Technical Progress, Population Growth and the Immiserization of the Sharetenants:

A Theoretical Analysis and Some Empirical Evidence

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I. Introduction

The two most important dynamic factors affecting development of peasant agriculture in less-developed countries, especially those of South Asia, are technical change (in production) and population growth. These two factors operate simultaneously and often influence important economic variables in conflicting ways. Because of this close interconnection, often the effect of one factor is confused with that of the other, and many apparent paradoxes seem to emerge. For example, as Bardhan (1979a) has noted, the regions of India which have a higher rate of technical progress have a higher incidence of sharecropping. But the time series evidence suggests that, with time, there is a decline in the incidence of sharecropping. Similar apparent paradox seems to exist with

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respect to real agricultural wage rate.[1] The purpose of the present exercise is two-fold. First, to isolated analytically the impact of technical progress and the population growth on the real wage rate and the extent of sharecropping. Secondly, to provide an explanation of the seeming paradox posed by Bardhan.[2] Unlike Bardhan who seeks to explain the paradox in terms of institutional factors, we seek to explain the phenomenon in terms of population gowth. Indeed, population growth is a vitally important factor for these economies whereas, paradoxically enough, in most modelling exercises in these areas this factor is blatantly ignored. With the incorporation of the population factor, the paradox mentioned by Bardhan can be explained easily and fully.

The model we posit here is a simple general equilibrium model of the peasant economy with the following features:

a. The economy consists of two classes of farmers — the landed and the landless.[3] The landed class owns the land. It cultivates part of its land with hired and own labor, the rest it rents-out to the sharetenants. The landless class does not own land but rents in land from the landed class. The landless class devotes part of its labor to the rented in land and part of it as wage-labor to the landlord's land.

b. The labor market is assumed to be competitive and the wage rate is assumed to be determined endogenously.[4]

c. The seasonality, though an important fact of life in agriculture, is assumed away for the sake of simplicity.

1 This has led many writers to the conclusion that technical progress leads to immiserization of small and landless peasantry. See, for example, Frankel (1971), Byres (1972), Griffin (1974), Lewis (1970), Rudra (1971), Lefeber (1973) etc.

2 Bardhan can explain, successfully, in terms of economic forces the results of the cross section data. But his explanation of the long run trend, in terms of institutions, seems far from satisfactory.

3 Such an aggregation scheme, which we presume reflects the dominant tenurial structure in South Asia, was adopted by many, including Bardhan and Srinivasan (1971), Stiglitz (1974).

4 The literature on this area — employment, unemployment and wage determination — is quite inconclusive. In the dual economy literature associated with the names of Lewis, Ranis, and Fei, agriculture is characterized by the following assumption: labour is paid a subsistence wage determined by tradition. Disguised unemployment is assumed to be prevalent in the whole sector. However, this notion of agriculture has been challenged by many. The empirical evidence that has accumulated in recent years for typical labor — surplus economies like Egypt and India tends to show that agricultural wages are related to the marginal productivity of labor and seem to respond to the forces of demand and supply. See, Hansen (1966), Hansen (1969) & Bardhan (1979b).

d. The rental rate is determined from outside the model,[5] presumably by institutional factors. The landlord is assumed to have a monopsonistic power in the allocation of land. Further, we assume there is a land constraint operating in the economy.

e. The model is essentially static — dynamic processes are approximated by methods of comparative statics.

f. For simplicity, like much important work in this area, we assume away uncertainties. We think for the problem at hand though uncertainties can contribute to the richness of the structure, it will not affect the quality of our results.[6]

The present paper is organized in the following way. Section I traces the optimizing behavior of the two classes of peasants in the absence of technical progress. Section II describes the general quilibrium properties of the model and derives some comparative static results. The effect of technical progress on the optimizing behavior of farmers is explored in Section III while Section IV investigates the general equilibrium aspects of technical progress. Some empirical evidence in support of the predictions of the model are given in Section V. Concluding remarks are presented in Section VI.

I

We assume that there are two classes of farmers in our agrarian economy — the land-owning and the landless. The landowning class possesses all land of the economy. It has the option of

5 The rental rate for sharecropping (50:50 share) has been remarkably unchanged in South Asia and other countries for a long period of time. In our view, this fixity of the rental rate can be explained, more convincingly, in terms of institutional factors. However, there has been a great deal of theorizing about how the rental rate is determined. The models run from simple competitive structure - as for example, Bardhan and Srinivasan (1971) where the rental rate is determined by the equality of demand and supply of sharecropped land - to noncompetivitive duopolistic models - as for example, Quibria and Rashid (1981), where the rental rate is determined by the interdependence structure of landlords posited there (i.e., the type of solution concept introduced there), or Bell and Zusman (1976) where a Nash-theoretic approach is employed for determining the rental rate. A survey of various theories can be found in Quibria and Rashid (1980).

6 Though uncertainty and agricultural risk is often assumed to be the main impetus for sharecropping, the most intriguing result emerging from the recent analysis involving uncertainty (see Newbery and Stiglitz (1979) seems to cast doubt on that presumption. They

cultivating its land with family labor and hired hands or rent out land at an institutionally fixed rental rate. Each farmer is assumed to have utility function of the form: $U = u(c, \lambda)$, where c is the total consumption and λ is leisure. The utility function is assumed to be strictly quasi-concave. There is a single homogenous crop produced in the economy so that both income and consumption are identical. The total income of the land-owning farmer is given by

$$c = f(x_1, x_2) - wl_h + r\,g(v)$$

where $x_1 = l_0 + l_h$ and $x_2 = z - v$. $= l_0$ and l_h indicate family and hired labor respectively. The farmer possesses a total of z units of land of which he rents out v units at an institutionally determined share rental rate r. Although the landowning farmers are assumed to be monopolists in the land lease market, they do not have any control over the labor market where wage w is determined. The production function f is assumed to be strictly concave in labor and land with positive but declining marginal productivities. The cross partials are also assumed to be positive. Thus,

$$\frac{\partial f}{\partial x_1} = f_1 > 0 \,;\ \frac{\partial f}{\partial x_2} = f_2 > 0 \,;\ f_{11} < 0 \,; f_{12} = f_{21} > 0 \text{ and}$$

$$f_{11}\ f_{12} - f_{12}^2 > 0$$

The perceived income of the landowning farmers from rented out land is given by r g(v) where g(v)[7] is the total production of the rented out land. g(v) is assumed to be increasing and concave in v. Thus,

$$\frac{\partial g}{\partial v} = g' > 0 \text{ and } g'' < 0.$$

show that a mixture of rental and wage agreements provides exactly the same outcome as the sharecropping, and they tend to argue that transactions costs, incentive problems or some other imperfections are to be held responsible for sharecropping. If the above result is correct, then our omission of uncertainty from our analysis would not affect the quality of our results.

7 This is a simplifying assumption. One could have in principle adopted a production function with land and labor as its two arguments. However, one economic defense in favor of postulating such a production function is that when the landlord rents out land, the information of labor supply on rented-out land is not available. Moreover, this way of modelling has the added advantage that it allows one to suppress the number of share-tenants to whom the landlord rents out land. Further note that the present way of positing the expected income function has the particular advantage that it can incorporate both the cases of sharecropping and fixed rental. When g is weakly concave, it can represent the case of fixed rental.

The problem of the optimizing farmer can now be stated as follows:

$$\max u(c, \lambda) \text{ subject to } c = f(x_1, x_2) - w\ell_h + rg(v)$$

The farmer maximizes utility with respect to his decision variables l_0, l_h and v and obtains the following necesssary conditions for an interior maximum:

$$(1) \quad \ldots \quad f_1 u_c - u_\lambda = 0$$

$$(2) \quad \ldots \quad f_1 - w = 0$$

$$(3) \quad \ldots - f_2 + rg' = 0$$

from (1) & (2) it follows that

$$(4) \quad \ldots \quad f_1 = \frac{u_\lambda}{u_c} = w$$

The last equality states that in equilibrium the marginal product of labor is equal to the real cost of labor (or leisure) which is equal to the wage rate. Equation (3) implies that the marginal productivity of owner-cultivated land is equal to what the land owner would receive, as his share, if he rented out the marginal unit of his cultivated land. These equilibrium conditions together define the equilibrium values of l_0, l_h and v in terms of the exogenous variables w, r and z.

To analyze the marginal properties of the equilibrium solution, the first order conditions are totally differentiated and the following are obtained:

$$\begin{pmatrix} a + u_c f_{11} & u_c f_{11} & -u_c f_{12} \\ f_{11} & f_{11} & -f_{12} \\ -f_{12} & -f_{12} & f_{22} + rg'' \end{pmatrix} \begin{pmatrix} dl_o \\ dl_h \\ dv \end{pmatrix} =$$

$$\begin{pmatrix} -(u_c f_{12} - mf_2) & ml_h & -mg \\ -f_{12} & 1 & 0 \\ f_{22} & 0 & -g' \end{pmatrix} \begin{pmatrix} dz \\ dw \\ dr \end{pmatrix}$$

$$\text{where } a = \frac{1}{u_c^2}\left(u_{cc}\,u_\lambda^2 - 2u_c\,u_\lambda\,u_{\lambda c} + u_{\lambda\lambda}\,u_c^2\right)$$

$$\text{and } \quad m = \frac{1}{u_c}\left(u_\lambda\,u_{cc} - u_c\,u_{\lambda c}\right)$$

The terms a and m are both negative. They follow from the quasiconcavity of the utility function and the condition of superiority of leisure, respectively. The determinant Δ of the matrix on the left hand side is given by

$$\Delta = \frac{1}{u_c^2}\left(u_{cc}\,u_\lambda^2 - 2u_\lambda\,u_c\,u_{\lambda c} + u_{\lambda\lambda}\,u_c^2\right)\left(f_{11}\,f_{22} - f_{12}^2 + rf_{11}\,g''\right).$$

By putting $b = f_{11} f_{22} - f_{12}^2 + rf_{11} g''$, we get, $\Delta = ab$. The concavity of f- and g- functions ensures that $b > o$, so that $\Delta = ab < o$. We can solve the above matrix of equations by routine calculations and arrive at the following results:

$$\frac{\partial lo}{\partial w} = \frac{ml_h - u_c}{a} > 0\,; \quad \frac{\partial l_h}{\partial w} = \frac{f_{22} + rg''}{b} - \frac{ml_h - u_c}{a} < 0\,;$$

$$\frac{\partial lo}{\partial r} = \frac{-mg}{a} < 0\,; \quad \frac{\partial l_h}{\partial r} = \frac{mg}{a} - \frac{g'\,f_{12}}{b} \lesseqgtr 0\,;$$

$$\frac{\partial lo}{\partial z} = -mbf_2 > 0\,; \quad \frac{\partial l_h}{\partial z} = \frac{mf_2}{a} - \frac{rf_{12}\,g''}{b} > 0\,;$$

$$\frac{\partial v}{\partial z} = \frac{f_{11}\,f_{22} - f_{12}^2}{b} > 0\,; \quad \frac{\partial v}{\partial w} = \frac{f_{12}}{b} > 0\,; \quad \frac{\partial v}{\partial r} = \frac{-g'\,f_{11}}{b} > 0.$$

An increase in the wage rate, ceteris paribus, will induce the owner-farmer to employ more self-labor on his cultivated land and reduce his demand for hired labor. An increase in the rental rate reduces the employment of self labor, but its effect on the demand for hired labor is ambiguous. The total effect consists of two opposite influences. An increase in the rental rate reduces the employment of self-labor so that there tends to be an increase in the demand for hired labor. But an increase in the rental rate also increases the supply of land by the owner-farmer for renting out to the sharecroppers and hence there is a corresponding reduction in the demand for hired labor. This can be clearly seen from the nature of the concerned term,

$$\frac{\partial l_h}{\partial r} = \frac{mg}{a} - \frac{g' f_{12}}{b} = (- \frac{\partial lo}{\partial r}) + \frac{f_{12}}{f_{11}} (\frac{\partial v}{\partial r}).$$

The first term on the rightside of the last equality is the self-labor effect on the demand for labor and is clearly positive. The second term which can be called the land supply effect is negative. Thus the ultimate effect of an increase in the rental rate on the demand for hired labor will depend on the relative strength of these two opposite magnitudes. If the self-labor effect is dominated by the land supply effect, then the demand for hired labor will decrease with an increase in the rental rate and vice versa.

An increase in the total holding of the owner-farmer will increase the employment of both his own-labor and hired labor. The supply of land by the owner-farmer for sharecropping will increase with an increase in any of the three exogenous variables, the wage rate, the rental rate and the total holding of the owner farmer. All these results are intuitively plausible and can easily be explained in economic terms.

Next we turn to the analysis of the behavior of the tenant farmer. The tenant farmer earns all his income by working as a wage laborer on the land owned and operated by the owner-farmer and by working on the land he rents in from the owner-farmer for sharecropping.[8] His total income (and consumption) is then given by,

$$C = (1 - r) F (X_1 , X_2) + wL_h$$

8 We have, for simplicity, assumed here that the tenant does not own any land. This assumption has helped us to avoid the problem often encountered in the real world: a landlord preferring a landed tenant to a landless tenant. This preference is quite rational and can be explained in terms of risk and default of rent on the part of small landless peasants. Another constraint which the landless peasant is likely to encounter in hiring-in land is the ownership of bullocks for cultivation. This constraint was emphasized by Bell (1974).

where $X_1 = L_0$ is the amount of labor he devotes to the sharecropped land X_2 and L_h is the amount of labor expended on the owner operated land at the given wage rate.

The problem of the optimizing sharecropper is then

$$\max\ U(C, \Lambda)\ \text{ subject to }\ C = (1-r)\,F(X_1, X_2) + wL_h$$

where leisure $\Lambda = 1 - L_0 - L_h$. Both the utility function U and production function F have properties similar to those discussed earlier. The landless sharecropper maximizes utility by varying his decision variables L_0 and L_h. The first order conditions are

$$(5)\ \ldots\ (1-r)\,U_c\,F_1 - U_\Lambda = 0$$

$$(6)\ \ldots\ U_c\,w - U_\Lambda = 0$$

from which it follows that

$$(1-f)\,F_1 = \frac{U_\Lambda}{U_c} = w$$

Thus the landless farmer attains equilibrium by equating the wage rate with the real cost of labor and with the amount of increased production that will accrue to him if he provided another unit of labor on the sharecropped land. Totally differentiating the above equations we obtain:

$$\begin{bmatrix} a + (1-r)U_c F_{11} & a \\ a & a \end{bmatrix} \begin{bmatrix} dL_o \\ dL_h \end{bmatrix} =$$

$$\begin{bmatrix} -(1-r)mF_2 - (1-r)U_c F_{12} & mF + U_c F_1 & -mL_h \\ -(1-r)mF_2 & mF & -mL_h - U_c \end{bmatrix} \begin{bmatrix} dX_2 \\ dr \\ dw \end{bmatrix}$$

$$\text{where}\quad a = \frac{1}{U_c^2}\left(U_{cc}\,U^2 - 2U_c\,U_\Lambda\,U_{\Lambda c} + U_{\Lambda\Lambda}\,U_c^2\right) < 0$$

and $$m = \frac{1}{U_c} (U_\Lambda U_{cc} - U_c U_{\Lambda c}) > 0$$

Marginal variations in the endogenous variables around the equilibrium due to small changes in the exogenous variables are given by

$$\frac{\partial L_o}{\partial X_2} = - \frac{F_{12}}{F_{11}} > 0 \; ; \quad \frac{\partial L_h}{\partial X_2} = \frac{F_{12}}{F_{11}} - \frac{(1-r)mF_2}{a} < 0 \; ;$$

$$\frac{\partial L_o}{\partial r} = \frac{F_1}{(1-r)F_{11}} < 0 \; ; \quad \frac{\partial L_h}{\partial r} = \frac{mF}{a} - \frac{F_1}{(1-r)F_{11}} > 0 \; ;$$

$$\frac{\partial L_o}{\partial w} = \frac{1}{(1-r)F_{11}} < 0 \text{ and } \frac{\partial L_h}{\partial w} - \left(- \frac{1}{(1-r)F_{11}} - \frac{U_c}{a}\right) - \frac{mL_h}{a} \gtreqless 0$$

An increase in the availability of land for sharecropping will increase the amount of labor devoted to the sharecropped land and reduce the supply of labor for hire, while an increase in the rental rate r will increase the supply of labor for hire and reduce the amount of labor devoted to sharecropped land. An increase in the wage rate will reduce the amount of labor devoted to sharecropped land, but its effect on the supply of labor for hire is ambiguous. An increase in the wage rate destroys the equalities $w = (1\text{-}r)F_1$ and $w = \frac{U_\Lambda}{U_c}$. The first equality can be restored, ceteris paribus, by a reduction in the application of labor on the sharecropped land, so that there is an unambiguous decrease in Lo. An increase in the wage rate increases the income (consumption) of the tenant-farmer and hence U_c declines. The labor released from the sharecropped land may be allocated either to leisure or to wage labor. The latter will increase consumption and reduce U_c further, while the former will reduce U_Λ. What allocation of time between wage labor and leisure will finally restore the equality will depend on the particular nature of the U- and F- functions. If U_c declines very fast and U diminishes slowly and if F_{11} is large, then an exogenous increase in the wage rate may actually reduce the amount of labor that the landless tenant will be ready to supply for wage. Under these circumstances, we shall get a backward bending supply curve of wage labor.

II

Let us assume that there are n identical owner-farmers and N landless peasants. The general equilibrium conditions can then be stated as:

$$(7) \ldots \quad n \cdot l_h \ (w, r, z) = NL_h \ (w, r, X_2)$$

$$(8) \ldots \quad n \cdot v \ (w, r, z) = N \cdot X_2$$

$$(9) \ldots \quad n \cdot z = K$$

Equation (7) states that in equilibrium the total demand for hired labor by the owner-farmers is equal to the total supply of wage labor by the landless peasants.[9] Equation (8) gives the condition that total supply of land for rent by the owner-farmers is equal to the total demand for it. That the total availability of land is constant is given by equation (9).

The above three equations can determine the equilibrium values for w, z, X_2, given the exogenous values of n,N,r and K. To derive the comparative static properties of the model, equations (7), (8) and (9) are differentiated logarithmically and the following are obtained:

$$(10) \ldots \quad y_1 \hat{w} - y_2 \hat{X}_2 + y_3 \hat{z} = (\hat{N} - \hat{n}) - Y_4 \hat{r}$$

$$(11) \ldots \quad y_5 \hat{w} - \hat{X}_2 + y_6 \hat{z} = (\hat{N} - \hat{n}) - y_7 \hat{r}$$

$$(12) \ldots \quad \hat{z} = -\hat{n} + \hat{K}$$

9 The recently available evidence (for example, Bardhan (1979a) shows that agricultural wage rate (either for casual or permanent laborers) is sensitive to demand and productivity conditions. Based on the above presumption, we venture to equate demand and supply of labor in the determination of equilibrium wage. A similar procedure was followed in Bardhan (1979b) where he equated demand and supply for determining the equilibrium wage. However, his model is a two-period one while the present exercise is essentially a one-period one. The present one-period model can be taken as an approximation of the two-period model. We make this simplification to focus on other aspects of the problem. Such a one-period model, as followed in the present exercise, was also adopted by Rosenszwig (1978) — where he probed the impact of land-reform on the rural wage.

where $\hat{w} = d(\ln w)/dt$, $\hat{z} = d(\ln z)/dt$ etc., and

$$y_1 = e(l_h, w) - e(L_h, w) < 0, \quad y_5 = e(v, w) > 0,$$

$$y_2 = e(L_h, X_2) < 0, \quad y_6 = e(v, z) > 0,$$

$$y_3 = e(l_h, z) > 0, \quad y_7 = e(v, r) > 0,$$

$$y_4 = e(l_h, r) - e(L_h, r) < 0,$$

Further note that elasticity parameters are denoted by e, i.e.,

$e(l_h, w) = \partial(\ln l_h)/\partial(\ln w)$ etc.

Equation (10), (11) & (12) can be solved for $\hat{w}$ and $\hat{X}_2$:

$$\hat{w} = [-(\hat{N} - \hat{n}) + y_4\hat{r} + y_3(\hat{K} - \hat{n}) + y_2\left\{(\hat{N} - \hat{n}) - y_7\hat{r} - y_6(\hat{K} - \hat{n})\right\}]/D$$

$$\hat{X}_2 = [y_1\left\{(\hat{N} - \hat{n}) - y_7\hat{r} - y_6(\hat{K} - \hat{n})\right\} - y_5\left\{(\hat{N} - \hat{n}) - y_4\hat{r} - y_3(\hat{K} - \hat{n})\right\}]/D$$

where $D = -y_1 + y_2y_5 > 0$ by Walrasian stability conditions. Now we can explore the effects of changes in various parameters on the wage rate and the per capita availability of land for sharecropping. We may distinguish the following cases:

Case I : $\hat{n} = \hat{r} = \hat{K} = 0$ and $\hat{N} > 0$

Then,

$$(13) \ldots \quad \hat{w} = [\hat{N}(y_2 - 1)]/D < 0$$

$$(14) \ldots \quad \hat{X}_2 = [\hat{N}(y_1 - y_5)]/D < 0$$

As the size of the landless peasantry increases, ceteris paribus, both the wage level and the per capita availability of land for sharecropping decline over time.

Case I : $\hat{r} = \hat{K} = 0$ and $\hat{n} = \hat{N}$ = a constant.

$$(15) \ldots \quad \hat{w} = [(-y_3 + y_2\,y_6)\hat{n}]/D < 0$$

$$(16) \ldots \quad \hat{X}_2 = [(y_1\,y_6 - y_3\,y_5)\hat{n}]/D < 0$$

In this case where the sizes of both the owner-farmers and the landless peasants are increasing at the same constant rate, the wage rate and the per capita availability of land decline. Irrespective of whether the size of the landed-peasants grows or not, the growth in the population of landless peasants is immiserizing: lower wage and less land for sharecropping.[10]

Case III : $\hat{n} = \hat{N} = \hat{K} = 0$ and $\hat{r} \neq 0$

$$(17) \ldots \quad \hat{w} = [(y_4 - y_2 \; y_7)\,\hat{r}]\,/D \gtreqless 0$$

$$(18) \ldots \quad \hat{X}_2 = [(y_4 \; y_5 - y_1 \; y_7)\hat{r}]\,/D \gtreqless 0$$

The effect of a change in the rental rate on the equilibrium wage rate and the supply of land for sharecropping is ambiguous — it may increase or decrease w and X_2 depending on the relative strength of the countervailing forces involved.

Case IV : $\hat{n} = \hat{N} = r = 0$ and $\hat{K} > 0$

In this case,

$$(19) \ldots \quad \hat{w} = [(y_3 - y_2 \; y_6)\,\hat{K}]\,/D > 0$$

$$(20) \ldots \quad \hat{X}_2 = [(-y_1 \; y_6 + y_3 \; y_5)\hat{K}]\,/D > 0$$

An increase in the total supply of land will induce an unambiguous increase the wage rate and per capita availability of land for sharecropping.

III

We can now analyze the impact of technical progress on the decisions of the optimizing farmers. We shall, in this section, consider the case of land-augmenting technical progress only.[11] The other cases can be analyzed in a similar way without much difficul-

10 With population increase, it is conceivable that the total incidence of sharecropping may decline. The total amount of rented-out land is given by $Q = NX_2$. Then $Q = N + X_2 = n + X_2 = EN + N$ where $E = (y_1y_6 - y_3y_5)/D$; $Q = \hat{N}(E + 1)$. Now one can easily see $Q < O$ if $|E| > 1$. Thus the incidence of sharecropping may decline if the absolute value of E is greater than unity.

ty. The problem of the landowning farmer is

$$\max\ u(c, \lambda)\ \text{ subject to }\ c = f(x_1, x_2) - wl_h + rg(\theta v)$$

where $x_1 = l_0 + l_h$ is the total labor input on the owner-operated effective land units x_2 where $x_2 = \theta(z - v)$. The land-augmenting technical progress is captured in the production functions by the multiplicative parameter θ and is assumed to take place in both the owner-operated and sharecropped land. The necessary conditions for maximization are:

$$\begin{aligned} u_c f_1 - u_\lambda &= 0 \\ f_1 - w &= 0 \\ -f_2 + rg' &= 0 \end{aligned}$$

Introduction of technical progress does not alter the firt-order conditions. The optimizing farmer still equates the marginal product of his labor with the real cost of labor and also with the wage rate. Totally differentiating the above system, holding z, w and r constant, we obtain

$$\begin{pmatrix} f_{11} + a^* & f_{11} & -\theta f_{12} \\ f_{11} & f_{11} & -\theta f_{12} \\ -f_{12} & -f_{12} & -(f_{22} + rg'')\theta \end{pmatrix} \begin{pmatrix} dl_o \\ dl_h \\ dv \end{pmatrix} =$$

$$\begin{pmatrix} -\dfrac{mf_2 z}{u_c} - (z - v) f_{12} \quad d\theta \\ -(z - v) f_{12} \quad d\theta \\ (z - v) f_{22} - vrg'' \quad d\theta \end{pmatrix}$$

11 The evidence shows that in a traditional agriculture (with high population density) the important forms of technical progress tend to be land-augmenting. This is well-documented in Hayami and Ruttan and Ishikawa (1971). The recent technological breakthrough in agriculture in South Asia — often labelled as the Green Revolution — has been largely land-augmenting in nature.

where $a^* = \frac{a}{u_c}$. Routine calculations yield:

$$\frac{\partial l_o}{\partial \theta} = -\frac{mf_2 z}{a} < 0 ; \quad \frac{\partial l_h}{\partial \theta} = \frac{mf_2 z}{a} - \frac{rz f_{12} g''}{b} > 0$$

$$\text{and} \quad \frac{\partial v}{\partial \theta} = -\frac{v}{\theta} + \frac{z(f_{11} f_{22} - f_{12}^2)}{\theta b} \gtreqless 0.$$

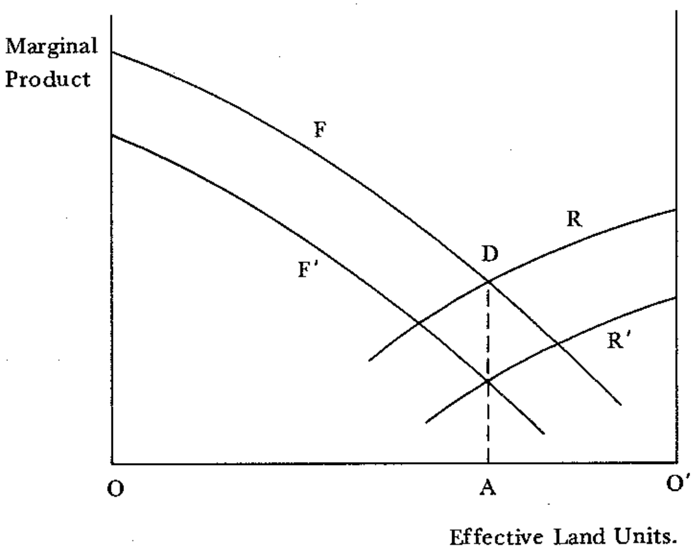
If technical progress takes place only on the owner-operated land, then

$$\frac{\partial v}{\partial \theta} = \frac{z(f_{11} f_{22} - f_{12}^2)}{\theta(f_{11} f_{22} - f_{12}^2) + rf_{11} g''} > 0$$

Thus technical progress in land reduces the supply of self-labor on the owner-cultivated land and increased the demand for wage labor. The impact of technical progress on the supply of

Figure 1

IMPACT OF TECHNICAL PROGRESS ON THE STUDY OF SHARECROPPED LAND



sharecropped land v is ambiguous. This can be explained with the help of the following diagram. 00′ measures the total amount of land z possessed by the owner-farmer. The amount of land cultivated by him is measured along 00′ while the amount of land rented out for sharecropping, v, is measured along 0′0. The marginal product of owner-operated land is shown by the curve F and the perceived share of the marginal product of sharecropped land is shown by the curve R. Their intersection point D gives the optimum distribution of land between the owner and the sharecroppers. The owner operates OA(= z - v) amount of land and sharecrops out O'A(= v) amount of land. The onset of technical progress in land shifts the marginal product curves downward to F' & R' (since $\frac{\partial f_2}{\partial \theta} < 0$; $\frac{\partial rg'}{\partial \theta} < 0$). Whether there will be any red istribution of land depends on where the two curves intersect: if they intersect at a point to the left of DA, the supply of land for sharecropping, v, will increase and it will decrease if the new intersection point is on the right side of DA. There will be no change in the distribution of F' and R' intersect at a point vertically below D as shown in the figure. It can be seen that there is an unambiguous increase in the supply of land for sharecropping if technical progress takes place only on the owner operated land.

The response of the tenant farmer to technical progress can be analyzed in a similar fashion. He maximizes his utility $U(C,\Lambda)$ subject to the income constraint $C = (1 - r) F(X_1, X_2^*) + wL_h$ where $X_1 = L_0$ is the amount of labor he devotes to the (effective) supply sharecropped land, $X_2^* = \theta X_2$. Equilibrium is attained when

$$(1 - r)\ F_1\ U_c - U_\Lambda = 0$$

$$wU_c - U_\Lambda = 0$$

In this case too, the necessary conditions are not altered by the introduction of technical progress. On total differentiation of the above, holding r, w and X_2 constant, we get,

$$\begin{bmatrix} a + (1 - r) U_c F_{11} & a \\ a & a \end{bmatrix} \begin{bmatrix} dL_o \\ dL_h \end{bmatrix} = \begin{bmatrix} \{- (1 - r) m X_2 F_2 - (1 - r) X_2 U_c F_{12}\} \\ \{- (1 - r) m X_2 F_2\} \end{bmatrix}$$

The tenant farmer's reaction to technical progress is then given by

$$\frac{\partial L_o}{\partial \theta} = -\frac{X_2\ F_{12}}{F_{11}} > 0 \text{ and } \frac{\partial l_h}{\partial \theta} = \frac{X_2\ F_{12}}{F_{11}} - \frac{(1-r)mX_2\ F_2}{a} < 0$$

Thus, we see that land-augmenting technical progress increases the amount of labor that the tenant-farmer expends on the sharecropped land and reduces his supply of labor for hire.

IV

We shall now investigate the impact of technical progress on the equilibrium wage rate and the per capita availability of land for sharecropping. With the introduction of technical progress the equilibrium equations (7), (8) & (9) become:

$$(21) \ldots \quad nl_h(w, r, z, \theta) = NL_h(w, r, X_2)$$

$$(22) \ldots \quad nv(w, r, z, \theta) = NX_2$$

$$(23) \ldots \quad nz = K$$

Assuming r and k do not change and logarithmically differentiating the above equations, we get,

$$(24) \ldots \quad y_1 \hat{w} - y_2 \hat{X}_2 + y_3 \hat{z} = (\hat{N} - \hat{n}) + y_8 \hat{\theta}$$

$$(25) \ldots \quad y_5 \hat{w} - \hat{X}_2 + y_6 \hat{z} = (\hat{N} - \hat{n}) - y_9 \hat{\theta}$$

$$(26) \ldots \quad \hat{z} = -\hat{n}$$

where $y_8 = e(L_h, \theta) - e(l_h, \theta) < 0$,

and $y_9 = e(v, \theta) > 0$,

Solving the system of equations (16), (17) & (18), we obtain the following:

$$\hat{w} = [(\hat{N} - \hat{n}) + y_8 \hat{\theta} + y_3 \hat{n} + y_2 \ \{(\hat{N} - \hat{n}) - y_9 \hat{\theta} + y_6 \hat{n}\}]/D$$

$$\hat{X}_2 = [y_1 \ \{(\hat{N} - \hat{n}) - y_9 \hat{\theta} + y_6 \hat{n}\} - y_5 \ \{(\hat{N} - \hat{n}) + y_8 \hat{\theta} + y_3 \hat{n}\}]/D$$

To focus sharply on the impact of technical progress, let us assume $n = N = o$ and $\hat{\theta} > o$. Then,

$$(27) \ldots \quad w = [-(y_8 + y_2 \; y_9)] \; \hat{\theta}/D > 0$$

$$(28) \ldots \quad X_2 = [-(y_5 \; y_8 + y_1 \; y_9)] \; \hat{\theta}/D > 0$$

If there is land-augmenting technical progress and no population growth, both the wage rate and the per capita availability of land for sharecropping will increase over time. This result seems to be corroborated by the Indian experience. The region which has experienced a greater technical progress has a higher wage rate and a greater incidence of sharecropping. Bardhan (1979a) also arrived at the same set of results although he used a different model.

To see how the above results are modified if population grows along with technical progress, let us set

$$\hat{n} = \hat{N} = \text{a constant and } \hat{\theta} > 0$$

For the sake of simplicity, we assume that the rates of growth of both the classes of peasants are the same.

From equations (16), (17) & (18) one can derive:

$$(29) \ldots \quad \hat{w} = [(-y_3 + y_2 \; y_6)\hat{n} - (y_8 + y_2 \; y_9)\,\hat{\theta}]\,/D$$

$$(30) \ldots \quad \hat{X}_2 = [(y_1 \; y_6 - y_3 \; y_5)\hat{n} - (y_5 \; y_8 + y_1 \; y_9)\,\hat{\theta}]\,/D$$

Using equations (15), (16), (27) and (28), we can write equations (29), (30) as:

$$(31) \ldots \quad \hat{w} = e(w, n)\hat{n} + e(w, \theta)\hat{\theta}$$

$$(32) \ldots \quad \hat{X}_2 = e(X_2, n)\hat{n} + e(X_2, \theta)\hat{\theta}$$

where $e(w, n) = \partial(1nw)\,\partial 1nn$, etc. Since $e(w, n) < 0$ and $e(w, \theta) > 0$ $\hat{w}$ may be positive or negative depending on the various parameters involved in (31). A low rate of growth of population and a high rate of technical progress may render $\hat{w}$ positive. The same will be the case if the elasticity of the wage rate with respect to population growth is absolutely smaller than the elasticity of wage rate with respect to the rate of technical progress. We already know that $e(X_2, n) < 0$ & $e(X_2, \theta) > 0$. Thus X_2 may be positive if the rate of growth of population is low and the the rate of technical progress is high; or if the elasticity of X_2 with respect to n is absolutely smaller than the elasticity of X_2 with respect to θ.

V. Empirical Evidence:

The model presented above seems to eliminate the seeming 'paradox' posed by Bardhan (1979a). On the basis of interregional cross-section data, he finds a singificant positive relationship between the land improvement factor and the extent of sharetenancy — the higher the extent of irrigated areas, the higher the incidence of sharetenancy. The positive association was also confirmed in other contexts as well. Bardhan reports that they checked from National Sample Survey inter-state landholdings data for 1960-61 that the correlation between the percentage of area under sharetenancy and that under irrigation is 0.638 and for 1970-71 data it is 0.663. On the other hand, the intertemporal evidence in Indian agriculture seems to suggest a decline in the extent of area under sharecropping. The precise position is summarized in Table 1 below:

Table 1

CHANGE IN THE EXTENT OF AREA UNDER SHARECROPPING OVER TIME IN INDIA

Year	Percent of total area under sharecropping
1954-55	20.34
1960-61	12.53
1961-62	10.70
1970-71	10.57

Source: N.S.S. cited in Narain and Joshi (1969).

So far as the wage rate is concerned, the Indian regions with higher technical progress seems to have experienced higher real wage growth[12] whereas the regions experiencing lower technical progress seem to have suffered a decline. This can be seen from the data compiled by Herdt and Baker (1972). The Punjab region which had one of the highest rate of technical progress (as indicated by the percent of total land under irrigation) experienced a rise in the daily real wage from Rs. 2.81 in 1954-55 to Rs. 3.43 in 1968-69. The same thing happend in the case of Madras. On the other hand, the real wage rate declined in Bihar/West Bengal region from Rs. 2.40 in 1954-55 to Rs. 1.79 in 1966-67 (data for 1968-69 could not be reported by Herdt and Baker due to nonavailability). The same thing happened for other areas experiencing low technical progress - like Assam/Tripura, Mysore/Andhra Pradesh etc.

Similar pattern can be detected in the case of Bangladesh, too. Cross-section data for 1978-79 as presented in the Table in the Appendix reveals a very high positive correlation of 0.755 between

Table 2

MOVEMENT OF AGRICULTURAL REAL WAGE OVER TIME IN BANGLADESH

Period	Real Wage Rate Taka per day
1959-63	2.34
1964-68	2.15
1969-73	1.91
1974	1.42
1975	1.28

Source: Islam, R. (14).

12 That the 'green revolution' has increased the demand for labor seems to be shared even by the skeptics who doubt its potential as an instrument for agricultural development. See, for example, Hossain (1981) and Lefeber (1973). However, this is not to suggest that the output elasticity of demand for labor under new technology is very high. For example, a government report of Bangladesh states, "The annual rate of growth in labor demand resulting from the Green Revolution package ..... has been only 1.4 per cent, for a year to year growth rate of rice production of 2.8 perent over 15 years (1960-61 to 1975-76)" (Government of Bangladesh, Country Report on *Agrarian Reform and Rural Development*, prepared for WEARRE, 1979, Ministry of Agriculture and Forests, pp. 150-51.)

technical progress (measured by the percentage of total area under irrigation) and wage rate. However, the time series data as summarized in Table 2 shows a clear decline in the real wage rate. An elaborate discussion on this data and results can be found in Islam (1981).

All the empirical evidences presented above are quite consistent with the predictions of our model. Agricultural wage rate of the technically better-off region tends to be higher than that of the worse-off region although there is a tendency of secular decline in the real wage. This apparent contradiction of findings from time series and cross section data can easily be explained in terms of population growth, which has been ignored in most studies so far. The foregoing results clearly show that the immiserization of the landless peasants and sharetenants so often mentioned in the literature is not owing wholely to the nature of technical progress as many would have us believe, but to a great extent to the rapid growth of population which characterizes most of the South Asian countries.[13] Only by increasing the pace of technical progress and/or reducing the rate of growth of population can the process of immiserization of the peasantry be brought to a halt.

VI. Conclusion

In the present exercise, the question of impact of technical progress and population growth on income distribution in a traditional peasant economy has been explored. The problem was posed within the context of a general equilibrium model in which there are two classes of peasants — the landed and the landless. Their optimizing behavior follows the postulate of utility maximization, as adopted by many including Bardhan & Srinivasan (1971). The landed peasants are assumed to be monopolists in the land lease market but not so in the labor market, where the wage level is competitively determined. Further, like most overpopulated countries, there is a land constraint operating in the economy. Given these specifications of the model, the following

13 Lipton (1978) seems to have a different — somewhat noneconomic — explanation for this immiserization process. He thinks that technical progress in general benefits the small farmer, but it is the political system that makes the bigger farmer better off, and the smaller one worse-off.

conclusions, among others, emerge:

a. The equilibrium wage rate and the per capita availability of land for sharecropping will, ceteris paribus, increase with technical progress and decline with population growth.
b. If the economy is experiencing technical progress and population growth simultaneously, the wage level and per capita availability of land for sharecropping may either increase or decrease depending on the strength of the countervailing forces involved. If the population is growing rapidly and the rate of technical progress is low, a phenomenon quite common in South Asian economies, there emerges the possibility of immiserization of the landless peasantry on both counts: a lower wage and a reduced supply of land for sharecropping.

The above analysis has helped to identify many important parameters that shape and condition income distribution in a peasant economy. Though we have used a simple genereal equilibrium model, we believe we have succeeded in stressing some important aspects of reality and explaining some important facts of it.

Appendix Table

INTER-DISTRICT AGRICULTURAL WAGE RATE AND AREA UNDER IRRIGATION IN BANGLADESH

Name of District	Wage Rate Taka Per Day (Without Food)	Percent of Total Area Under Irrigation
Dacca	10.8	0.23
Mymensingh	11.83	0.16
Tangail	9.88	0.17
Faridpur	10.92	0.06
Chittagong	13.08	0.38
Noakhali	11.80	0.15
Comilla	12.42	0.24
Sylhet	12.50	0.36
Rajshahi	9.42	0.15
Dinajpur	10.00	0.11
Rangpur	9.58	0.10
Pabna	10.58	0.07
Khulna	9.08	0.07
Bakerganj	11.33	0.13
Patuakhali	9.33	0.08
Jessore	9.64	0.10

Source: The Yearbook of Agricultural Statistics of Bangladesh 1979-80, Bangladesh Bureau of Statistics.

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