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# An analysis of population growth, Green Revolution and terms of trade in the presence of cropsharing in agriculture

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## Abstract

This explores the welfare effects of some persistent trends in some developing countries on different groups of farmers. It takes a general equilibrium approach in modelling a representative developing economy comprising a manufacturing sector and an agricultural sector where both self-cultivating landlords and tenants carry on production. It is shown that while population growth tends to depress welfare of both the tenant and the landlord, Green Revolution has the opposite effect such that when both trends are present, peasants may or may not be better off. An adverse movement in the agricultural terms of trade reduces welfare of the landlord, but the tenant is made better off.

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## 1. Introduction

In recent decades, many developing countries like Bangladesh have experienced two persistent trends. The first is a rapid increase in population and the second is the spread of HYV technology, also popularly known as the Green Revolution, in agriculture.<sup>1</sup> Since non-agricultural sectors of some of these countries have not expanded sufficiently rapidly to keep pace with population growth, much of the increase in population had to be accommodated in agriculture. The total availability of arable land being constant in many cases, such an increase in population has meant a sharp fall in the land–man ratio in agriculture.

Farm households which had previously rented out a part of their land to tenants have been forced to reduce the amount of land rented out in order to accommodate a rising family population. Thus an increase in population could not only have depressed the living standard of the self-cultivating households, it could also have had an adverse effect on the welfare of tenants through a reduction in the supply of rental land. This tendency toward pauperization and marginalisation of a large section of the cultivating population was (perhaps partially) offset by the spread of the Green Revolution technology. The latter substantially increases the demand for labour by requiring more intensive use of labour in individual crop production and also permitting a more intensive use of land through multiple cropping. The yearly yield of farm land, therefore, rises which might prevent a fall in living

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<sup>1</sup> HYV stands for High Yield Variety.

Table 1  
Some trends in Bangladesh Economy

Year	Population <sup>a</sup> (million)	Net sown area (million acres)	Cropping intensity	Total use of chemical fertilizer (million metric tonnes)	Proportion of rice and wheat area under HYV crops (%)	Proportion of net sown area under irrigation (%)	Yield of rice crops (lb per acre)	Agricultural terms of trade (1969–70 = 100)	Share of manufacturing in GDP (%)
1969–70	67.32	21.76	1.51	0.28	2.76	3.8	1003	100.00	9.3
1972–73	72.4	20.97	1.42	0.38	11.10	12.3	953	77.55	6.4
1976–77	80.82	20.45	1.48	0.51	14.2	16.9	1102	88.78	10.3
1980–81	88.68	20.87	1.54	0.74	25.4	18.6	1119	84.30	10.6
1984–85	96.73	21.34	1.54	1.43	31.5	19.7	1227	103.40	10.0
1988–89	104.53	20.56	1.68	1.69	38.7	32.9	1354	113.53	8.4
1990–91	108.53	20.45	1.72	2.04	44.1	35.5	1544	101.50	9.8

<sup>a</sup> Estimated population as of 1st July.

lb, pound = 0.4536 kg (def); acre = 0.4047 ha; lb/acre = 1.121 kg/ha.

metric tonne = 1000 kg.

Source: Bangladesh Bureau of Statistics, *Statistical Yearbook*, various issues.

Table 2  
Farm size in Bangladesh over time

Average farm size (acres):	1960	1978	1883–84
Self-cultivating landowners	3.12	2.36	2.13
Owner tenants	4.26	3.53	2.58
Landless tenants	2.42	1.34	0.91
All farmers	3.54	2.62	2.27
Per cent of cultivated land rented		22.34	18.77

Source: Bangladesh Bureau of Statistics, *Yearbook of Agricultural Statistics*, various issues.

standard of farm households (or at least, as large a fall as) implied by the rapid increase in population.

Table 1 shows trends in some relevant variables in a densely populated developing country, viz. Bangladesh. The population of the country increased by nearly 50% since it became independent in December 1971. But the net sown area in agriculture has remained virtually constant indicating that all arable land is already under cultivation and there is little hope of increasing the scale of farming in the country. The pressure to accommodate a rapidly rising population has resulted in a more intensive use of the land. The cropping intensity has risen markedly – by nearly 20% – in the last two decades. In order to employ more people and extract more out of the land to feed extra mouths, farmers have steadily substituted local crops for HYV crops. While less than 3% of the total rice and wheat area was under HYV crops just before the independence of the country, the figures for more recent years stand at about 40%. Consumption of chemical fertilizer increased by more than 7 times during the same period. As a result of the spread of the HYV technology, the average yield of rice crops increased by about 50% during the last two decades. The increase in population and the labour force have also led to a reduction in the availability of land per household. As shown in Table 2, the average farm size was 3.54 acres ( $\approx 1.4$  ha) in 1960, but fell to 2.27 acres by 1983–84. The farm size of self-cultivating landowners fell from 3.12 to 2.13 acres and that of owner tenants, i.e. tenants who also own some land, fell from 4.26 to 2.58 acres during the same

period. The plight of the landless tenants is grim. While they farmed 2.42 acres in 1960, their farm size fell to a pitiful 0.91 acres by 1983–84. The decline was caused by both an increase in the number of tenant households and a reduction in the supply of rental land (at least partly) due to an increase in the population of self-cultivating landowners. As shown in Table 3, the number of owner tenant households increased by more than 50% and landless tenant household by 37% between 1960 and 1983–84. This fact alone would have reduced the farm size of these groups of households substantially.<sup>2</sup> The situation was exacerbated by an even larger increase, more than two-thirds, in the number of self-cultivating landowners. In 1978, more than 22% of the total cultivated land was rented out (or in), but by 1983–84 this fell to less than 19%. The emerging shortage of supply of rental land might have contributed to a decline in the welfare of tenants.

This paper attempts a theoretical analysis of the effects of these trends in agriculture on some variables including the welfare of self-cultivating landowners and share tenants. In contrast to most studies in the area, it takes a general equilibrium approach in order to capture inter-sectoral as well as intra-sectoral effects.<sup>3</sup> The economy we consider comprises an urban manufacturing sector where production is undertaken with wage labour, and an agricultural sector where production is carried on by both self-cultivating landowners who rent out part of their land to others (hence also referred to as landlords) and share tenants. The production technology of the landlord need not be different from that of the tenant, although the possibility is not ruled out. One of the oft-cited arguments for the alleged difference is that the landlord, who supposedly has a better access to information, market and credit facilities, would adopt modern cultivation practices, but the poverty-ridden tenant will be unable to do so. However, recent evidence seems to contradict such a notion. Hossain (1988) found

<sup>2</sup> See also Taslim, 1993, pp. 366–368.

<sup>3</sup> Such an attempt was first made by Lahiri, 1989.

Table 3  
Number and operated area of households

Year	Number of Households ('000s)			Operated area of households (1000 acres)		
	Self-cultivating landowners	Owner tenants	Landless tenants	Self-cultivating landowners	Owner tenants	Landless tenants
1960	3731	2380	100	11654	9830	242
1983	6239	3593	137	13266	9284	124

Source: Bangladesh Bureau of Statistics, *Yearbook of Agricultural Statistics*, various issues.

tenants adopting high yield technology at about the same rate as the landlords. When tenants have equal access to technology, any difference in the choice of technology is likely to be a product of the optimisation process rather than an exogenously specified restriction. Hence, the model below does not require the production technology of the two groups of farmers to be necessarily different.

A distinguishing feature of the model is that hired labour has to be supervised to ensure the delivery of full effort. Therefore, anyone employing substantial amount of wage labour must suffer some supervision costs in addition to the normal wage cost. This aspect of wage employment is well-known in the literature (see Quibria and Rashid, 1986). Indeed, there is an increasing appreciation that the problem of control of wage labour provides an impetus to seeking cropsharing contracts (see Taslim, 1989). If there were no shirking problems, cropsharing would not be adopted at all as it would be everywhere dominated by wage cultivation (Bell and Braverman, 1980) and also fixed renting (Taslim, 1986).

## 2. Model

The economy we consider in this paper comprises two sectors: the urban manufacturing sector, and a rural agricultural sector. The production of the manufacturing good,  $X_m$ , is undertaken by a representative capitalist with a given stock of capital,  $C$ , and hired labour. The agricultural output,  $X_a$ , is produced by a representative landowner and a share tenant with a given supply of land,  $H$ , and labour. Agriculture production is assumed not to require any capital and manufac-

turing does not use land. All land is owned by the landowner who retains part of the land for self-cultivation with the help of hired labour and leases out the rest to the share tenant at an exogenously specified share rate,  $r$ .<sup>4</sup> The tenant accepts whatever land the landlord wishes to rent out, and farms the rental land with primarily family labour. The bulk of the labour hired by the urban and rural producers is provided by a class of landless workers who neither own any non-labour means of production, nor the know how to engage in production independently. The total supply of labour of the tenant and the landless workers is assumed to be constant at  $L$ .

We assume that both the industrial and the agricultural production functions are linear homogeneous:  $X_m = L_m f_m(c_m)$  and  $X_i = L_i f_i(\alpha h_i)$ , where  $c_m = C/L_m$  and  $h_i = H_i/L_i$ . The subscripts  $m$  and  $i = o, s$  identify variables pertaining to the manufacturer, landowner and share tenant, respectively, and  $\alpha$  is an index that measures the spread of land-augmenting technical progress or Green Revolution. Without any loss of generality the initial value of  $\alpha$  is set to unity.

The price of the manufactured good,  $p_m$ , and that of the agricultural good,  $p_a$ , are assumed to be constant.<sup>5</sup> The total product of the economy,  $Q$ , is given by  $Q = p_m X_m + p_a X_a = p_m X_m + p_a X_o + p_a X_s$ . All factors of production are assumed to be fully employed.<sup>6</sup> Hence,  $L = L_m + L_o + L_s$ ,  $H = H_o + H_s = L_o h_o + L_s h_s$  and  $C = c_m L_m$ . Fol-

<sup>4</sup> For the sake of simplicity we ignore the possibility that  $r$  may be determined by market interactions.

<sup>5</sup> This may be achieved by assuming that the prices are determined in the world market.

lowing neoclassical analysis, the agents are assumed to maximise profit or income. The income of the manufacturer is the difference between the value of the manufactured output and the cost of employing labour. As foreshadowed earlier, the hired labourers do not deliver full effort unless carefully monitored. The employment of labour, therefore, requires the incurrence of some monitoring or supervision cost,  $S$ . This cost is taken to be proportional to the wage cost:  $S = swL_m$ , where  $s$  is the factor of proportionality. The income of the capitalist can be expressed as:  $y_m = p_m L_m f_m(c_m) - \lambda w L_m$ ;  $w$  is the competitively determined wage rate, and  $\lambda = (1 + s)$ . The capitalist maximises profit income with respect to the only decision variable,  $L_m$ . The necessary condition for such maximisation is:

$$p_m(f_m - c_m f'_m) - \lambda w = 0$$

Throughout, a prime denotes the first derivatives of the production functions and a double prime denotes the second derivatives. The above equation is the familiar profit-maximising condition that the marginal product of hired labour must be equal to the cost of employing them.

The total income of the cultivating landlord,  $y_o$ , consists of two types of income: income from self-cultivation, and the share of the income of the tenant. The landlord cultivates the land with only hired labour and hence, suffers from supervision problems of the same severity as that suffered by the capitalist. The income of the landlord is, therefore, given by:  $y_o = p_a L_o f_o(h_o) - \lambda w L_o + p_a(1 - r)L_s f_s(h_s)$ . The first-order conditions for maximisation are:

$$p_a(f_o - h_o f'_o) - \lambda w = 0$$

$$f'_o - (1 - r)f'_s = 0$$

The marginal product of hired labour is set equal to the per unit supervision and wage cost, and the marginal product of the retained land is equalised with the landlord's share of the marginal product of the rented land.

The tenant's net income from cropsharing is  $p_a r L_s f_s(h_s) - w L_s$ , and his total income from

both cropsharing and wage labour is  $y_s = p_a r X_s + w(L_s^* - L_s)$ , where  $L_s^*$  is the total labour supply of the tenant. Such an income function implies that the tenant imputes the market wage rate to his labour expended on the rental land. This could be justified on the ground that otherwise the tenant could have employed this labour in the market to earn the going wage rate  $w$ . The important difference between the income function of the tenant and that of the capitalist and the landlord is that the tenant does not incur any monitoring problems since he relies primarily on own labour for farming. This is crucial for the analysis below as it provides the *raison d'être* for the existence of cropsharing alongside wage cultivation. The tenant maximises income with respect to the only decision variable,  $L_s$ .<sup>7</sup> The necessary condition is:

$$r p_a(f_s - h_s f'_s) - w = 0$$

The tenant employs only so much labour on the rental land as would equate his share of the marginal value product of labour to the market wage rate. This equation embodies the Marshallian inefficiency argument that a share tenant would not voluntarily supply labour on the rental land to the point that equates the marginal value product of labour with the wage rate, a situation that would prevail under pure wage cultivation,

The total income of the economy,  $Y$ , is defined as the sum of the earnings of all individuals:  $Y = y_m + y_o + y_s + wL = p_m X_m + p_a X_a - sw(L_m + L_o) = Q - sw(L_m + L_o)$ . Note that the income of the economy is less than the value of the total product. This is so because part of the output is used up in monitoring the wage labourers and, hence, not available as income to any of the individuals.

### 3. Growth in labour supply

The consequences of an increase in the supply of labour of the economy due to say, population

<sup>6</sup> An alternative assumption would be the existence of Harris-Todaro-type unemployment (see Lahiri, 1989).

<sup>7</sup> Given the fixed supply of labour ( $L_s^*$ ), the amount employed in the wage market is uniquely determined by the choice of  $L_s$ .

growth, are analysed below. There is a widespread belief that population growth is immiserizing. The analysis below shows that such growth is immiserizing only when the tenant farm is more land-intensive than the landlord farm. Differentiating the first-order conditions with respect to  $L$  and solving, we find:  $dw/dL = dc_m/dL = dh_o/dL = dh_s/dL = 0$ . It is interesting that an increase in labour endowment affects neither the wage rate nor the capital-labour and land-labour ratios.<sup>8</sup> Since the capital stock is fixed and the marginal product of labour in manufacturing is uniquely related to the capital-labour ratio, an increase in labour supply does not alter the level of employment in the manufacturing sector, i.e.

$$\frac{dL_m}{dL} = 0$$

However, the effects of labour growth on employment on the landlord and the tenant farms are not the same. Differentiating the factor endowments conditions with respect to  $L$  and using the results above we can show that:

$$\frac{dL_o}{dL} = -\frac{h_s}{h_o - h_s}$$

and

$$\frac{dL_s}{dL} = \frac{h_o}{h_o - h_s}$$

Whether the growth in labour force will increase employment in the tenant or the landlord farm depends crucially on the land-labour ratios of the two farms. If  $h_o < h_s$ , employment will increase in the landlord farm and decline in the tenant farm. There is considerable evidence to suggest that share tenants cultivate land less intensively than owners implying that the land-labour ratio would be higher for tenant than landlord farms – see, for example, Bell (1977) and Hossain (1988). Henceforth, we shall assume this to be the case. Utilizing the results above we find that the landlord retains more land for self-cultivation:

$$\frac{dH_o}{dL} = -\frac{h_o h_s}{h_o - h_s} > 0$$

<sup>8</sup> See below for an explanation of this counter-intuitive test.

and consequently the tenant has less land to farm:

$$\frac{dH_s}{dL} = \frac{h_o h_s}{h_o - h_s} = -\frac{dH_o}{dL} < 0$$

Since the landlord now employs more of both labour and land on his farm, his output must increase:

$$\frac{dX_o}{dL} = -\frac{f_o h_s}{h_o - h_s} > 0$$

The reverse is true of the tenant farm:

$$\frac{dX_s}{dL} = \frac{f_s h_o}{h_o - h_s} < 0$$

The change in total agricultural output is the sum of these changes:

$$\frac{dX_a}{dL} = \frac{f_s h_o - f_o h_s}{h_o - h_s} = \frac{h_o h_s}{h_o - h_s} (q_s - q_o)$$

Given the assumption that the tenant farm is more land-intensive, we must have:  $q_s < q_o$  if both the tenant and landlord have access to the same technology of production.<sup>9</sup> In this case,  $dX_a/dL > 0$ ; the total agricultural output expands as a result of an increase in the labour supply. But this increase in output does not make the tenant or the landlord better off. Differentiating the income equations we find:

$$\frac{dy_o}{dL} = \frac{p_a h_o h_s}{h_o - h_s} (q_s - f'_o)$$

and

$$\frac{dy_s}{dL} = \frac{p_a r h_o h_s f'_s}{h_o - h_s}$$

We have  $q_s > f'_s$  and  $(1-r)f'_s = f'_o$ . Therefore,  $(1-r)q_s > f'_o$  and consequently the income of the landlord decreases with an expansion of the

<sup>9</sup> Since by assumption  $h_o < h_s$ , we must have:  $l_o > l_s$ , where  $l_o = 1/h_o$  and  $l_s = 1/h_s$ . Now  $q_o = X_o/H_o = F_o(L_o/H_o, 1) = g_o(l_o)$  and  $q_s = X_s/H_s = F_s(L_s/H_s, 1) = g_s(l_s)$ . Since  $F_o$  and  $F_s$  are linearly homogeneous,  $g'_o, g'_s > 0$ . If  $F_o$  and  $F_s$  are the same production function,  $l_o > l_s$  implies  $g_o(l_o) > g_s(l_s)$ , i.e.  $q_o > q_s$ . There is considerable empirical evidence to support this result – see Bell (1977) and Hossain (1988).

labour force. The income of the tenant also declines. Thus, although the total agricultural product increases, both the landlord and the tenant are made worse off. The reason for this result is that the high-cost landlord farm suffering from supervision problems expands at the expense of the low cost tenant farm such that a greater part of the agricultural output is now wasted on supervision. Since the wage rate is constant, the income of the capitalist remains constant, but the total wage earnings increase. Hence, the national income will increase only if the increase in total wage earnings is greater than the reduction in the incomes of the landlord and the tenant. But note that even when this is true and total income rises, no individual is made better off. The incomes of the capitalist and the individual wage labourer are constant, but the incomes of the landlord and the tenant are lower. Since no individual is made better off but some are worse off, it may be said that the increase in labour supply is immiserizing.

The intuitive explanation of these results is that an increase in labour supply *initially* tends to reduce the wage rate. This encourages the landlord farm to expand its scale of operation by reducing the amount of land leased out to the tenant. Since the tenant farm is more land-intensive, a contraction in its scale of operation releases relatively more land than labour. On the other hand the expansion of the landlord farm, which is labour-intensive, permits the employment of more labour on the redeemed land than is released by the contracting tenant farm. There is thus a net increase in the demand for labour. This puts an upward pressure on the wage rate that counteracts the initial decrease in the wage rate. The landlord farm expands (and the tenant farm contracts) until it reaches a scale sufficient to absorb not only the labour released from the tenant farm but also the entire increase in the total labour supply. When this happens the wage rate has been pushed back to its original level and the land–labour ratios are the same as before. Since the wage rate ultimately does not change, employment and output in the manufacturing sector remain unaltered.

One might wonder why the landlord should increase the scale of his operation if this were to

ultimately reduce his income. When the wage rate initially falls in response to an increase in the labour supply, the landlord redeems land from the tenant and farms it himself in order to increase his income. As explained above, this very action raises the demand for labour sufficiently such that the wage rate is ultimately pushed back to its original level. When all the adjustments are over and the economy settles to a new equilibrium, the landlord is worse off. But he cannot avoid suffering this loss; if he were to reduce the size of his farm now, his income would be even lower. Hence, we get this paradoxical result that the very drive of the landlord to increase income ultimately leads to a reduction in income.

#### 4. Green Revolution

In analysing the impact of the Green Revolution technology it should be borne in mind that the  $f_i$  functions are now functions of effective land–labour ratios  $\alpha h_i$ . Profit maximisation by the landlord and the tenant now implies:

$$p_a(f_o - \alpha h_o f'_o) - \lambda w = 0$$

$$f'_o - (1 - r)f'_s = 0$$

$$rp_a(f_s - \alpha h_s f'_s) = 0$$

where  $f'_i = df_i/d\alpha h_i$ . All other equations of the model remain unchanged. Differentiating the equations above with respect to  $\alpha$  and solving we get:  $dw/d\alpha = 0$ . The wage rate is not affected by a land-augmenting technical progress. Since the capital–labour ratio in the manufacturing sector is uniquely related to the wage rate, a constant wage rate implies a constant capital–labour ratio in this sector, and a constant capital–labour ratio in turn implies a constant level of employment of labour in manufacturing:

$$\frac{dc_m}{d\alpha} = \frac{dL_m}{d\alpha} = 0$$

The wage rate is also uniquely related to the effective land–labour ratios in agriculture. Hence, the effective land–labour ratios do not change. But an unchanged effective land–labour ratio implies a fall in the actual land–labour ratio;



$dh_o/d\alpha = -h_o/\alpha < 0$  and  $dh_s/d\alpha = -h_s/\alpha < 0$ . The actual land-labour ratios decrease in the same proportion as the technical progress parameter increases. We also have:

$$\frac{dL_o}{d\alpha} = \frac{H}{\alpha(h_o - h_s)} < 0$$

and

$$\frac{dL_s}{d\alpha} = -\frac{H}{\alpha(h_o - h_s)} = -\frac{dL_o}{d\alpha} > 0$$

The employment of labour decreases on the landlord farm and increases on the tenant farm by the same amount. The landlord also reduces the amount of land retained for self-cultivation:

$$\frac{dH_o}{d\alpha} = h_o \frac{dL_o}{d\alpha} + L_o \frac{dh_o}{d\alpha} < 0$$

and rents out more land:

$$\frac{dH_s}{d\alpha} = -\frac{dH_o}{d\alpha} > 0$$

The tenant now has more land and employs more labour. His output, therefore, must increase. On the other hand, the output of the landlord declines:

$$\frac{dX_o}{d\alpha} = \frac{Hf_o}{\alpha(h_o - h_s)} < 0$$

$$\frac{dX_s}{d\alpha} = -\frac{Hf_s}{\alpha(h_o - h_s)} > 0$$

To find the impact of land-augmenting technical progress on the incomes of various groups, differentiate relevant income functions with respect to  $\alpha$  and solve,  $dy_m/d\alpha = 0$ :

$$\frac{dy_o}{d\alpha} = \frac{(1-r)p_a H h_s}{\alpha(h_o - h_s)} (f'_s - q_s) > 0$$

and

$$\frac{dy_s}{d\alpha} = \frac{rp_a h_o h_s f'_s}{\alpha(h_o - h_s)} (L_o + L_s) > 0$$

The income of the capitalist is not affected by the onset of technical progress in agriculture. Since  $f'_s < q_s$ , the income of the landlord increases as does the income of the tenant. The wage rate

being fixed, the wage earnings, and hence, the welfare of the hired labourers, remain constant. Total income of the community, therefore, increases unambiguously.

## 5. Terms of trade

It is noteworthy that none of the events described above affects the manufacturing sector. The reason for this is that these events do not impinge on any of the parameters of the sector. Both the capital stock in manufacturing and the prices of goods and labour are constant. Since the capital-labour ratio is uniquely related to the real wage rate, it also remains constant. This implies that employment in manufacturing is also unchanged. Unless one or more of these parameters change, the industrial sector will remain unaffected by what goes on elsewhere. To appreciate this better, let us now consider what happens if the price of the manufactured good rises due to say an increase in world demand. Some developing countries have indeed experienced a decline in the terms of trade of their primary products because of an increase in the price of the manufactured goods. As Table 1 shows, during most of the last two decades, the terms of trade of agriculture was much below the level of 1969–70. Following the same method as above, it can be shown that an increase in the price of the industrial good does not affect the equilibrium conditions in the agricultural sector:  $dw/dp_m = dh_o/dp_m = dh_s/dp_m = 0$ . But an increase in  $p_m$  raises the value marginal product of labour in the manufacturing sector prompting an increase in the employment of labour which lowers the capital-labour ratio. From the equilibrium condition of the capitalist we find that:

$$\frac{dc_m}{dp_m} = \frac{f_m - c_m f'_m}{p_m c_m f''_m} < 0$$

Since the capital stock is constant, this increase in the capital-labour ratio implies a corresponding increase in manufacturing employment. However, the effect of an increase in  $p_m$  on the agricultural sector depends crucially on the land-labour ra-

tios of landlord and tenant farms. It is easily demonstrated that:

$$\frac{dL_o}{dp_m} = -\frac{h_s L_m (f_m - c_m f'_m)}{p_m c_m^2 f''_m (h_o - h_s)} < 0$$

and

$$\frac{dL_s}{dp_m} = -\frac{h_o dL_o}{h_s dp_m}$$

Since the landlord employs less labour and the tenant employs more, but the land-labour ratios are constant, the farm area of the landlord and the tenant must change correspondingly:

$$\frac{dH_o}{dp_m} = h_o \frac{dL_o}{dp_m} < 0$$

and

$$\frac{dH_s}{dp_m} = h_s \frac{dL_s}{dp_m} > 0$$

Because the manufacturing sector now employs more labour, the agricultural sector as a whole has to employ less labour. There is a relative abundance of land supply. Equilibrium is attained by contracting the scale of operation of the labour-intensive landlord farm and increasing the scale of operation of the land-intensive tenant farm. Again differentiating the production functions we can show that:

$$\frac{dX_m}{dp_m} = -\frac{L_m (f_m - c_m f'_m)^2}{p_m c_m^2 f''_m} > 0$$

The landlord employs less of both labour and land. His output must decline. On the other hand, the tenant uses more of both land and labour. His output must rise. So we have:

$$\frac{dX_o}{dp_m} = f_o \frac{dL_o}{dp_m} < 0$$

and

$$\frac{dX_s}{dp_m} = f_s \frac{dL_s}{dp_m} > 0$$

The change in the total agricultural output, which is the sum of the changes in the output of the landlord and the tenant farm, is negative:

$$\frac{dX_a}{dp_m} = h_o \frac{dL_o}{dp_m} (q_o - q_s) < 0$$

Although the manufacturing output increases, the income of the capitalist does not increase as all increase in output is consumed by increased wage expenditure and supervision costs:

$$\frac{dy_m}{dp_m} = p_m L_m f'_m \frac{dc_m}{dp_m} + (p_m f_m - w) \frac{dL_m}{dp_m}$$

Substituting the values of  $dc_m/dp_m$  and  $dL_m/dp_m$ , we find that  $dy_m/dp_m = 0$ . We also have:

$$\frac{dy_o}{dp_m} = -p_a \frac{dH_o}{dp_m} [f'_o - (1-r)q_s]$$

and

$$\frac{dy_s}{dp_m} = r p_a f'_s \frac{dH_s}{dp_m}$$

The expression in the square bracket is negative. Therefore, the income of the landlord decreases. The income of the tenant on the other hand increases. Consequently the effect of an increase  $p_m$  on national income is uncertain.

$$\frac{dY}{dp_m} = \frac{p_a L_m h_o h_s (f_m - c_m f'_m)}{p_m c_m^2 f''_m (h_o - h_s)} [f'_s - (1-r)q_s]$$

Hence,  $\text{SIGN}(dY/dp_m) = \text{SIGN}[f'_s - (1-r)q_s]$ . While the sign of the term is uncertain, it is obvious that the smaller the share of the landlord in the output of the rented land, the greater the probability that an adverse movement in the agricultural terms of trade will have an immiserizing effect on the economy.

## 6. Conclusion

It has been shown above that an increase in the labour supply tends to reduce the welfare of the self-cultivating landlord and the tenant while the onset of Green Revolution raises the welfare of both. Hence, when an economy experiences both these phenomena simultaneously, the ulti-

mate effect on peasant welfare will depend on the relative strength of their effects. If the economy can sustain technical progress at a rate sufficient to offset the adverse effect of population growth, the peasantry will prosper. Otherwise their situation will worsen.<sup>10</sup> This perhaps explains why Green Revolution has brought prosperity to some regions but has failed to improve the lot of the peasants in other regions. The analysis above also dispels a seeming paradox posed by Bardhan (1979). Cross section data from India suggested that regions experiencing a higher rate of technical progress in agriculture had a higher incidence of tenancy, but intertemporal data showed a decline in the incidence of tenancy over time despite the spread of Green Revolution. As the analysis above indicates, such technical progress does indeed tend to raise the incidence of tenancy, but this is swamped by a counteracting effect on tenancy of an increase in population over time.<sup>11</sup>

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<sup>10</sup> It can be easily demonstrated that if the rate of growth of population is greater than the rate of technical progress, then the welfare of tenants will necessarily decline. However, the reverse is not necessarily true. The rate of population growth would have to be sufficiently lower than the rate of technical progress to ensure that the welfare of the tenants rises.

<sup>11</sup> A similar argument was also put forth by Quibria and Taslim, 1982.