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Technological Progress, Income Distribution and Unemployment in the less Developed Countries

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DISCUSSION PAPERS

Technological Progress, Income Distribution and Unemployment in the less Developed Countries

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CONTENTS

ABSTRACT

In this paper we investigate the effects of technological progress on income distribution, and unemployment, in the framework of the original Harris-Todaro model. We study several forms of technological progress that takes place both in the urban and the rural sector of the economy. One basic result of our analysis is that no form of technological progress can be immiserizing, despite the presence of a wage distortion, and urban unemployment.

1. INTRODUCTION

The theory of economic development and international trade has been particularly enriched after the publication of the seminal article by Harris and Todaro (1970), on the rural-urban migration, and the persistence of urban unemployment in the developing countries. Harris and Todaro (henceforth H-T) considered a simple general equilibrium model, consisting of an urban and a rural sector which is characterized by persistent unemployment in the urban sector. The source of this phenomenon is the basic assumption that the wage rate in the urban sector is fixed, institutionally, at a level which is higher than the wage rate prevailing in the competitive rural sector. In view of this higher urban wage, workers migrate from the rural to the urban sector until the rural wage is equal to the expected urban wage which is assumed to be the urban wage times the employment rate there.

Several authors have extended the H-T model in various ways. For example, Fields (1975), and Sabot (1982) have tested and relaxed the assumption about the labour market, Corden and Findlay (1975) allowed for intersectoral capital mobility, and Bhagwati and Srinivasan (1974, 1975), and Khan (1980) have related this model with the theory of international trade. More recently, Neary (1981), and Amano (1983) presented a dynamic analysis of the H-T model with intersectoral capital mobility.

Although the H-T model has been extended in many ways, very

little has been done on the effects of technological progress on income distribution and unemployment in this framework. It is only recently that Beladi and Naqvi (1988) analysed the effects of economic expansion in the H-T type model with intersectoral capital mobility.

Given that the assumption of perfect factor mobility can be considered as describing long-run situations, it seems to us that the effects of economic expansion in the shorter-run, i.e. when only some factors are mobile are worth examining. It is the purpose of this paper to examine the effects of technological progress on income distribution and unemployment in the framework of the original H-T model, where only labour is mobile. This approach is consistent with the interest of trade theorists in the sector-specific model as developed by Jones (1971). Moreover, as Neary (1981) has stressed "... the sector-specific capital model exhibits properties which are at least as interesting as those of the much better explored Heckscher-Ohlin model with intersectoral capital mobility."

In the first section of this paper the basic features of our variant of the H-T model are laid out. In the second part, we examine the effects of technological progres on income distribution and unemployment. Finally, in a concluding section we summarize our main findings, and compare our results with those of Beladi and Naqvi, which can be considered as the long-run version of our model.

2. THE MODEL

Our type of the Harris-Todaro model may be described as follows: There are two sectors, the rural and the urban which produce two commodities, one agricultural (X_A), and one manufactured commodity (X_M). The production functions are linearly homogeneous, and each good is produced by using labour (L), and one specific factor, capital in manufacturing (K_M), and land (K_T) in agriculture. Perfect competition is assumed to prevail in all markets, and the economy is a small open one. Capital and land are fully employed. Also the wage rate in the urban sector is exogenously set, and is therefore fixed. As a result there is unemployment in the urban sector. More formally, the production functions can be written as follows:

$$X_i=F_i(L_i,K_i;t) \tag{1}$$

where t is a parameter standing for technological progress. The zero profit conditions are:

$$a_{LM}w_M+a_{KM}r_M=p_M \tag{2}$$

$$a_{LA}w_A+a_{KA}r_A=p_A \tag{3}$$

where a_{ij} is the per unit of output j requirement of input i, w_j is the wage rate in sector j, r_j is the rental to the specific factor in sector j, and p_j is the price of the jth commodity, (i=L,K; j=A,M). As we mentioned earlier the urban wage is fixed

exogenously, and the rural wage rate is set competitively. The basic hypothesis put forward by Harris and Todaro is, that since the urban wage is assumed to be fixed at a level higher than that of the rural sector, there will be migration of workers from the rural to the urban sector until the rural wage rate is equal to the expected urban wage rate. The expected urban wage rate is defined to be equal to the urban wage times the probability to find employment in the urban sector. Thus, we have:

$$w_A=w_M(L_M/L_M+L_U) \tag{4}$$

where L_j (j=A,M) is the employment in the jth sector, and L_U is the urban unemployment. We also have that:

$$L_A+L_M+L_U=L \tag{5}$$

and

$$a_{ij}=a_{ij}(w_j/r_j;t) \tag{6}$$

Differentiating totally eqs. (1)-(6), and after some manipulations we obtain:

$$\hat{X}_j=\Theta_{Lj}\hat{L}_j+\Theta_{Kj}\hat{K}_j+\pi_j \tag{7}$$

$$\Theta_{Lj}\hat{w}_j+\Theta_{Kj}\hat{r}_j=\hat{p}_j+\pi_j \tag{8}$$

$$\lambda_{LU}\hat{L}_U=\lambda_{LU}\hat{L}_M-(1-\lambda_{LA})\hat{w}_A \tag{9}$$

$$\lambda_{LA}\hat{L}_A+\lambda_{LM}\hat{L}_M+\lambda_{LU}\hat{L}_U=\hat{L} \tag{10}$$

$$\hat{a}_{Lj}-\hat{a}_{Kj}=\hat{L}_j=-\sigma_j(\hat{w}_j-\hat{r}_j)+\hat{b}_{Kj}-\hat{b}_{Lj} \tag{11}$$

where a caret (^) indicates proportional change, i.e. $\hat{x}=dx/x$, θ_{ij} is the share of factor i in the output of sector j, λ_{ij} is the proportion of factor i employed in the jth sector, $\pi_j=\theta_{Lj}\hat{b}_{Lj}+\theta_{Kj}\hat{b}_{Kj}$, $\hat{b}_{ij}=-(1/a_{ij})(\partial a_{ij}/\partial t)$ represents the proportional reduction in a_{ij} due to technological progress at constant factor prices, σ_j is the elasticity of substitution between labour and the specific factor in the jth sector, and $\theta_{Lj}+\theta_{Kj}=1$.

We have eight equations (7)-(11) with eight unknown variables ($\hat{X}_A$, $\hat{X}_M$, $\hat{L}_A$, $\hat{L}_M$, $\hat{L}_U$, $\hat{w}_A$, $\hat{r}_A$, $\hat{r}_M$), and eight exogenous variables ($\hat{K}_T$, $\hat{K}_M$, $\hat{L}$, π_M, π_A, $\hat{p}_A$, $\hat{p}_M$, and $\hat{w}_M$). We can, therefore, proceed to the examination of the effects of technical progress on income distribution and unemployment. In doing so we shall be using the terms urban sector and manufacturing, and rural and agricultural sector interchangeably.

3. THE EFFECTS OF TECHNOLOGICAL PROGRESS

We shall examine the effects of various forms technological progress on income distribution and employment, and we start from the assumption that the technological progress takes place in the manufacturing sector. The definition of technological progress to be used in the following analysis is that of Hicks.

a. Technological Progress in Manufacturing

Let us consider first the effects of a Hicks-neutral technical progress in manufacturing, which implies that $\hat{b}_{LA}=\hat{b}_{KA}=0$, and $\hat{b}_{LM}=\hat{b}_{KM}=\hat{b}_{M}>0$. We also have that w_M is fixed exogenously, L, K_M, K_T are in fixed supply, and the prices of the two commodities are given exogenously since the economy in consideration is a small open one. Solving simultaneously eqs. (7)-(11) we obtain the following changes for factor prices and employment:

$$\hat{r}_M=\hat{b}_M/\theta_{KM} \tag{12}$$

$$\hat{r}_A=-\theta_{LA}(1-\lambda_{LA})\sigma_M\hat{b}_M/\theta_{KM}\Delta \tag{13}$$

$$\hat{w}_A=\theta_{KA}(1-\lambda_{LA})\sigma_M\hat{b}_M/\theta_{KM}\Delta \tag{14}$$

$$\hat{L}_M=\sigma_M\hat{b}_M/\theta_{KM} \tag{15}$$

$$\hat{L}_A=-(1-\lambda_{LA})\sigma_M\sigma_A\hat{b}_M/\theta_{KM}\Delta \tag{16}$$

$$\hat{L}_U=\sigma_M[\lambda_{LU}\lambda_{LA}\sigma_A-\lambda_{LM}(1-\lambda_{LA})\theta_{KA}]\hat{b}_M/\lambda_{LU}\theta_{KM}\Delta \tag{17}$$

where $\Delta=\lambda_{LA}\sigma_A+(1-\lambda_{LA})\theta_{KA}$.

It is clear from these relationships that the capital-owners

in manufacturing, and workers in the rural sector benefit because of the technical progress, while land-owners lose. With regard to employment, we observe that it will rise in manufacturing, and will fall in agriculture. The change in urban unemployment, however, is ambiguous, and as eq. (17) reveals if the elasticity of substitution between labour and land is high, then unemployment may rise and vice versa. The change in unemployment depends also positively on the initial level of unemployment, i.e. the higher the initial level of unemployment the higher the likelihood that it will rise.

An intuitive explanation for these changes could be the following: As the technological progress takes place, with commodity prices fixed, the output of the manufacturing sector will rise at the expense of the agricultural output. Given that capital and land are in fixed supply, the level of employment in manufacturing will rise. As a result the wage rate in the rural sector will rise, the return to capital will rise, and the level of employment in manufacturing will also rise. This extra labour may come out of the rural sector and/or the pool of urban unemployed. As employment, however, in the urban sector rises the expected urban wage will also rise, and therefore more labour will flow into the urban sector from the rural sector. Depending therefore, on the elasticities of substitution between factors of production, the initial level of unemployment, and the relative factor proportions, the level of urban unemployment may rise or fall.

Turning to other types of technological progress we find that the effects of a Hicks capital-saving technical progress are qualitatively similar to those of a Hicks-neutral technical progress. The quantitative changes are, of course, different.

If the nature of technical progress is Hicks labour-saving then the changes in factor-prices and employment are quite different. Assuming $\hat{b}_{KM}=0$, and $\hat{b}_{LM}>0$, we obtain from eqs. (7)-(11) the following:

$$\hat{r}_M=\Theta_{LM}\hat{b}_M/\Theta_{KM} \tag{18}$$

$$\hat{r}_A=-(s_M-1)[\Theta_{LA}(1-\lambda_{LA})]\hat{b}_{LM}]/\Delta \tag{19}$$

$$\hat{w}_A=(s_M-1)[\Theta_{KA}(1-\lambda_{LA})\hat{b}_{LM}]/\Delta \tag{20}$$

$$\hat{L}_M=(s_M-1)\hat{b}_{LM} \tag{21}$$

$$\hat{L}_A=-(s_M-1)[(1-\lambda_{LA})\sigma_A\hat{b}_{LM}]/\Delta \tag{22}$$

$$\hat{L}_U=(s_M-1)[\lambda_{LU}\lambda_{LA}\sigma_A-\lambda_{LM}(1-\lambda_{LA})\Theta_{KA}]\hat{b}_{LM}/\lambda_{LU}\Delta \tag{23}$$

where $s_M=\Theta_{LM}\sigma_M/\Theta_{KM}$.

It is clear that the only factor that gains unambiguously is capital in the manufacturing sector. The changes in the other factor-prices and employment depend on the value of s_M. It can be shown that $s_M=\Theta_{LM}\sigma_M/\Theta_{KM}$, is the short-run price elasticity of output supply in manufacturing.[1] If $s_M=1$, then with the

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[1]. From eq. (7) we have that $\hat{X}_M=\Theta_{LM}\hat{L}_M+\pi_M$ since $\hat{K}_M=0$. We have from (11) that $\hat{L}_M=\sigma_M(\hat{r}_M-\hat{w}_M)+\hat{b}_{KM}-\hat{b}_{KM}$. Thus, $\hat{X}_M=\Theta_{LM}\sigma_M(\hat{r}_M-\hat{w}_M)+\Theta_{LM}(\hat{b}_{KM}-\hat{b}_{LM})+\pi_M$. Equation (8) could be also written as $\hat{r}_M-\hat{w}_M=(\hat{p}_M-\hat{w}_M+\pi_M)/\Theta_{KM}$. By substitution we obtain $\hat{X}_M=[\Theta_{LM}\sigma_M(\hat{p}_M-\hat{w}_M+\pi_M)/\Theta_{KM}]+\Theta_{LM}(\hat{b}_{KM}-\hat{b}_{LM})+\pi_M$, Q.E.D. See also Neary (1981b).

exception of an increase in the return to capital, no other change takes place. If, on the other hand, the short-run supply elasticity of manufacturing output is greater than one i.e. $s_M > 1$, then in addition to a rise in the return to capital, the wage rate in agriculture will also rise, while employment in the rural sector will fall, and in the urban sector will rise. The change in the urban unemployment, however, depends not only on the s_M, but also on the factors we mentioned earlier on the effects of the Hicks-neutral technical progress. In a similar way we can analyse the case with $s_M < 1$. It is, therefore, possible that we have a reduction in the urban unemployment even with a labor-saving technical progress.

Another aspect worth examining is the consequences of technical progress on the overall level of output. It can be easily shown that all forms of technical progress in manufacturing lead to an increase in the national output. In the case of a Hicks-neutral or capital-saving technical progress, the output in the manufacturing sector rises while that of the agricultural sector falls. In the case of a labour-saving technical progress the output of the manufacturing sector will rise, and that of the agricultural sector will rise or fall depending on whether the short-run elasticity of manufacturing output supply is greater or less than one. In both cases, however, national income will rise. So, despite the presence of

a wage distortion technical progress cannot be immiserizing.[2]

b. Technological Progress in Agriculture

Suppose, now, that a Hicks-neutral technological progress takes place in the agricultural sector. This implies that $\hat{b}_{KM}=\hat{b}_{LM}=0$, and $\hat{b}_{KA}=\hat{b}_{LA}=\hat{b}_{A}>0$. Given that $\hat{w}_{M}=\hat{p}_{A}=\hat{p}_{M}=0$, and $\pi_{M}=0$, we have that $\hat{r}_{M}=0$, and consequently $\hat{L}_{M}=0$. In other words, the return to capital and the employment in the urban sector will not be affected at all by the technical progress in agriculture. From eqs. (8)-(11) we can derive the following relationships for factor-price and employment changes in the rural sector:

$$\hat{r}_{A}=[1-\lambda_{LA}(1-\sigma_{A})]\hat{b}_{A}/\Delta \qquad (24)$$

$$\hat{w}_{A}=\lambda_{LA}\sigma_{A}\hat{b}_{A}/\Delta \qquad (25)$$

$$\hat{L}_{A}=(1-\lambda_{LA})\sigma_{A}\hat{b}_{A}/\Delta \qquad (26)$$

$$\hat{L}_{U}=-[\lambda_{LA}(1-\lambda_{LA})\sigma_{A}]\hat{b}_{A}/\Delta \qquad (27)$$

As these equations reveal, a Hicks-neutral technological progress will lead to an increase in the rural wage, to an increase in the rural employment, and to a reduction in the urban unemployment. The return to land will rise if the elasticity of substitution between labour and land is less than one. If this elasticity is greater than one, then the return to land may rise

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[2]. These results can be formally derived by substituting equations (15) and (16), or (21) and (22) into equation (7), and then into $\hat{Y}=\Theta_{M}\hat{X}_{M}+\Theta_{A}\hat{X}_{A}$, where Θ_{j} is the share of the output of sector j in the national income (j=M,A).

or fall depending on whether one is greater or smaller than $\lambda_{LA}(1-\sigma_A)$. It is clear from the preceding analysis that the output of the manufacrturing sector will remain unchanged, while the output of the agricultural sector will rise. As a result national output will rise.

If we assume that the technical progress is land-saving, i.e. $\hat{b}_{KA}>0$, and $\hat{b}_{LA}=0$ then we have again that the manufacturing sector is not affected at all, while the changes in the rural sector are the following:

$$\hat{w}_A=\lambda_{LA}\theta_{KA}(1+\sigma_A)\hat{b}_{KA}/\Delta \tag{28}$$

$$\hat{r}_A=[\theta_{KA}-\lambda_{LA}(1-\theta_{KA}\sigma_A)]\hat{b}_{KA}/\Delta \tag{29}$$

$$\hat{L}_A=\theta_{KA}(\sigma_A+1)(1-\lambda_{LA})\hat{b}_{KA}/\Delta \tag{30}$$

So, as a result of the land-saving progress the wage rate in the rural sector will rise, and rural employment will also rise. With the level of employment in manufacturing unchanged, it is obvious that urban unemployment will fall. The return to land may rise or fall depending on the magnitude of σ_M and the relative factor shares.

Finally, we shall consider the effects of a labour-saving technical progress in the agricultural sector, i.e. $\hat{b}_{LA}>0$, $\hat{b}_{KA}=0$. With no changes in the manufacturing sector, we obtain the following changes in the rural sector:

$$\hat{w}_A=\lambda_{LA}(\theta_{LA}\sigma_A-\theta_{KA})\hat{b}_{LA}/\Delta \tag{31}$$

$$\hat{r}_A=\theta_{LA}(\lambda_{LA}\sigma_A+1)\hat{b}_{LA}/\Delta \qquad (32)$$

$$\hat{L}_A=(1-\lambda_{LA})(\theta_{LA}\sigma_A-\theta_{KA})\hat{b}_{LA}/\Delta \qquad (33)$$

It is clear that land-owners will benefit unambiguously, while the change of the wage rate in the rural sector depends on relative factor intensities, and the elasticity of substitution between land and labour. The rural wage will rise if $(\theta_{LA}\sigma_A/\theta_{KA})>1$, which means that it depends on whether the short-run price elasticity of the agricultural output supply is greater or smaller than one.[3] The same condition holds for the employment in the rural sector. If rural employment rises, with urban employment unchanged, the urban unemployment will consequently fall. It can be also derived, rather easily, that with all forms of technical progress in agriculture its output will rise, and with manufacturing output unchanged the national income will also rise.

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[3]. For the definition and derivation of the short-run supply elasticity see footnote 1.

4. CONCLUDING REMARKS

In this paper we have attempted to analyse the effects of technical progress in the framework of the original Harris-Todaro model. A similar approach was undertaken by Beladi and Naqvi, but in their model both factors of production, namely labour and capital were intersectoraly mobile, while in our model the only mobile factor was labour. Hence, our model can be considered as a short-run version of the Beladi-Naqvi model.

We have analysed several forms of technological progress and their effects on factor-prices, and employment. Our analysis showed that if technical progress takes place in manufacturing, then the urban unemployment does not necessarily rises as in the Beladi-Naqvi model. In fact it is quite possible that the urban unemployment may even fall, depending on factor substitutability and relative factor intensities. With regard to the effects of technical progress in the agricultural sector, we have found that if it is Hicks-neutral or land-saving, the urban rate of unemployment will fall as in the Beladi-Naqvi model. In the case, however, of a labour-saving technical progress the urban unemployment will not necessarilly fall (as in the Beladi-Naqvi model), but it may also rise if the short-run price elasticity of the agricultural output supply is less than one.

Finally, it is worth mentioning that under all forms of technical progress the national output rises, i.e. technical progress is not immiserizing, despite the presence of a

distortion in the form of a fixed urban wage and the urban unemployment.

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