

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Most of the world's poor live in rural areas and are engaged in farming. This fact has led many researchers to conclude that agricultural development is essential in helping the poor not only by directly increasing the incomes of the poor who farm but also by releasing labor and capital that can be used in non-agricultural enterprises and by stimulating the demand for non-agricultural goods (Lipton and Ravallion, 1995; Johnson 2000, Lanjouw and Lanjouw, 2001). This literature emphasizes the positive linkages between agricultural development and non-farm activity growth - local trickle-down from improving farm productivity. Recently it has been argued that an emphasis on agricultural development is unnecessary in a globalized world with increasing mobile capital, and that policies that encourage investment in the rural, non-farm sector may be the best means of reducing rural poverty (Haggblade, Hazell, and Reardon, 2001). However, it is unclear which policies lead to increased rural non-farm investments in the absence of a dynamic agriculture, especially in the presence of credit constraints, labor rigidities and inadequate schooling that is emphasized in the vast theoretical literature on the rural poor and in discussions of the relationship between the non-farm sector and rural inequality (Reardon *et al.* , 2000).

The debate on which strategies for rural development are most "pro poor" continues in part because empirical evidence on the relative efficacy of farm and non-farm growth as sources of reduction in rural poverty and inequality is limited and inconclusive. A key limitation of this literature has been the absence of appropriate data. Timmer (1997), using cross-country data on sectoral GDP and income inequality at the country level (Deininger and Squire, 1996), has concluded that income increases across the income distribution do not depend on the source of growth. However, the cross-country data base does not provide information on income distribution or on non-farm incomes by sector and thus cannot be used to identify the precise linkages between sources of growth and rural poverty. Perhaps the strongest evidence to date on the effects of sources of growth on rural poverty and inequality has been compiled by Ravallion and Datt (1996, 1999) using a state-level data set from India that combines multiple national-level cross-sectional household surveys with state-level aggregate data on sectoral

income. These authors find evidence that agricultural growth decreases rural poverty but provide a more mixed picture of the effects of non-agricultural growth, with overall effects depending, among other things, on initial conditions. As they acknowledge, however, an important limitation of their data is that non-farm income is not available from their data sources separately for rural and urban areas. Because the impacts of urban and rural non-farm growth on rural poverty may be different from each other and even of opposite sign, it is difficult to know what Ravallion and Datt's results tell us about the extent to which rural growth in the farm and non-farm sectors is likely to be more successful in reducing rural poverty. Moreover, it is also not possible with such data to assess the more fundamental policy or institutional determinants of sectoral income growth.

But even within rural areas, the treatment of non-farm activity as a single homogenous good is not appropriate (Haggblade, Hazell, and Reardon, 2001). As noted by Ranis and Stewart (1973), rural non-farm activity ranges "...from household and village production on a very small scale, producing very simple, low-quality products, to small modern factories using modern horsepower, sometimes using imported technology, and producing modern high quality products". In the Ranis and Stewart framework this distinction is critical in terms of the potential importance of the non-farm sector in long-run growth and poverty reduction under a regime of openness. However, the high-quality products sector that plays a central role in this framework combines two separate elements: production of exportable goods that can be traded on the larger market and production of non-tradable goods and services. We show that the further distinction based on tradeability, ignored in previous analyses, is key for understanding the roles played by agricultural development and investment and trade policies in the determination of rural income growth and inequality.¹ The literature thus has also lacked a theoretical framework that is both rich enough to capture the heterogeneity of the non-farm sector and tractable enough to generate

¹Ranis and Stewart attempt to assess their model based on differences in the levels and trends in the share of non-farm activity in two countries with different colonial experiences and different macro-policy environments in the post-colonial period, Taiwan and the Phillipines. There are, of course, many differences between the two economies and it is difficult if not impossible to identify which of these differences are most responsible for the different patterns of economic growth and inequality.

falsifiable predictions.

In this paper we address the limitations of the existing literature by developing and testing a simple general equilibrium model of the farm and rural non-farm sectors using newly-available panel data from India. The model distinguishes between different types of non-farm sector activities and yields a series of testable implications for the effects of farm and non-farm growth on sector-specific economic activity, on poverty reduction and on income inequality. The key prediction of the model is that while both agricultural development and capital mobility and openness increase rural incomes, the growth of a rural, export-oriented manufacturing sector reduces both local and spatial income inequality relative to agriculture-led growth. The new data set provides information on a large panel of rural Indian households and villages collected over a 30-year period (1968-1999) and enables the empirical assessment of the contributions of agricultural productivity improvements and rural factory expansion to rural income growth, poverty reduction and rural income inequality in the light of the model.

India over the last three decades provides a useful laboratory for assessing the determinants of rural poverty and inequality. As is well-known, India has experienced substantial productivity growth in agriculture resulting from both private and public investments in agricultural innovation since the late 1960's (Evenson and McKinsey, 1999) And, though less well-documented up until now, there has also been a substantial expansion of rural industry, with factory employment in or near villages expanding tenfold since the early 1980's resulting in part from pro-rural investment policies.² Moreover, for the purpose of identifying the determinants of rural economic growth by source, India's villages are, on average, sufficiently isolated that they operate as distinct economies in which there is local variation in wages and other non-tradable prices. Moreover, as has been established previously (Foster and Rosenzweig 1996) there is substantial variation across India in the magnitudes of agricultural productivity growth due to differences in the suitability to different crops. There has also been

²Our data show that in 1999 factories employed approximately 10% of the male labor force in the 50% of rural villages with factory employment and that in the overall rural population non-farm employee income is 40% of total rural income.

differential growth in this period in rural industry, some of which is a consequence of different policy environments at the state level (Besley and Burgess 2003).

Our empirical results, which exploit both the spatial variability in policies and technical change and the panel component of the data, suggest the importance of considering separately the non-tradable and tradable non-farm sectors, the neglect of this distinction having possibly led to opposite predictions in the literature as to the consequences of growth propelled by either farm or non-farm expansion. On the one hand we find that the non-tradable sector is driven by local demand conditions and thus is positively influenced by growth in agricultural productivity - agricultural growth and this non-farm activity are complements. On the other hand, we find that the tradable non-farm sector in the form of relatively small-scale factories enters areas with relatively low wages and thus is negatively influenced by growth in agricultural productivity. Estimates of the impact of agricultural technical change and factory employment growth on income, wages, and inequality suggest that both forms of growth increase rural incomes and wages, and thus reduce poverty. But the estimates also show that the growth in rural factory employment over the 1982-99 period in India accounts for twice the share of rural wage growth as HYV yield improvements and that factory location decisions reduced spatial wage inequality by 42%. Consistent with our model, factory investment in a local area also reduces local-area inequality in rural household incomes, while agricultural technology improvements increase inequality where they occur. Finally, we find little evidence of labor-market rigidities in the sense that employment in the non-farm sector does not seem to be tied to the ownership of assets. We also do not find evidence that local credit constraints or lack of investments in schools are barriers to non-agricultural rural income expansion. Rather policies that facilitate flows of investment capital into rural areas for the purpose of producing tradable goods are critical for raising wages for unskilled, rural workers, the poorest of the poor.

1. Theory

In order to clarify the debate about the role of the non-farm sector in rural economic growth and how it interacts with agricultural technical change, policies pertaining to openness and capital market constraints, we develop a simple theoretical model of the rural economy that yields a series of testable

implications. We consider three general-equilibrium, small-country representative-agent models in which there is both farm and non-farm activity. In all models labor is sectorally mobile but does not move across “countries” while agricultural goods are traded across countries. The agricultural sector uses credit as an input, which is locally generated. In the first model there are restrictions on the mobility of external capital so that the non-farm sector is restricted to the production of non-tradable goods and services that meet the consumption needs of the local farmers. In the second model, these restrictions are removed so that external manufacturing concerns may enter the local economy and produce for the world market. In the third model agents are distinguished by their ownership of land in order to assess the distributional consequences of different sources of growth.

1.1 Restricted capital movement

Consider a household with A units of agricultural land and l units of labor. Household utility

$$(1) \quad u(c_z, c_g, c_f)$$

is determined by the consumption c_z of a non-tradeable good c_z , the consumption c_g of agricultural goods, and the consumption of factory produced goods. We assume that agricultural and factory goods are traded at world prices p_g and p_f , respectively, with agricultural goods serving as the numeraire ($p_g=1$). Initially we assume that only the non-tradeable and agricultural goods are produced locally. Agricultural income is produced according to a CRS production function in agricultural labor l_g and land net of labor costs

$$(2) \quad y_g = \theta A g(l_g/A) - w \rho l_g$$

where θ denotes the level of technology, $g()$ is the per-land unit production function, w denotes the wage, and $\rho \geq 1$ reflects the cost of working capital.³ Non-traded income is produced according to a CRS

³Given that labor is the only flexible input in agricultural in the model, one may think the cost of working capital as being the cost of paying agricultural wages in advance of the harvest.

production function in labor l_z net of labor costs

$$(3) \quad y_z = p_z \zeta l_z - w l_z$$

where p_z is the local price of the non-traded good, and ζ denotes the non-traded good technology. The assumption that the local traded good depends only on labor captures a key distinction between the non-traded and agricultural sector, namely that land is an important fixed input in the latter but not the former and credit plays a crucial role in agriculture, given the temporal nature of farm production. It also is consistent with patterns in rural India where non-tradable services are small-scale enterprises such as tailors and bakers with low intensity of capital and land.⁴

The time budget constraint faced by the household is thus

$$(4) \quad l_g + l_z = l$$

and the money budget constraint is

$$(5) \quad p_z c_z + c_g + p_f c_f = y_z + y_g + w l.$$

We assume that households maximize utility (1) subject to (2)-(5), that labor markets are competitive and that family and hired labor are perfect substitutes. We consider below a test of this assumption.

To simplify and fix ideas, we assume that the utility and agricultural production functions are Cobb-Douglas with the agricultural goods share being v in the case of the former and the land share being α in the latter. The agricultural profit function is thus

$$(6) \quad y_g = \alpha A \theta^\alpha \left(\frac{(1-\alpha)}{w p} \right)^{\frac{1-\alpha}{\alpha}},$$

with agricultural profits increasing in technology and decreasing in wages and the cost of working capital.

⁴In our sample of rural households in 1999, business capital accounted for less than 3% of total capital assets excluding land and housing. Financial wealth accounted for approximately a third of household non real-estate wealth and the rest is agricultural assets.

Given that wages and the price of the non-traded good must equilibrate their respective markets, it is possible to solve explicitly for the equilibrium wage and the allocation of labor across the two sectors. In particular,

$$(7) \quad w = \frac{\theta(1-\alpha)}{\rho} \left(\frac{l(1-\nu\zeta)(1-\alpha)}{A(1-\alpha(1-\rho\nu\zeta))} \right)^{-\alpha}$$

$$(8) \quad l_z = \frac{\nu\zeta l(1-\alpha(1-\rho))}{(1-\alpha(1-\rho\nu\zeta))}$$

$$(9) \quad l_g = \frac{l(1-\nu\zeta)(1-\alpha)}{1-\alpha(1-\rho\nu\zeta)}$$

Expressions (8) and (9) indicate that although changes in agricultural technology increase the wage and thus both non-agricultural and non-agricultural incomes, they do not influence the equilibrium labor allocation. This is because increases in agricultural productivity both increase the return to agricultural labor and increase household income. This increase in income increases the demand for the non-traded good which results, in turn, in a higher return to non-traded good labor. Under the Cobb-Douglas assumptions these effects precisely cancel. Moreover, agricultural productivity growth results in proportionate income increases in both sectors. To see this note that agricultural and non-farm incomes, respectively, inclusive of labor earnings by sector for the representative household may be written

$$(24) \quad Y_G = y_g + wl_g = \frac{1-\alpha(1-\rho)}{1-\alpha} wl_g$$

and

$$(25) \quad Y_z = y_z + wl_z = wl_z.$$

An increase in agricultural technology, which increases the equilibrium wage, yields proportionate positive effects on agricultural and non-traded income. Thus, in this closed-economy (to foreign industrial capital) model, economic growth propelled solely by agricultural technical change leads to balanced growth.

1.2 Capital mobility

Opening up the local economy to external entrepreneurs with access to capital who can introduce

factory good production sharply alters the conclusions of the general equilibrium model. In particular, non-farm activities are of two types, with distinct responses to external change because labor demand in the non-farm sector is no longer linked to local demand as is the case for the non-tradable sector.

Moreover, the share of agricultural income or activities in the economy will depend on the external source of growth. We assume that the agents in the factory sector are located outside the local economy and face a constant cost of capital r and a Cobb-Douglas technology with capital share ξ , and costs that are increasing in labor utilization. Factory income for the representative entrepreneur is thus

$$(26) \quad y_f = l_f f(k_f/l_f) - (w + \frac{l_f}{\delta})l_f - rk_f$$

Increasing average costs of may be thought of as arising from labor regulation that differentially applies to large employers or to greater likelihood of collective labor action.⁵ The assumption that this effect is present in the factory sector but not the other sectors seems justified given that, as will be shown below, the non-traded and agricultural sectors are almost exclusively family businesses with few employees while factories are large employers and frequently employ workers from outside the village in which they are located.⁶

The income-maximizing level of capital and labor allocations from (10) yields the result that the demand for factory labor is decreasing in the wage

$$(27) \quad l_f = \kappa_f - \delta w$$

where

$$(28) \quad \kappa_f = \frac{\delta(1-\phi)}{\phi} \left(\frac{\phi p_f}{r} \right)^{1/(1-\phi)}$$

and ϕ is the capital share in factory-good production function. In contrast, both non-tradable and

⁵National governmental rules for lay-offs in India only apply to establishments employing more than 300 workers. Some states impose different (lower) employment thresholds

⁶In the factories located in our sample of villages in 1999, on average 63% of factory workers were hired from outside the villages. Note that as specified, an increase in δ represents a decrease in the costs of labor regulation.

agricultural labor are increasing in the equilibrium wage: under these circumstances the labor equilibrium conditions for the z and g sectors are given by

$$(29) \quad l_z = \frac{\zeta v(l(1-\alpha(1-\rho))-\alpha\rho(\kappa_f-w\delta))}{1-\alpha(1-\rho\zeta v)}$$

and

$$(30) \quad l_g = \frac{(1-\alpha)((1-\zeta v)l-(\kappa_f-w\delta))}{1-\alpha(1-\rho\zeta v)},$$

respectively, where the equilibrium wage solves the following equation:

$$(31) \quad w = \frac{\theta(1-\alpha)}{\rho} \left(\frac{(1-\alpha)((1-\zeta v)l-(\kappa_f-w\delta))}{1-\alpha(1-\rho\zeta v)} \right)^{-\alpha}.$$

The contrast between the factory sector and the agricultural and non-traded sectors arises from the ability of external entrepreneurs to move capital in and out of the village, which implies that labor demand in the factory sector is quite elastic.⁷ Because agricultural land, by contrast, is fixed and non-traded good demand must be met locally, labor demand in either of these sectors is much less elastic. This contrast in wage effects carries forward to the effects of local agricultural productivity increases. As in the closed (to external capital) model, the wage is increasing in θ :

$$(32) \quad \frac{dw}{d\theta} = \frac{\rho w l_g (1-\alpha(1-\rho\zeta))}{\theta(\alpha(1-\alpha)\delta w + l_g(1-\alpha(1-\rho v\zeta)))} > 0.$$

However, both agricultural and non-tradable labor are increasing in technology but total non-farm labor ($l_f + l_z$) labor is decreasing in technology:

$$(33) \quad \frac{dl_f}{d\theta} = -\frac{\delta\rho w l_g (1-\alpha(1-\rho n\zeta))}{\theta(\alpha(1-\alpha)\delta w + l_g(1-\alpha(1-\rho v\zeta)))} < 0$$

$$(34) \quad \frac{dl_g}{d\theta} = \frac{(1-\alpha)\delta\rho w l_g (1-\alpha(1-\rho n\zeta))}{\theta(\alpha(1-\alpha)\delta w + l_g(1-\alpha(1-\rho v\zeta)))} > 0$$

and

$$(35) \quad \frac{dl_z}{d\theta} = \frac{\alpha\delta\rho v\zeta w l_g (1-\alpha(1-\rho n\zeta))}{\theta(\alpha(1-\alpha)\delta w + l_g(1-\alpha(1-\rho v\zeta)))} > 0.$$

⁷Note that it would be perfectly elastic in the absence of the increasing marginal cost of labor.

As in the closed model, both agricultural income and income from the non-traded sector increase when there are improvements in agricultural productivity. However, with mobile capital and world trade in manufactured goods, where there are improvements in agricultural technology the share of agricultural income in total income may actually increase. Given that wages, agricultural labor, and profits are all increasing in technology, total agricultural income

$$(36) \quad Y_g = y_g + wl_g = wl_g \frac{1-\alpha(1-\rho)}{1-\alpha}$$

is increasing in technology:

$$(37) \quad \frac{dY_g}{d\theta} = \left(\frac{dw}{d\theta} l_g + w \frac{dl_g}{d\theta} \right) \frac{1-\alpha(1-\rho)}{1-\alpha} > 0$$

In contrast, the effect of an increase in technology on total non-farm income,

$$(38) \quad Y_{fz} = wl_f + wl_z = wl - wl_g,$$

$$(39) \quad \frac{dY_{fz}}{d\theta} = - \frac{wl_g((1-\alpha(1-\rho v \zeta))(l_f + l_z) - (1-\alpha)\delta w)}{\theta(\alpha(1-\alpha)\delta w + l_g(1-\alpha(1-\rho v \zeta)))},$$

is unclear. Because non-traded good income is increasing in technology, this expression will be positive if the elasticity of factory labor demand is less than one in absolute value.⁸

An alternative source of wage growth is the expansion in the overall demand for factory goods (or decreases in the cost of capital for factory investment). The effects on the sectoral allocation of labor of an increase in the factory good price p_f are the opposite of the effects of an increase in agricultural technology. In particular,

$$(40) \quad \frac{dw}{dp_f} = \frac{\alpha(1-\alpha)w(d\kappa/dp_f)}{\alpha(1-\alpha)\delta w + l_g(1-\alpha(1-\rho v \zeta))} > 0,$$

$$(41) \quad \frac{dl_f}{dp_f} = \frac{l_g(1-\alpha(1-\rho v \zeta))(d\kappa/dp_f)}{\alpha(1-\alpha)\delta w + l_g(1-\alpha(1-\rho v \zeta))} > 0,$$

⁸ For the case, for example, that the labor share is $1/2$, this will occur when $8wr^2/p_f^2 < 1$.

$$(42) \quad \frac{dl_z}{dp_f} = -\frac{\alpha\rho v\zeta l_g(d\kappa/dp_f)}{\alpha(1-\alpha)\delta w + l_g(1-\alpha(1-\rho v\zeta))} < 0,$$

and

$$(43) \quad \frac{dl_g}{dp_f} = -\frac{(1-\alpha)l_g(d\kappa/dp_f)}{\alpha(1-\alpha)\delta w + l_g(1-\alpha(1-\rho v\zeta))} < 0.$$

Thus an expansion in the price of factory goods increases total non-farm activity relative to that in agriculture. There is also a compositional shift in non-farm activity from the non-tradable to the factory sector. Non-farm income expands as both wages and non-farm labor increase, while there are opposite effects with respect to agricultural income due to the higher wages combined with declining quantity of agricultural labor. Indeed, for this parametric structure, the net effect of an expansion in the demand for factory goods, is a reduction in the both the amount and share of agricultural income in total income

$$(44) \quad \frac{dY_g}{dp_f} = -\frac{(1-\alpha)wl_g(1-\alpha(1-\rho))(d\kappa/dp_f)}{\alpha(1-\alpha)\delta w + l_g(1-\alpha(1-\rho v\zeta))} < 0.$$

The effects of decreasing labor regulatory cost for factories in rural areas are similar to those for an increase in the price of the factory good - activity in the agricultural and non-traded sectors declines but total non-farm income expands at the expense of agricultural income:

$$(45) \quad \frac{dw}{d\delta} = \frac{\alpha(1-\alpha)wl_f}{\delta(\alpha(1-\alpha)\delta w + l_g(1-\alpha(1-\rho v\zeta)))} > 0,$$

$$(46) \quad \frac{dl_f}{d\delta} = \frac{l_g l_f (1-\alpha(1-\rho v\zeta))}{\delta(\alpha(1-\alpha)\delta w + l_g(1-\alpha(1-\rho v\zeta)))} > 0,$$

$$(47) \quad \frac{dl_z}{d\delta} = -\frac{l_g l_f \alpha \rho v \zeta}{\delta(\alpha(1-\alpha)\delta w + l_g(1-\alpha(1-\rho v\zeta)))} < 0,$$

$$(48) \quad \frac{dl_g}{d\delta} = -\frac{(1-\alpha)l_g l_f}{\delta(\alpha(1-\alpha)\delta w + l_g(1-\alpha(1-\rho v\zeta)))} < 0,$$

and

$$(49) \quad \frac{dY_g}{d\delta} = -\frac{(1-\alpha)wl_f l_g (1-\alpha(1-\rho))}{\delta(\alpha(1-\alpha)\delta w + l_g(1-\alpha(1-\rho v\zeta)))} < 0.$$

Finally, how do local credit constraints affect non-farm activity? An increase in the working cost of capital effectively increases the cost of labor in the agricultural sector resulting in a decline in overall

labor demand within the local economy. Thus, the wage falls

$$(50) \quad \frac{dw}{d\rho} = -\frac{(1-\alpha)wI_g(1+\alpha\rho v\zeta)}{\rho(\alpha(1-\alpha)\delta w + I_g(1-\alpha(1-\rho v\zeta)))} < 0$$

and agricultural labor declines.

$$(51) \quad \frac{dl_g}{d\rho} = -\frac{I_g(\alpha\rho v\zeta I_g + (1-\alpha)\delta w)}{\rho(\alpha(1-\alpha)\delta w + I_g(1-\alpha(1-\rho v\zeta)))} < 0.$$

The decline in the wage induces a flow of capital for factory work

and there is expansion in the factory labor force:

$$(52) \quad \frac{dl_f}{d\rho} = \frac{(1-\alpha)\delta w I_g(1+\alpha\rho v\zeta)}{\rho(\alpha(1-\alpha)\delta w + I_g(1-\alpha(1-\rho v\zeta)))} > 0.$$

However, employment in the non-traded sector can rise or fall as the decline in the wage, which might otherwise increase non-traded labor, is offset by a decline in household income and thus the demand for the non-traded good:

$$(53) \quad \frac{dl_z}{d\rho} = \frac{\alpha v \zeta I_g (I_g - (1-\alpha)\delta w)}{\rho(\alpha(1-\alpha)\delta w + I_g(1-\alpha(1-\rho v\zeta)))}.$$

Lifting credit constraints in the local economy may thus actually decrease non-farm activity, given the credit-intensity of agriculture and the existence of external capital for the factory sector.

1.3 Poverty Reduction and Distributional Effects

Does the source of rural economic growth and the regime under which it occurs matter for income distribution? Thus far the model has been silent on the issue of the distributional consequences of growth in the non-farm sector as it has assumed a representative household. However, the model also can yield insights into distributional issues with only slight modifications if we make the plausible assumption in the context of rural India that the primary distinction between the poor and the less poor is

land ownership.⁹ In particular, suppose that there are two types of households. The representative poor household is landless household, owning only labor l^N , while the representative non-poor or landed household owns A units of land and l^A units of labor, with

$$(54) \quad l^N + l^A = l.$$

Because total land and labor endowments are preserved relative to the homogenous household model above and consumption is linear in income the comparative statics presented above apply to this augmented model in terms of wages, prices, and total (landed plus landless) labor allocations and income by sector. The “household” distribution of income in the context of this augmented model thus depends only on the distribution of factor endowments and the returns to the factors. Because landless households have only a labor endowment, landless household income is

$$(55) \quad Y^N = w l^N.$$

Thus, increases in the wage will increase income of the poor and it follows from the previous analysis that increases in agricultural technology or increases in the demand for (price of) factory goods will help the poor.

A more direct picture of how changes in factory employment and agricultural technology *ceteris paribus* influence the level and distribution of income emerges by solving the equilibrium condition for the wage in terms of θ and factory employment l_f :

$$(56) \quad w(\theta, l_f, l, M) = \frac{(1-\alpha)\theta}{\rho} \left(\frac{(1-\alpha)((1-\zeta v)l - l_f)}{1-\alpha(1-\rho\zeta v)} \right)^{-\alpha}$$

Differentiating (56) yields the result that the wage, and thus the income of poor households, given factory employment, is increasing in θ ,

⁹The quantity of land owned explains 34% of the variation in total household income in a 1971 nationally representative survey of rural Indian households (described below).

$$(57) \quad \frac{\partial \ln w(\theta, l, l_f, \rho)}{\partial \ln \theta} = 1$$

and in employed factory labor, for given θ ¹⁰

$$(58) \quad \frac{\partial \ln w(\theta, l, l_f, \rho)}{\partial \ln l_f} = \frac{\alpha l_f}{l(1-v\zeta) - l_f} > 0.$$

Thus the source of local income growth does not matter, at least qualitatively, for poverty reduction. However, the effects of agricultural technical change and of augmenting the demand for factory labor may have opposite effects on local income inequality. As landed income may be written

$$(59) \quad Y^A = \frac{\alpha \rho}{1-\alpha} w l_g^A + w l^A,$$

the landed-landless income difference is

$$(60) \quad \Delta Y(\theta, l, l_f, \rho) = Y^A(\theta, l, l_f, \rho) - Y^N(\theta, l, l_f) = \theta(1-\alpha) \left(\frac{l_g(l, l_f, \rho)}{A} \right)^{-\alpha} \left(\frac{\alpha \rho}{1-\alpha} l_g(l, l_f, \rho) + l - 2l^N \right),$$

where

$$(61) \quad l_g(l, l_f, \rho) = \frac{(1-\alpha)((1-\zeta v)l - l_f)}{1-\alpha(1-\rho\zeta v)}.$$

The effects on the difference in incomes between the two land classes from improving agricultural technology and increasing the demand for factory labor depend importantly on the extent to which landed households are net employers in the labor market. If household sizes do not differ substantially so $l - 2l^N$ is small relative to l_g , increasing agricultural productivity increases inequality

¹⁰Expression (56) also suggest that increases in the total size of the labor force (population) hurt the poor,

$$\frac{\partial \ln w(\theta, l, l_f, \rho)}{\partial \ln l} = -\frac{\alpha l(1-v\zeta)}{l(1-v\zeta) - l_f} < 0$$

as do increases in the cost of working capital

$$\frac{\partial \ln w(\theta, l, l_f, \rho)}{\partial \rho} = -\frac{(1-\alpha)(1+\alpha\rho\zeta v)}{1-\alpha(1-\rho v\zeta)} < 0.$$

$$(62) \quad \frac{\partial \Delta Y}{\partial \theta} = (\alpha \rho l_g + (l - 2l^N)(1 - \alpha)) \left(\frac{l_g}{A} \right)^{-\alpha} > 0,$$

while the expansion of the factory sector decreases local inequality¹¹

$$(63) \quad \frac{\partial \Delta Y}{\partial l_f} = - \frac{(\rho l_g - (l - 2l^N))(1 - \alpha)^2 \alpha \theta}{l_g (1 - \alpha (1 - \rho v \zeta))} \left(\frac{l_g}{A} \right)^{-\alpha} < 0.$$

The reason for the opposite effects on inequality from increasing agricultural technology and the demand for factory labor, even though both raise the wage and thus reduce poverty, is that technological change in agriculture, given factory labor, is neutral with respect to land and labor, as seen in the immobile capital case, given the assumed specification of the agricultural production function and the non-tradeability of the labor-intensive z-good. An increase in factory labor demand, however, makes labor relatively scarce, raising wages and thus landless incomes but hurting landed households who are net hirers of agricultural labor.

Finally, not only does increasing factory employment decrease local inequality, if factory capital is mobile it provides a potential mechanism to reduce inter-economy inequality induced by local variation in technical change by shifting factory jobs to areas with relatively low productivity in agriculture.

2. Data

To assess how agricultural change and rural industrialization affects the composition of rural incomes and income inequality using the model framework, we exploit the “village economy” of India over the period 1982-1999. India is a particularly good setting for examining how the sources of growth

¹¹Population growth and increases in the cost of local capital increase inequality:

$$\frac{\partial \Delta Y}{\partial l} = \frac{(\rho l_g - (l - 2l^N))(1 - \alpha)^2 \alpha \theta (1 - v \zeta)}{l_g (1 - \alpha (1 - \rho v \zeta))} \left(\frac{l_g}{A} \right)^{-\alpha} + (1 - \alpha) \theta \left(\frac{l_g}{A} \right)^{-\alpha} > 0,$$

$$\frac{\partial \Delta Y}{\partial \rho} = - \frac{\theta \alpha l_g (1 - \alpha) ((1 - v \zeta) l - l_g) \alpha v \zeta}{(1 - \alpha (1 - \rho v \zeta))^2} \left(\frac{l_g}{A} \right)^{-\alpha} < 0.$$

affect rural incomes. First, Indian village economies in part mimic small countries in that permanent migration between villages is relatively small, so that wages are determined by village demand and supply characteristics (Foster and Rosenzweig, 2003), while agricultural prices are set nationally by the central government. Although industry is regulated, entrepreneurs are able to establish factories wherever they wish across India. Second, there has been substantial improvements in agricultural productivity associated with the green revolution starting in the late 1960's - due to the importation of new, high-yielding seeds and public investment in seed development (Evenson and McKinsey, 1999) - and the growth in agricultural productivity has varied widely across India due to natural soil and water conditions. Finally, though less well-known, there has been significant growth in rural industry over the past twenty years.

We use data from a new village and household panel survey that provides information on rural Indian households residing in 242 villages over the period 1982-1999. The new data are from a continuing survey of rural households residing in approximately 250 villages located in the 17 major states of India that began in 1968 and has been carried out by the National Council of Applied Economic Research (NCAER). The first round of the survey for which there is complete village and household information, in 1971, includes 4,527 households in 259 villages and is meant to be representative of the entire rural population of India residing in the 17 major states. In 1982, 250 of the original 259 villages were revisited (the state of Assam was excluded) and 4,979 households surveyed, approximately two-thirds of which were the same households as in the 1971 round. In 1999, all of the 1971 villages were surveyed, but excluding the 8 sample villages in Jammu and Kashmir. In this survey round, all of the surviving households in the 1982 survey were surveyed again, including in this round all split-off households residing in the same villages, plus a small random sample of new households. Because of household division and the new sample design incorporating all village-resident male 1982 surveyed

household members, the number of households in the 1999 round increased to 7,474.¹² The data in both 1982 and 1999 provide information on agricultural yields by seed type and crop, on infrastructure and industry, and on wages and prices at the village level, and on assets and incomes, by source, at the household level. There is also information on household member characteristics and on inheritances of assets in both years.

To characterize the growth in agricultural productivity, we constructed from the village-level data on prices, seed types and yields an index of high-yielding variety (HYV) seed yields for each village for each of the three survey years using a Laspeyres-weighted index for four HYV crops - corn, rice, sorghum and wheat - of output per acre on irrigated lands. This measure represents for each village and point in time the maximum yield local farmers could obtain.¹³ To measure one component of industrialization costs δ that might affect the location of factory capital we used the state-specific index of industrial labor regulations computed in Besley and Burgess (2003) by state and year that were based on amendments at the state level to the Industrial Disputes Act of 1947. This index is the cumulation of regulations starting in 1951, each of which is given a value of +1 or -1 by the authors depending on whether the regulation favored labor or not. Besley and Burgess found that an increase in this index leads to a reduction in formal industry employment and to an increase in informal employment in urban areas. To the extent that the regulations are enforced in rural areas, villages in states with more regulations favoring labor should thus have fewer factory jobs. On the other hand, if the rural sector is exempt, *de facto* or *de jure*, states with more anti-business regulations might have a greater factory presence in rural areas, the rural sector acting as an escape valve for industry. Finally, we also appended

¹²Because of the custom of patrilocal exogamy, women leave the village when married. Thus the panel households in 1999 are defined in terms of male members related to the 1982 household head and who resided with him in 1982.

¹³This measure of frontier yields was used in Foster and Rosenzweig (2003) to examine the effects of the green revolution on deforestation.

to the data information on rainfall, obtained from the monthly time-series available from 40 Indian weather stations, using our geo-coding of the villages and weather stations to compute nearest-station rainfall measures for the villages.

Table 1 provides the characteristics of the panel of 242 villages in 1982 and 1999. The data indicate that there has been a substantial increase in (maximum) HYV crop yields over the period, of over 74%. However, yield growth was not spatially uniform. For example, Figure 1 depicts the maximum yield index for the sampled villages in four regions of India defined by wheat and rice plantings in the 1970-71 crop year. As can be seen, in the villages located in areas in which wheat but not rice was grown in 1971 (26% of villages), the yield index doubled between 1982 and 1999. In the exclusively (no wheat) rice-growing villages (37% of villages), the four-crop HYV yield index increased by 73%; the yield index grew by only 51% in the 30% of villages growing both wheat and rice but grew by 94% in villages growing neither crop in 1971.

The expansion and diffusion of the factory sector has been even more impressive than the growth in HYV yields. The figures in Table 1 indicate that the percentage of villages with factories grew from 17% in 1982 to almost 51% in 1999 and average factory employment of the villagers increased tenfold. This occurred despite, or because of, the fact that the Besley-Burgess of state labor regulations became clearly more anti-business over the period. At the same time, however, the number of local businesses associated with non-traded goods has essentially remained the same.¹⁴ The growth in agricultural productivity and rural industrialization between 1982 and 1999 is evidently reflected in substantial real wage and income growth; between 1982 and 1999 real agricultural wages grew by over 66%, and average

¹⁴The 1982 data do not provide employment for enterprises other than factories. The 1999 data indicate that the average number of workers in service enterprises was only 2.45. Thus it is unlikely that overall employment in the service sector grew substantially

real household income grew by almost 70%.¹⁵ The rise in wages is particularly impressive given that population in the villages increased by 47% over the 17-year period. During the same time income inequality within the villages, as measured by the coefficient of variation in household incomes, grew on average by 16%. However, between-village inequality in wages dropped substantially, by 50%. The relatively small rise in intra-village inequality and the substantial inter-village decline in wage inequality, as suggested by the model, is consistent with a regime in which factory capital is both spatially mobile and growing, offsetting the inequality effects induced by spatially-differentiated agricultural technical change.

The expansion of rural industry is also exhibited in the changing income shares of the panel households over the 1982-99 period, as depicted in Table 2. While all incomes by source rose in real terms between 1982 and 1999, the share of total income accounted for by agriculture and by local business fell and that from non-farm wage and salary jobs rose substantially. In the 1982 survey, 70.7% of total household income originated from agricultural sources (inclusive of agricultural wage work). By 1999, among all of the households with at least one male member from a surveyed 1982 household, the agricultural income share had fallen to 58.8%. Paralleling the stagnation in local service businesses seen in Table 1 over the period, the share of household business income also fell in the panel households, from 9.7% to 7.2%, with the level of income from business only rising by 17% in real terms. Interestingly, the small increase in income from business occurred while average non-land household wealth, which might be considered a source for financing business activities, more than doubled. In contrast, income from non-agricultural wage and salary (employee) jobs rose by 174%, and the income share from non-farm wage and salary jobs rose from 19.5% of total household income to 34%.

3. Empirical Findings

¹⁵All 1999 incomes and asset values are deflated by the rural consumer price index, using 1982 as the base.

3.1 Estimates of the Determinants of Business Activities in the Villages

Before turning to the estimates of the determinants of incomes by source in the rural households using the household panel, we examine two key predictions of the model with mobile factory capital - that agricultural productivity is complementary with non-traded goods production and that factory capital avoids areas with high agricultural yields, and thus high wages. We also assess directly how and whether the Besley-Burgess index affects rural factory location and non-traded goods activities - whether such regulations encourage rural (as opposed to urban) factory employment or not, their effect should be opposite that for the rural non-traded goods sector. In particular, we estimate using the village-level data the reduced-form determinants of non-traded business l_z , as measured by the number of service establishments in the village, and factory employment l_f , as measured by the log of the number of factory workers residing in the village. The log-linear approximation to the model reduced-form is given by

$$(64) \quad \ln l_{kit} = \gamma_{k\theta} \ln \theta_{it} + \gamma_{k\delta} \delta_{fit} + \gamma_{k\rho} \rho_{it} + \gamma_{kl} \ln l_{it} + \gamma_k t + f_{ki} + \epsilon_{kit},$$

for $k=z,f$, where i indexes the village and ϵ_{kit} is an iid error term. We employ as measures of local θ and labor regulatory cost our constructed variables based on maximum HYV yields and the Besley-Burgess index, respectively. Other determinants include the local cost of capital ρ and the total labor force l , as measured by the log of the village population. Because factory capital costs r and the price of factory goods p_f are assumed to not vary by location, they are subsumed in a time dummy variable t .

We make three departures from the model reduced-form. First, we allow for fixed unmeasured determinants of the non-farm activities, such as proximity to a fixed geographic feature (river, coastline), impounded in f_{ki} , that may be correlated with the measured determinants. Second, we add to the specification proximity to organized agricultural markets (*mandis*) (which may affect the farm-gate price), an indicator of whether or not the village is electrified, and the number of public secondary schools, all of which vary across villages and over time. The latter is included to assess to what extent a better schooled labor force fosters or attracts business activities. The third modification is that we employ

the average household wealth in the village instead of the village- and time-specific cost of local capital ρ (which is not available in the data), where we assume that ρ is inversely related to wealth.

There are three estimation issues. First, as noted, the measured determinants of village non-farm activities may covary with unobserved characteristics of the village - for example, HYV yields might be higher in villages near rivers, which might also make attractive locations for factories, or states with good business “climates” may also happen to be states with bad climates for growing crops. We exploit the panel by differencing (64) across time to remove these unmeasured fixed factors. Second, estimating (64) in differenced form induces a correlation between the differenced error and differenced wealth - a positive shock to factory employment in the first period, for example, may lead to greater capital accumulation, biasing downward the wealth coefficient. Third, the HYV index measures with error agricultural technology, and differencing magnifies measurement error bias (Griliches, 1967). To remedy these latter problems, we employ instrumental variables. The variables we use to predict the changes in the HYV index and mean village wealth include the presence of electrification and a bank in the village in 1971, the log of the village HYV yield index in 1971, the estimate of 1971-82 agricultural technical change based on profit function estimates obtained from Foster and Rsoenzweig (1996), the proportion of village area cropped in wheat and cropped in rice in 1971, and the difference in total village annual and March rainfall between the decades 1990-99 and 1971-1980.

Table 3 reports fixed-effect-instrumental variables (FE-IV) estimates of (64) for the log of the number of local service enterprises (column 2) and the log of factory employment (column 3). The results support the model in which non-farm activities are distinguished by whether they produce non-traded or traded commodities. In particular, the estimates indicate that increases in agricultural yields induce more service enterprise activity but decrease the local employment of labor in the factory sector, which produces tradeable commodities. The point estimates suggest that a 50% rise in the yield index increases the number of local non-tradeable-goods businesses by over 25% but reduces local factory employment

by 64%. Consistent with the substitutability of labor between the two non-farm activities - the state labor regulation index increases local rural factory employment while decreasing local non-tradeable enterprises. This sign pattern is consistent with the escape-valve hypothesis - more anti-business legislation in the formal, urban sector leads to greater rural industrial employment.

None of the other variables are statistically significant except the positive time coefficient in the factory specification, which is consistent with both the rising domestic consumption of consumer durables, seen in Table 1, and post-1990 Indian economic reforms reducing constraints on foreign domestic investment.¹⁶ The lack of significance of the school variable is suggestive of the fact that factories are not attracted by an educated work force, but rather by low, unskilled wages. The absence of a positive village wealth effect suggests that local capital constraints do not play an important role in the formation of small local service enterprises.¹⁷

3.2 The Determinants of Household Income, by Source

a. Econometric implementation at the household level. In order to estimate the determinants of household income by source and to empirically test key insights from the static model presented above using panel household-level data there are three challenges. The first is that local capital is treated as exogenous in the general-equilibrium model, but households endogenously accumulate and de-cumulate capital over time. Second, as noted, households divide over time, and this is also not taken into account in the static general equilibrium model. Third, the assumption in the model that hired and family labor are perfect substitutes in all sectors implies that workers are completely indifferent between working in the non-traded and traded sectors. Thus there is no prediction about how family labor should be allocated

¹⁶Suppression of the statistically insignificant intercept in the enterprise specification results in reduced standard errors for the HYV and regulation coefficients, which have asymptotic t-ratios of 2.63 and 2.07, respectively. None of the other coefficient standard errors change substantially.

¹⁷It is possible that the instruments are relatively weak for village wealth. The F-statistic (9,211) for the excluded instrument set is 2.14 ($\rho=.027$); for the HYV index, the comparable F-statistic is 4.20 ($\rho=.0001$).

across sectors, given local-economy wages and prices, and a source for explaining the inter-household heterogeneity of sectoral labor choices is needed.

To obtain a framework that takes into account these issues suitable for the econometric exploration of the household panel data, we augment the representative agent model by incorporating wealth and saving, tracking households as they split over time, and allowing for taste-driven variation in labor allocations across households. First, let M_{it} and m_{it} denote the non-land wealth and saving of household i at time t at time t , respectively, a_{it} denote net investment in land, $\tilde{c}_{it} = [c_{git}, c_{zit}, c_{fit}]$ denote the vector of consumption goods, and $\Psi_t = [\theta_t, p_{ft}, \delta_t]$ denote the vector of exogenous village-level conditions that affect sectoral returns within the village that appear as regressors in Table 3. Also let the working capital cost $\rho_{it} = \rho(M_{it})$ and l_{xit}^u denote household sector-specific utilization of labor so that agricultural profits are

$$(65) \quad y_{git} = \theta_{it} g(A_{it}, l_{git}^u) - w_t \rho(M_{it}) l_{git}^u,$$

and non-traded profits are

$$(66) \quad y_{zit} = p_{zt} \eta_t l_{zit}^u - w_t l_{zit}^u,$$

sector profit functions.

To track the disposition of assets as households split, let $D(I_{it})$ denote the set of possible partitions of the original household - the dynasty,¹⁸ let $N_{d,j}$ and $\phi_{d,j}$ be the number of households and the share of assets accruing to household j , respectively, given that partition $d_{it} \in D(I_{it})$ is chosen, and let i_{ij}^* denote the index in period $t+1$ of the j^{th} split-off of household i in period t . Then one may write household-specific capital adjustment equations

$$(67) \quad M_{i_{ij}^* t+1} = \phi_{d_{it}, j} ((1 + \rho(M_{it})) M_{it} + m_{it})$$

¹⁸Formally, the set $D(l)$ may be thought of as the set of sets of positive integers that sum to l . For example, $D(3) = \{\{3\}, \{1, 2\}, \{1, 1, 1\}\}$. That is a household of three can remain intact, can partition into two unequally sized households, or can partition into three separate households.

$$(68) \quad A_{i_{jt+1}}^* = \phi_{d_{ij}} A_{it} + a_{it}$$

$$(69) \quad l_{i_{jt+1}}^* = \phi_{d_{ij}} (1 + \rho) l_{it}$$

for capital, land, and labor, respectively.

Finally, to allow systematic variation in allocation of labor across households while retaining the result from the representative agent model that wages are equated across sectors we assume an allocation rule that maps household choices and sectoral labor demand into household-specific labor supply:

$$(70) \quad \tilde{l}_{xit}^e = \lambda_x(\tilde{q}_{it}, \tilde{q}_t^*, l_{it}, l_t^*, \tilde{l}_t^{u*})$$

where l_{xit}^e is a household labor allocation to sector x , $\tilde{q}_{it} = [q_{git}, q_{zit}, q_{fit}]$ is a vector of household decisions that influence labor supply,¹⁹ \tilde{q}_t^* is the village average of \tilde{q}_{it} , l_t^* is the village average l_{it} , and

$\tilde{l}_t^{u*} = [l_{gt}^{u*}, l_{zt}^{u*}, l_{ft}^{u*}]$ is the village per-household labor demand by sector. This function is assumed to have

the properties that household labor allocations sum to total household labor

$$(71) \quad l_{it} = \sum_x \lambda_x(\tilde{q}_{it}, \tilde{q}_t^*, l_{it}, l_t^*, \tilde{l}_t^{u*})$$

and village average household labor allocations by sector equal village average labor demand,

$$(72) \quad \tilde{l}_{xit}^u = \frac{1}{H} \sum_i \lambda_x(\tilde{q}_{it}, \tilde{q}_t^*, l_{it}, l_t^*, \tilde{l}_t^{u*}),$$

where H is the number of households in the village.

Consistent with the literature on dynastic utility functions we then define maximum utility recursively for the dynasty initiated with household i at time t as follows:

¹⁹One particular mechanism that yields this formulation is that (1) workers are randomly matched with jobs, (2) workers may accept or reject the matched job, (3) workers that reject their first matched job are randomly matched with jobs rejected in the first round (4) second-round jobs must be accepted. In this case the decision variable q_{xit} denotes whether i accepts in the first round if he is matched with a job in sector x in the that round.

$$(73) \quad V(M_{it}, l_{it}, \Psi_{it}) = \max_{\tilde{c}, \tilde{q}, \tilde{l}, u, m, d} u(\tilde{c}; l_{it}; \omega_{it}) + \sum_{x \in \{g, z, f\}} \mu_{xit} l_{xit}^e + \sum_{j=1}^{N_d} V(M_{i_{yt+1}^*}, l_{i_{yt+1}^*}, \Psi_{t+1})$$

subject to

$$(74) \quad y_{git} + y_{zit} + w_t \sum_x l_{xit}^e = \sum_x p_x c_{xit} + m_{it} + p_A a_{it}$$

where $\mu_{xit} = \mu_{xi} + u_{xit}$ and $\omega_{it} = \omega_i + \epsilon_{it}$ are stochastic variables representing taste shocks to utility and to sectoral labor choices, which consist of fixed dynasty-specific and idiosyncratic components. Note that given the separability of the labor-taste component of (73), the optimal labor allocations for any household i will depend, consistent with the representative-agent general-equilibrium model, on the average labor endowments and tastes of other households in the village and aggregate hiring by sector, and only on its own labor endowment and tastes. In particular, for any given sectoral activity, larger households will allocate more labor to the activity. However, other household-level variables such as wealth and landholdings will not affect household labor allocations, and total labor earnings will not be influenced by the sector in which household members work. These are testable restrictions.

Solving the model in general equilibrium with endogenous wages w , non-traded good prices p_z , and land prices p_A , yields estimable sector- x specific income, for example, as a function of period- t household state variables and village-level technology and price parameters, and the household taste variables

$$(75) \quad y_{xit} = y_x(M_{it}, l_{it}, \Psi_{it}, \hat{\rho}_{xi}, \hat{u}_{xit}),$$

where $\hat{\rho}_{xi}$ and \hat{u}_{xit} are composite error terms derived from μ_{xi} , u_{xit} , ω_i , and ϵ_{it} . Taking linear

approximations to (75), we get

$$(76) \quad y_{xit} = \beta_{xt} + \beta_{xM} M_{it} + \beta_{xl} l_{it} + \beta_{x\Psi} \Psi_{it} + \hat{\rho}_i + \hat{u}_{it}.$$

Parallel to the estimation of the village-level determinants of sources of labor demand, the household stock variables reflect past decisions and thus are correlated with the fixed effect. We thus difference

over time treating the relevant unit as the dynasty and accounting for dynasty division by differencing each split-off household from its respective origin household. Thus, let Δ_j denote the difference between the j^{th} split-off in period $t+1$ and the origin household in period t , so that

$$(77) \quad \Delta_j y_{xit} = y_{xi_{ij}^* t+1} - y_{xit},$$

where i_{ij}^* is the index in period $t+1$ of the j^{th} split-off of i in period t . Then, for $j \in \{1, 2, 3, \dots, N_{d_{t+1}}\}$, the first difference estimator may be written as

$$(78) \quad \Delta_j y_{xit} = \Delta_j \beta_{xt} + \beta_{xk} \Delta_j M_{it} + \beta_{xl} \Delta_j I_{it} + \beta_{x\psi} \Delta_j \Psi_{it} + \Delta_j \hat{u}_{it}$$

for each split-off j .²⁰

Finally, removal of the fixed effect creates another source of bias as the period t shock to income ϵ_{it} may affect subsequent capital investment and household division and thus the state variables M and I in period $t+1$. Solving this problem requires the use of instruments. In addition to the instruments used to predict the change in yields and village wealth from 1982-1999, we need instruments that predict each individual household's change in assets and size over the same time period. We use retrospective information from the 1999 survey on the inheritance of assets for each dynasty prior to 1982 to characterize initial-period household asset conditions. The value of inherited assets prior to 1982 is uncorrelated with the initial-period (1982) shock but is a significant determinant of subsequent asset accumulation by a household. We also include in the instrument set the standard deviation of the age of adult males in each household in 1982 and whether or not the 1982 household head dies after 1982. These

²⁰Note that using this procedure the initial-period origin household will effectively appear in the data set once for each of the split households originating from that household in the subsequent period. A procedure such as Huber standard errors based on origin-household clusters must then be used to account for the resultant inter-observation correlations.

variables were found by Foster and Rosenzweig (2002) to be strong predictors of household splits.²¹

b. Estimates of the determinants of household income components. Table 4 reports GLS, FE and FE-IV estimates of the linear approximation to (75) for total household agricultural earnings supplemented by rainfall data that empirically appear to significantly affect agricultural yields.²² As would be expected, the GLS estimates indicate that a household's agricultural income is strongly and positively related to its size, wealth, landholdings and to the HYV yield index. Surprisingly, however, given the results in Table 3 that factory employment is higher in areas in which urban worker regulations are stricter, agricultural earnings, and thus employment, is also higher in such villages. However, when the household (and village) fixed effect is eliminated the sign of the regulation variable is reversed, conforming to the FE and FE-IV results for factory employment - where labor is more heavily regulated and local rural factory employment is thus greater, a household's agricultural earnings are reduced, given wealth and land holdings. The sign and statistical significance of the other variable coefficients are not substantially changed when FE is used, except for the yield index, which declines by two-thirds. However, when instruments are used, the yield index coefficient increases fivefold, suggesting substantial measurement error in that variable. The other FE-IV coefficient estimates are not very different from their FE counterparts.²³

²¹Foster and Rosenzweig (2002) show that household division is the major determinant of asset changes and size for households over periods longer than a decade.

²²An auxiliary regression of an indicator of whether there was adverse, yield-reducing weather in the village on total rainfall in the crop year and each month's rainfall for all twelve months during the crop year was estimated using the 1982 and 1999 village information. Aggregate annual rainfall and rainfall in March and September were the variables having a statistically significant relationship with the dependent variable and are included in the household income equations.

²³The set of instruments explaining the change in HYV yields and household characteristics appear to perform well. The F-statistics $F(15, 218)$ for the set of identifying instruments in the first-stage equations for the change in family size, household landholdings, household wealth and village HYV yields are 128.4, 68.5, 5.83 and 3.81, respectively. Our ability to predict aggregate wealth at the village level is less good. The F-statistic for the instruments in the village-level wealth change equation is 1.84, statistically significant at the .03 level.

The FE-IV estimates of the determinants of non-farm wage and salary income, business income and total non-farm income are presented in Table 5. The patterns of changes in coefficients by estimation procedure are similar to those observed for agricultural income, and the GLS and FE estimates are thus not reported.²⁴ The estimates indicate, consistent with the estimates at the village level for the independently-collected information on local business service enterprises and for factory employment and with the model incorporating a mobile factory sector, that improvements in agricultural technology reduce participation by households in wage and salary jobs. Moreover, agricultural productivity improvement, while reducing wage and salary incomes, increases household income from local, service-related business enterprises. Given these opposite effects, lumping together both types of non-farm incomes, as in the last column, evidently results in an insignificant relationship between total non-farm income and agricultural productivity. Clearly it is not appropriate to see non-farm activity as homogenous. The estimates also indicate that regulations that directly or indirectly promote factory employment increase households' wage earnings but do not appear to affect business incomes - factory employment does not crowd out locally-oriented business activity. Thus, total non-farm income is positively related to factors encouraging factory employment.

Although the estimates in Tables 3-5 indicate the importance of agricultural productivity and factory employment in affecting the sources and levels of rural household incomes, household wealth does not appear to be important in affecting the division of household labor between wage employment or local business activity, consistent with the model and the descriptive statistics in which local service business enterprise is not capital intensive.²⁵ Lack of credit or local wealth does not therefore appear to be important in explaining non-farm business activity, other than the fact that wealth is evidently

²⁴They are available from the authors by request.

²⁵The F-statistic for the cross-equation joint significance of the wealth variable in the wage and business income equations is 1.31 (p=.270).

productively used in agriculture (Table 4). Moreover, households with larger families are observed on average in all activities - agriculture, wage and salary employment and business enterprise, suggesting that labor is locally mobile across sectors. However, the fact that business income is higher in villages with more secondary public schools suggests that there may be returns to schooling specific to that sector. Finally, although the sign patterns for the rainfall coefficients in the non-farm earnings specifications are opposite to those for agricultural income in Table 4, the sets of rainfall variables are not jointly statistically significant (unlike for agriculture), indicating that neither non-farm sector contributes significantly to inter-annual, *ex post* consumption smoothing. However, the fact that earnings in the sectors are less subject to the vagaries of weather, suggests that the observed increases in employment in these sectors has reduced intertemporal household earnings variability in India over the past two decades.

3.3 Sources of Rural Growth, Poverty Reduction and Inter and Intra-village Inequality

a. Wages. The estimates in Tables 4 and 5 indicate that agricultural technical change and variables affecting factory location importantly affect the level, variability and sources of incomes among rural households. We now use the village-level panel data to assess how agricultural productivity growth and rural industrialization affect the poor and the distribution of incomes across and within villages. Because wage income dominates the income of the poor, we first estimate a log-linear approximation to the wage function (56):

$$(79) \quad \ln w_{it} = \gamma_{w\theta} \ln \theta_{it} + \gamma_{w\delta} \ln l_{jit} + \gamma_{w\rho} \rho_{it} + \gamma_{wl} \ln l_{it} + \gamma_{wt} t + f_{wi} + \epsilon_{wit},$$

where we again substitute the village-level asset variable M for ρ . In this specification we are essentially running a horse race between the two major sources of rural income growth with respect to wage growth and thus rural poverty reduction. Because factory location and employment levels respond to wages, estimation of (79) in the cross-section will lead to biased estimates, as l_{jit} will be correlated with both the fixed factors determining wages and temporary wage shocks. We again difference, and use as

instruments those variables determining agricultural technology change over the period and the index of state regulations of urban factory labor, which are excluded from (56) given l_{fit} .

GLS, FE, and FE-IV estimates of (79) are reported in Table 6. The results show clearly, as predicted by the model, that higher agricultural productivity growth and expansion in the factory sector increase wages. Both sources of rural income growth thus reduce poverty rates. The estimated effect of an increase in yields and the number of factory workers does not differ appreciably across estimation methods. However, the village population variable only has the theoretically correct sign when the fixed effect is removed and instruments are used. The fact that the GLS and FE estimates of the effect of population on wages are positive suggest, as might be expected, that areas with more favorable conditions, such as high land quality or favorable wage shocks, may have both higher wages and higher populations. The wealth effect is positive as expected but not significantly different from zero.

The FE-IV point estimates suggest that both HYV productivity gains and growth in the rural factory sector contributed importantly to wage growth in the 1982-1999 period. However, the effect of the latter is substantially higher. In particular, the 74 percent increase in HYV productivity for 1982-1999 exhibited in Table 1 resulted, *ceteris paribus*, in a 47.7% increase in the village agricultural wage. By comparison the 900% increase in the number of factory workers resulted, *ceteris paribus*, in a 93% increase in the wage. The factory growth component of wage growth exceeds the 66% increase in the mean wage over this period, reflecting, among other things, the negative effects of population on wages and overall population growth over this period.

b. Inter-village inequality. In combination with information on data covariances, the wage estimates in Table 6 may be used to show that the tendency for factories to locate in low-wage areas inclusive of those with lower HYV productivity substantially reduces inter-village inequality. Based on (79) the inter-village log wage variance is

$$(80) \quad \text{var}(\ln w) = \gamma_{w\theta^2} \text{var}(\ln \theta) + \gamma_w l_f^2 \text{var}(w \ln l_f) + \text{var}(e) + \gamma_{w\theta} \gamma_{w l_f} \text{cov}(\ln \theta, \ln l_f) \\ + \gamma_{w\theta} \text{cov}(\ln \theta, e) + \gamma_{w l_f} \text{cov}(l_f, e)$$

where e is the compound error term in (79) $f + \epsilon$.

The terms $\gamma_{\theta} \gamma_{l_f} \text{cov}(\theta, l_f)$ and $\gamma_{l_f} \text{cov}(\ln l_f, e)$ reflect the consequences for spatial wage inequality of the fact that factories are not randomly located across space. Factories avoid high-productivity areas, as seen in Table 3, and areas with positive wage endowments e . The coefficients for the two covariance terms are obtained from Table 6, the technology-factory worker covariance can be computed from the estimated elasticity of factory workers with respect to yield (-1.27) in Table 3 using, in addition, the 1999 standard deviation in yields from Table 1 (473.5). We obtained an estimate of the endowment-factory worker covariance by applying the FE-IV ln wage coefficient estimates to the cross-sectional data on wages, HYV yields, and factory employment to estimate e and then computing the covariance with $\ln l_f$ directly. Comparing these terms to the actual variance in log wages, we find that the variance in log wages would be 17.8% higher if factory location were not responsive to agricultural productivity and 41.9% higher if factor location were neither responsive to agricultural productivity nor to residual sources of the spatial variation in wages. Thus the choice by factory entrepreneurs to locate in low wage areas has had a major impact on inter-village inequality in agricultural wages and poverty across rural India.

c. Intra-village inequality. We now examine how local agricultural productivity change and the presence of a factory affects intra-village inequality. The household survey data for 1982 and 1999 permits the computation of measures of income and endowment inequality for each village. We constructed for the 240 panel villages for each of the two survey years the coefficient of variation in total household income, wealth and landholdings to estimate a linear approximation to (60), which relates intra-village inequality to agricultural technology and factory employment. In the simple two household-type model in which only landed households hold wealth, the coefficient of variation in wealth is a

simple monotonic function of mean wealth. More generally, however, the variation in wealth across landed households will also contribute to inequality and thus it is critical from an empirical perspective to use variation in wealth to control for endowment inequality. If HYV productivity growth or factory presence were correlated with wealth inequality growth among landed households one might obtain a misleading picture of the determinants of income inequality *given* endowment inequality that is the focus of the analysis here.

The equation we estimate is thus

$$(81) \quad CV(Y_{it}) = \gamma_{cv\theta} \ln \theta_{it} + \gamma_{cv\delta} \ln l_{fit} + \gamma_{cv\rho} CV(M_{it}) + \gamma_{cvA} CV(A_{it}) + \gamma_{cvi} \ln l_{it} + \gamma_{cvf} f + f_{cvi} + \epsilon_{cvi}.$$

We also include in the specification the number of public secondary schools in the village. Schooling can affect inequality in income, if schooling returns are significant. It is easy to show that within the context of the model unmeasured village fixed factors such as land quality will affect income inequality in the village and the village wage rate. Thus factory location and wealth inequality will likely be correlated with the fixed effect f in (81) and we again estimate a cross-time differenced version of equation (81). It is less clear why temporary shocks to village inequality would significantly affect the subsequent evolution of factory placement. However, we employ the same set of instruments as was used to predict the changes in θ , $\ln l_p$, and $M(\rho)$ in the wage specification to predict the changes in θ , $\ln l$, and $CV(M(\rho))$ and $CV(A)$ in (81), and test for endogeneity.

Table 7 presents GLS, FE and FE-IV estimates of the determinants of intravillage inequality based on the panel of villages. In the first column the results conform to the predictions of the model - agricultural technical change and increases in population size increase inequality and factory employment decreases inequality. However, only the technical change measure coefficient is statistically significant. This could be due to the fact that θ and unmeasured land quality are positively correlated. The elimination of the influence of the village fixed effect, column 3, results in the factory presence coefficient becoming statistically significant, but the technical change measure coefficient loses

statistical significance. We applied Wu-Hausman tests to test whether θ , $\ln l_t$, and $CV(M(\rho))$ and $CV(A)$ were correlated with the differenced residual in the fixed effects specification. Only the agricultural technical change variable residual was statistically significant, suggesting again that this variable contains substantial measurement error. Accordingly, we estimated the differenced form of (81) using the instruments to predict on the change in θ . The FE-IV results are reported in the last column of Table 7. In this specification both the agricultural technology and factory employment coefficients are measured precisely, and, in conformity with the model have important opposite effects on income inequality. In particular, if we apply the actual 1982-1999 changes in these variables, the point estimates suggest that the 74% increase in HYV productivity increased village income inequality by 14%, while the 900% increase in factory employment resulted in a 62% decrease in village inequality. Clearly the entry of factories in the non-formal sector played a critical role in reducing inter-village inequality in India over the corresponding period by raising agricultural wages.

4. Conclusion

Empirical evidence on the relative efficacy of farm and non-farm growth as sources of reduction in rural poverty and inequality has been limited and inconclusive despite the fact that a large share of the world's poor reside in rural areas. One key limitation has been the absence of appropriate data. A data set for examining these effects must be of sufficiently long duration to capture significant sectoral transformation, of sufficient spatial variation to contain different patterns of growth, and sufficiently disaggregated to permit examination of income by sector at the household level. This literature has also lacked a theoretical framework that is both rich enough to capture heterogeneity in the nature of the non-farm sector and tractable enough to generate falsifiable predictions. As a result, empirical researchers frequently present contrasting results that are not readily resolved. There is, for example, much debate about whether the agricultural and non-farm sectors are substitutes or complements. There is also controversy about whether the share of non-farm income is increasing or decreasing in household income

at a given point in time. The model we develop and our empirical results indicate that the inconsistent conclusions with respect to the former result from neglecting heterogeneity in the rural non-farm sector. They also suggest that the latter results are not informative about the distributional consequences of growth in the farm and non-farm sector. Rather, what is important is whether an intervention either increases the endowments of the poor or raises the returns to the endowments that the poor possess.

In this paper we addressed the limitations of the existing literature by developing and testing a simple general equilibrium model of farm and non-farm sector that distinguishes between different types of non-farm sector activities and income classes and yields a series of testable implications for the effects of farm and non-farm growth on economic activity by sector and on poverty reduction. The theoretical model was used to frame an empirical assessment of the effects of farm and non-farm growth on incomes of rural households using a new household panel based on a nationally representative sample of rural Indian households and collected over the past 30 years, a period of rapid agricultural productivity improvement and rural industrialization.

Our results illustrate clearly the importance of considering separately the non-tradable and tradable non-farm sectors within a general-equilibrium framework. Consistent with the model, while the non-tradable sector is driven by local demand conditions and thus is positively influenced by growth in agricultural productivity, the tradable non-farm sector - factories - enters areas with relatively low wages and thus is negatively influenced by growth in agricultural productivity. As a consequence non-farm growth tends to reduce inter-village rural inequality induced by agricultural technical change. Moreover, the factory sector employs low-skilled labor. Thus, the growth in factory employment increases the incomes of the poor and, given that the better off, landed households, are net hireres of agricultural labor, decreases intra-village inequality. By contrast, particularly in the presence of mobile capital, which dampens regional variation in wages, agricultural productivity growth tends to increase inter-village inequality.

Although our theoretical framework allowed for an imperfect local capital market, the empirical results suggest that this barrier to development and industrialization emphasized in the theoretical literature was not important, given evidently well-functioning labor and goods markets and an external source of mobile capital. These results highlight the importance of a reduction in barriers to the movement of industrial capital as an important instrument of rural poverty reduction along with investments in agricultural technology. India has a long history of public investments in agricultural innovation, accompanied by industrial regulation, preferential credit for certain types of industries, and constraints on trade. Our results do not speak to the question of whether the impact of rural industrialization on rural poverty arises as a consequence or in spite of these controls, although we do have evidence that a subset of these regulations significantly affected the location and magnitude of rural factory employment. Clearly, however, more needs to be done to better understand the process of rural industrialization so that the most appropriate policies can be put in place.

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Table 1
Rural Economic Development: 1982-1999

Indicator	1982	1999
Laspeyres HYV Yield Index	579.6 (345.1) ^a	1009.2 (473.5)
Percentage of Villages with Factories	17.2 (37.8)	50.6 (50.1)
Average Number of Factory Workers per Village	5.65 (18.2)	56.7 (113.0)
Average Number of Service Establishments per Village	36.2 (.65.1)	33.2 (44.7)
Besley-Burgess index of state regulations pertaining to urban factory labor	-.0298 (3.80)	.508 (4.38)
Mean Male Agricultural Wage	9.61 (6.00)	16.0 (4.95)
Average Real Household Income	5500.8 (5422.2)	9338.2 (13859)
Average Real Household Nonland and Nonhousing Wealth	3939.3 (7986.8)	10651 (35846)
Average Annual Real Household Expenditures on Consumer Durables	93.1 (476.9)	785.4 (4512)
Percentage of Villages with Electrification	71.9 (45.0)	89.8 (30.3)
Percentage of Villages with Public Secondary Schools	22.6 (42.0)	36.5 (48.2)
Village Population Size	2563.9 (3109.7)	3764.1 (4688.1)
Average Within-Village Coefficient of Variation in Household Income	66.6 (29.3)	77.2 (33.1)
Average Across-Village Coefficient of Variation in Male Agricultural Wage	.624	.309

^aStandard deviation in parentheses.

Table 2
 Characteristics of Panel Households: Means and Standard Deviations,
 by Survey Year

Variable	1982	1999
Total agricultural income ^a	3888.2 (4555.3) ^b	5092.3 (13794)
Business income	534.6 (1742)	626.8 (2652.5)
Nonfarm wage and salary income	1074.0 (2792.3)	2940.5 (5829.2)
Owned land (hectares)	3.88 (5.75)	2.73 (5.63)
Total wealth, excluding house and land	4371.6 (7862.3)	9909.7 (40371)
Family size	6.10 (2.98)	5.85 (3.43)
Number of households	3776	5748

^aAll monetary units are 1982 rupees.

^bStandard error in parentheses.

Table 3
 FE-IV Village-Level Estimates:
 Effects of Agricultural Productivity Growth and Urban Regulations Governing Factory Labor on Rural
 Nonfarm Business Activities, by Type

Variable	Log of Number of Village Service Enterprises	Log of Number of Village Factory Workers
Log HYV yield index ^a	.551 (1.87)	-1.27 (2.01)
Besley-Burgess index of state regulations pertaining to urban factory labor	-.0971 (2.25)	.173 (2.04)
Village electrified	.0147 (0.06)	.764 (1.83)
Village near organized market (<10km)	-.0267 (0.17)	-.0937 (0.30)
Average village wealth(x10 ⁻⁴) ^a	-.239 (1.27)	.627 (1.55)
Log of village population size	.00764 (0.32)	.0528 (1.14)
Number of public secondary schools in village	.0252 (0.14)	-.322 (0.74)
Time	.187 (0.69)	1.30 (2.12)
N	454	454

^aEndogenous variable. Instruments include presence of electrification and bank in 1971, HYV yields in 1971, 1971-82 agricultural technical change estimate, whether a wheat or rice growing area, and the difference in total annual and March rainfall between the decades 1990-99 and 1971-1980.

^aAbsolute value of robust asymptotic t-ratio in parentheses.

Table 4
Household Panel Estimates: Determinants of Total Agricultural Income, by Estimation Procedure

Variable	GLS	FE	FE-IV
Log HYV yield index ^a	2849.0 (7.94) ^b	975.4 (2.59)	5204.0 (2.34)
Besley-Burgess index of state regulations on urban factory labor	129.4 (2.12)	-289.6 (1.94)	-317.2 (1.57)
Household size ^a	454.9 (6.02)	614.9 (6.32)	441.7 (3.14)
Household owned land (hectares) ^a	637.6 (8.39)	378.5 (6.27)	320.9 (5.55)
Household wealth, excluding land and house (1982 rupees) ^a	.00203 (2.47)	.0948 (2.33)	.167 (2.38)
Total rainfall (mm) in crop year	1.69 (2.72)	3.56 (2.61)	4.02 (2.43)
Rainfall in March	-17.5 (2.35)	-27.6 (3.21)	-30.1 (2.37)
Rainfall in September	-15.2 (4.12)	-10.2 (2.72)	-16.8 (3.23)
Village near organized market (<10km)	1627.4 (3.25)	1115.2 (2.50)	1435.2 (2.04)
Village electrified	628.4 (1.25)	-459.3 (0.72)	-1527.4 (1.35)
Number of public secondary schools in village 10 years ago	293.4 (0.68)	884.7 (1.14)	953.9 (0.81)
Average village wealth ^a	-.000417 (1.10)	.0602 (2.26)	.0349 (0.40)
Total village arable land	7.66 (1.44)	-	-
Log of village population size	399.1 (2.76)	51.3 (0.22)	106.7 (0.49)
Constant (time)	-22261 (7.79)	768.5 (1.24)	-2549.7 (1.83)
N	9429	5705	5705

^aEndogenous variable in column 4. Instruments include presence of electrification and village bank in 1971; HYV yields in 1971; 1971-82 agricultural technical change estimate; the difference in total annual and March rainfall between the decades 1990-99 and 1971-1980; the number of potential inheritors (heirs) and the standard deviation in heirs' ages in 1982; whether the 1982 head died after 1982; total inherited agricultural assets, land, and farm equipment.

^bAbsolute value of robust asymptotic t-ratio in parentheses corrected for household (column 2) and village (columns 3 and 4) clustering.

Table 5
FE-IV Household Panel Estimates: Determinants of Non-agricultural Income, by Type

Variable	Non-farm Wage and Salary Income	Business Income	Total Nonfarm Income
Log HYV yield index ^a	-1388.1 (2.18)	1248.0 (2.07)	-161.4 (0.24)
Besley-Bugess index of state regulations on urban factory labor	127.3 (1.66)	17.6 (0.26)	158.7 (1.84)
Household size ^a	315.9 (3.79)	181.5 (2.95)	474.9 (4.18)
Owned land (hectares) ^a	1.35 (0.06)	-12.5 (0.52)	-7.40 (0.19)
Household wealth, excluding house (1982 rupees) ^a	.0190 (0.69)	-.0350 (1.17)	-.00994 (0.29)
Total rainfall (mm) in crop year	-.734 (1.19)	.101 (0.26)	-.702 (1.04)
Rainfall in March	5.51 (0.87)	-2.23 (0.49)	3.27 (0.49)
Rainfall in September	5.97 (2.88)	-.581 (0.36)	5.49 (2.47)
Village near organized market (<10km)	82.9 (0.28)	-120.0 (0.48)	41.3 (0.15)
Village electrified	-131.8 (0.32)	-301.4 (0.86)	-410.0 (0.87)
Number of public secondary schools in village 10 years ago	-456.0 (1.43)	756.3 (2.70)	304.9 (0.87)
Average village wealth ^a	.0504 (1.31)	-.0378 (1.03)	.0154 (0.41)
Log of village population size	19.5 (0.29)	30.3 (0.47)	33.6 (0.50)
Time	2540.0 (5.27)	-382.9 (0.93)	2082.8 (3.73)
N	5354	5354	5354

^aEndogenous variable. Instruments include presence of electrification and village bank in 1971; HYV yields in 1971; 1971-82 agricultural technical change estimate; the difference in total annual and March rainfall between the decades 1990-99 and 1971-1980; the number of potential inheritors (heirs) and the standard deviation in heirs' ages in 1982; whether the 1982 head died after 1982; total inherited agricultural assets, land, and farm equipment.

^bAbsolute value of robust asymptotic t-ratio in parentheses corrected for village clustering.

Table 6
Village-Level Estimates: Effects of Agricultural Productivity Growth and Industrialization
on Log Rural Wage^a

Variable	GLS	FE	FE-IV
Log HYV yield index ^b	.187 (6.64) ^c	.269 (5.97)	.274 (1.97)
Log of number of village factory workers ^b	.0802 (8.06)	.0692 (4.67)	.0927 (1.78)
Log of population in village	.00444 (0.63)	-.00756 (0.76)	-.0201 (1.95)
Village wealth (x10 ⁻⁵)	.576 (2.70)	.315 (0.83)	.387 (0.50)
Number of public secondary schools in village 10 years ago	.0262 (0.97)	.183 (2.66)	.0913 (1.16)
N	444	444	444

^aAll specification include rainfall variables.

^bEndogenous variable in column 4. Instruments include presence of electrification and bank in 1971, HYV yields in 1971, 1971-82 agricultural technical change estimate, whether a wheat or rice growing area, the difference in total annual and March rainfall between the decades 1990-99 and 1971-1980, and the Besley-Burgess index of state regulations of urban factory labor.

^cAbsolute value of robust asymptotic t-ratio in parentheses.

Table 7
Village-Level Estimates: Effects of Agricultural Productivity Growth and Industrialization
on the Within-Village Coefficient of Variation of Household Income^a

Variable	GLS	FE	FE-IV
Log HYV yield index ^b	.0499 (2.39) ^c	.0342 (1.02)	.202 (2.42)
Log of number of village factory workers	-.00200 (0.25)	-.0201 (2.01)	-.0221 (1.95)
Log of population in village	.00520 (1.00)	.00614 (1.01)	.00937 (1.38)
CV(Wealth)	.0237 (1.93)	.0229 (1.58)	.0193 (1.25)
CV(Land)	-.00269 (0.62)	-.0829 (0.68)	-.00896 (0.62)
Number of public secondary schools in village	.0939 (3.73)	.0652 (1.24)	.0876 (1.48)
N	448	448	448

^aAll specification include rainfall variables.

^bEndogenous variable in column 4. Instruments include presence of electrification and bank in 1971, HYV yields in 1971, 1971-82 agricultural technical change estimate, whether a wheat or rice growing area, the difference in total annual and March rainfall between the decades 1990-99 and 1971-1980, and the Besley-Burgess index of state regulations of urban factory labor.

^cAbsolute value of robust asymptotic t-ratio in parentheses.

HYV Yields 1982-99 by Crop Regions in 1971

