

## **Foreign Capital Inflow, Skilled-Unskilled Wage Gap, and Welfare in the Presence of the Informal Sector**

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This paper attempts to analyse the impact of trade liberalisation on the skilled-unskilled wage gap and the level of welfare of developing countries, which are generally characterised by large “informal” labour markets. A neo-classical full-employment four-sector model has been developed, where the informal sector produces either a final product or an intermediate product on subcontracting basis. Evidence shows that in either case, trade liberalisation, in the form of an increase in foreign capital inflow, widens the skilled-unskilled wage gap of the economy under some reasonable conditions. It also shows that as a result of an increase in the foreign capital inflow, the level of welfare of the economy increases, when the informal sector produces a final product. However, when the informal sector produces an intermediate product on subcontracting basis, the level of welfare of the economy falls.

### **1. INTRODUCTION**

International trade and skilled-unskilled wage gap has recently emerged as a topic of substantial research interest in economics. The issue is particularly important in the context of liberalisation of developing countries. In spite of the existence of a large number of studies on this topic, we find most of the works are confined to the issue in the context of developed countries. Only a few studies are conducted for the developing countries. Robbins (1994, 1994a, 1995, 1995a, 1996, 1996a) and Wood (1997) have conducted some studies for the East Asian and Latin American developing countries on the wage-gap issue. The results of these studies show that liberalisation has reduced the wage gap in East Asia but has widened the same in Latin America.

In recent years some attempts have been made to theoretically justify these empirical facts. Feenestra and Hanson (1995) have developed a simple model to show that increase in foreign investment in Mexico has widened the wage gap

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between the skilled and unskilled workers. Similar results have been derived by Marjit (1998, 1999); Marjit, Broll, and Sengupta (1997) and Acharyya and Marjit (2000) in their respective papers.

The present paper also tries to analyse the impact of a relatively open trade regime on the skilled-unskilled wage gap in the developing economy. Our purpose here is to focus on some of the structural features of a typical developing economy, to incorporate them in the model and then to look for the consequences of liberalisation. One of the most widely observed characteristics of the labour markets in developing countries is its formidable reservoir of unskilled labour employed in the informal segment of the economy. This has been pointed out in numerous papers. But in most of the papers the informal sector has been considered in a Harris-Todaro framework (1970), which has been criticised in recent years by a number of authors.<sup>1</sup> Therefore in this paper a neo-classical full-employment model has been considered.

In the present paper we consider a multisectoral neo-classical full-employment model where the labour force of the economy is divided into two major categories—skilled and unskilled. Skilled labour is used to produce an exportable product by sector  $x$  and an importable product by sector  $m$ . Sector  $y$  produces an agricultural product and the informal sector  $i$  produces a final product<sup>2</sup> with the help of unskilled labour. In order to produce its product, sector  $x$  uses foreign capital, which is sector specific, in addition to skilled labour. (Domestic) formal capital is perfectly mobile between sectors  $y$  and  $m$  whereas informal capital is specific to the informal sector  $i$ .

Our purpose here is to examine the impact of liberalisation, in the form of an increase in the foreign capital inflow, on the skilled-unskilled wage gap of the economy and on the level of welfare of the economy in the presence of an informal sector.

After specifying the basic model we consider an alternative version of the model. In the alternative version of the model we assume that the informal sector produces an intermediate product on a subcontracting basis<sup>3</sup> for sector  $x$ , instead of a final good. For the sake of simplicity we assume that the informal sector, instead of sector specific capital, uses the same capital as that used by sectors  $y$  and  $m$ . Here also our purpose is to examine the impact of liberalisation in the form of foreign capital inflow on the level of skilled-unskilled wage gap of the economy and the level of welfare of the economy.

The interesting results of this paper can be summarised in the following manner: In the basic version of our model we find that investment liberalisation, in

<sup>1</sup>See the works of Acharyya and Marjit (2000); Chaudhuri and Mukherjee (2002), etc.

<sup>2</sup>The informal sector sometimes produces final traded goods like small engineering goods, jewellery, clay toys, etc. See the works of Chandra and Khan (1993); Bandyopadhyay and Gupta (1995) and Gupta (1997), etc.

<sup>3</sup>See the work of Gupta (2002).

the form of increased foreign capital inflow, widens the skilled-unskilled wage gap of the economy. However, increase in foreign capital inflow increases the level of welfare of the economy. Thus we can say that the Brecher-Alejandro proposition<sup>4</sup> (1977) is not valid, as there is a change in the level of welfare even in the absence of tariff. In the alternative version of our model we also find that increase in foreign capital inflow widens the skilled-unskilled wage gap of the economy but reduces the level of welfare of the economy. In other words, we can conclude that investment liberalisation always widens the skilled-unskilled wage gap of a developing economy, irrespective of the fact that the informal sector of the economy produces a final traded good or an intermediate good on a subcontracting basis. But the level of welfare of the economy increases when the informal sector produces a final traded product. On the other hand, when the informal sector produces an intermediate product, the level of welfare of the economy falls.

The layout of the paper is as follows: The basic model is developed in Section 2. Section 3 examines the comparative static results. Section 4 describes the alternative version of the model and the comparative static exercises of this model. Finally, concluding remarks are made in Section 5.

## 2. THE BASIC MODEL

We consider a small open economy with four sectors—the urban skilled sector ( $x$ ) producing exportable, another urban skilled sector ( $m$ ) producing importable, the rural unskilled sector ( $y$ ) producing agricultural products and the traded final good producing unskilled informal sector ( $i$ ). The products of sectors  $x$  and  $y$  are exported. All the sectors use labour and capital as inputs to produce their products. Skilled labour is perfectly mobile between the two sectors  $x$  and  $m$  whereas unskilled labour is perfectly mobile between the other two sectors,  $y$  and  $i$ . There exists full employment of both types of labour force. Sector  $x$  uses sector-specific foreign capital, which is exogenously given.<sup>5</sup> Similarly informal capital, is specific for the informal segment of the economy. However (domestic) formal capital is perfectly mobile between the other two sectors,  $y$  and  $m$ . The small open economy assumption implies that the economy is a price taker in the international market. Finally, we have the usual assumptions of a neo-classical general equilibrium model like constant returns to scale production function for each sector and competitive market conditions.

<sup>4</sup>See the work of Brecher and Alejandro (1977).

<sup>5</sup>We assume that the rate of return on foreign capital which the foreign capitalists receive by investing in small open economy cannot be less than the given world rate of return on foreign capital. However, we also assume that there is control on the entry of foreign capital in the economy. The government of the economy directly regulates it, so that its stock is given exogenously. This is the experience of many developing countries in the context of liberalisation. Marjit (1994) has cited the example of Asian tigers in this context. See Gupta and Gupta (1997) for details.

The notations used in this model are stated in the following manner:

- $P_j$  – world price for the product of  $j$ th sector,  $j = x, m, y, i$ .  
 $a_{ij}$  – quantity of the  $i$ th input required for the production of one unit of output of the  $j$ th sector  
 $i = S, K, L, K_F, K_I$  and  $j = x, m, y, i$ .  
 $S$  – stock of skilled labour  
 $L$  – stock of unskilled labour  
 $K$  – stock of (domestic) formal capital  
 $K_F$  – stock of foreign capital  
 $K_I$  – stock of (domestic) informal capital.  
 $W_S$  – wage rate of skilled labour  
 $W$  – wage rate of unskilled labour  
 $r$  – rate of return on (domestic) formal capital  
 $r_F$  – rate of return on foreign capital  
 $r_I$  – rate of return on (domestic) informal capital  
 $X$  – level of output of sector  $x$   
 $Y$  – level of output of sector  $y$   
 $M$  – level of output of sector  $m$   
 $I$  – level of output of sector  $i$   
 $Z$  – total factor income of the economy.

The equational structure of the model can be explained as follows:

The competitive equilibrium conditions are given by the following four equations

$$P_x = a_{Sx} W_S + a_{KFx} r_F \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (1)$$

$$P_m = a_{Sm} W_S + a_{Km} r \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (2)$$

$$1 = a_{Ly} W + a_{Ky} r \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (3)$$

$$P_i = a_{Li} W + a_{KI} r_I \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (4)$$

The product of the rural sector is considered as the numeraire and its price has been set equal to unity.

Factor market equilibrium conditions are given by the following equations.

$$a_{Sx} X + a_{Sm} M = S \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (5)$$

$$a_{KFx} X = K_F \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (6)$$

$$a_{Km} M + a_{Ky} Y = K \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (7)$$

$$a_{Ly}Y + a_{Li}I = L \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (8)$$

$$a_{Ki}I = K_I \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (9)$$

Equations (5) to (9) imply that there exists full employment in the factor markets.

In this model we have nine equations with nine endogenous variables— $W_S$ ,  $W$ ,  $r_F$ ,  $r$ ,  $r_b$ ,  $X$ ,  $M$ ,  $Y$  and  $I$ . Thus the system is determinable.

The working of the model can be explained in the following manner. From Equation (1) we find that, given  $P_x$ ,  $r_F$  is a decreasing function of  $W_S$ . Again, from Equation (2) we find that, given  $P_m$ ,  $W_S$  is a decreasing function of  $r$ . Thus it can be concluded that both  $r_F$  and  $W_S$  are functions of  $r$ .

i.e.  $r_F = r_F(r)$  and  $W_S = W_S(r)$  where  $\partial r_F / \partial r > 0$  and  $\partial W_S / \partial r < 0$

Using Equation (6), Equation (5) can be written as

$$(a_{Sx} / a_{KFx}) K_F + a_{Sm} M = S$$

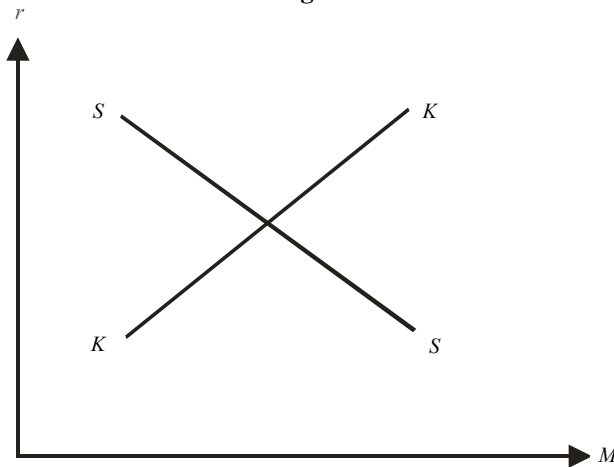
$$\Rightarrow \Psi(r) K_F + a_{Sm} M = S \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (5.1)$$

where  $\Psi = (a_{Sx} / a_{KFx})$ ,  $a_{Sx} = a_{Sx}(W_S/r_F) = a_{Sx}(r)$   
 and  $a_{KFx} = a_{KFx}(W_S/r_F) = a_{KFx}(r)$   
 Thus  $\Psi = \Psi(r)$  where  $\Psi' > 0$ .

The combination of  $r$  and  $M$  which maintains equilibrium in the market for skilled labour is given by the  $SS$  locus, in Figure 1. The slope of this locus, as obtained from Equation (5.1) is given by

$$(dr/dM) |_{SS} = - a_{Sm} / (K_F \Psi' + M a_{Sm}')$$

**Fig. 1.**



Since the input-output ratio is positive and the function  $\Psi$  and the input-output ratio  $a_{Sm}$  varies directly with  $r$ , therefore the curve  $SS$  is negatively sloped.

Substituting Equation (9) in Equation (8),  $Y$  can be derived<sup>6</sup> as a decreasing function of  $r$ . Thus Equation (7) can be rewritten as

$$a_{Km}(r)M + a_{Ky}(r)Y(r) = K \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (7.1)$$

The locus of  $r$  and  $M$ , which maintains the equilibrium of the domestic capital market, is given by the  $KK$  curve in Figure 1. The slope of this curve as obtained from Equation (7.1) is given by

$$(dr/dM)|_{KK} = -a_{Km}' / (M a_{Km}' + Y a_{Ky}' + a_{Ky} Y')$$

Since the input-output ratios are positive and the functions  $a_{Km}$ ,  $a_{Ky}$  and  $Y$  varies inversely with  $r$ , the curve  $KK$  is positively sloped.

The intersection of  $SS$  and  $KK$  locus gives us the equilibrium values of  $r$  and  $M$ . Once  $M$  is determined one can easily determine  $X$  from Equation (5) and  $Y$  from Equation (7). When  $Y$  is known,  $I$  can be determined easily from Equation (8). Similarly the factor prices  $W_S$ ,  $r_F$ ,  $W$  and  $r_I$  can be determined with the help of Equations (1), (2), (3) and (4), once the value of  $r$  is determined.

### 3. THE COMPARATIVE-STATIC EFFECTS

In this section we consider the impact of liberalisation on the skilled-unskilled wage gap of the economy. It is captured through an increase in the stock of foreign capital inflow into the economy. With the larger inflow of foreign capital into the economy, the level of output of the sector using it increases. For given  $r$  and hence for given input-output ratios  $a_{KFx}$ ,  $a_{Sx}$  and  $a_{Sm}$ , an increase in  $K_F$  implies an increase in the level of output of sector  $X$ . As the endowment of skilled labour force,  $S$ , is given it implies a contraction of  $M$ . In other words, from Equation (5.1) we find that for given  $r$ , an increase in  $K_F$  implies a reduction in  $M$  i.e. a leftward shift of  $SS$  locus. However there will be no effect on the  $KK$  curve. Hence a new equilibrium has been obtained, where both  $r$  and  $M$  fall. As a result of decrease in  $r$ , both  $W$  and  $W_S$  rise (as  $P_m$  and  $P_y$  are given). Hence from competitive equilibrium conditions (1) and (4) we find that both  $r_F$  and  $r_I$  fall and in order to determine the impact of liberalisation on the skilled-unskilled wage gap of the economy, we have to examine the movement of  $(W_S/W)$  with a rise in  $K_F$  i.e

$$(\hat{W}_S - \hat{W}) / \hat{K}_F$$

<sup>6</sup>From Equation (9) we get  $I = K_I / a_{KI}$ , substituting the value of  $I$  in Equation (8) we get

$$a_{Ly} \{W(r)/r\} Y + a_{Li} \{W(r)/r\} \{K_I / a_{KI}(r)\} = L$$

$$\Rightarrow a_{Ly}(r)Y + \{a_{Li}(r)/a_{KI}(r)\}K_I = L$$

$$\therefore Y = f(r) \text{ where } (\delta Y / \delta r < 0)$$

Taking total differentiation of Equations (2) and (3) and then dividing Equations (2) and (3) by  $P_m$  and  $P_y$ , respectively we get

$$\hat{P}_m = \theta_{Sm} \hat{W}_S + \theta_{Km} \hat{r} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (2.1)$$

$$\hat{P}_y = \theta_{Ly} \hat{W} + \theta_{Ky} \hat{r} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (3.1)$$

where  $\theta_{ij}$  implies the share of  $i$ th input in the product of  $j$ th sector and  $\hat{z} = dz / z$  for  $z = P_m, P_y, r$  etc.

Putting  $\hat{P}_m = \hat{P}_y = 0$ , the equations can be further transformed as

$$\hat{W}_S = -(\theta_{Km} / \theta_{Sm}) \hat{r} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (2.2)$$

$$\hat{W} = -(\theta_{Ky} / \theta_{Ly}) \hat{r} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (3.2)$$

Subtracting Equation (3.2) from Equation (2.2) we get

$$\begin{aligned} (\hat{W}_S - \hat{W}) &= \hat{r}[(\theta_{Ky} / \theta_{Ly}) - (\theta_{Km} / \theta_{Sm})] \\ \Rightarrow (\hat{W}_S - \hat{W}) / \hat{K}_F &= (\hat{r} / \hat{K}_F)[(\theta_{Ky} / \theta_{Ly}) - (\theta_{Km} / \theta_{Sm})] \end{aligned}$$

In an economy where the agricultural sector is backward and the manufacturing sector is highly capital-intensive, we would expect the value of  $(\theta_{Ky} / \theta_{Ly})$  to be very low and the value of  $(\theta_{Km} / \theta_{Sm})$  to be very high. In such an economy we would expect

$$\begin{aligned} (\theta_{Ky} / \theta_{Ly}) &< (\theta_{Km} / \theta_{Sm}) \\ \therefore (\hat{r} / \hat{K}_F) &< 0 \therefore (\hat{W}_S - \hat{W}) / \hat{K}_F > 0. \end{aligned}$$

Thus it can be concluded that, under some reasonable conditions, increase in foreign capital inflow raises the skilled-unskilled wage gap of the economy.

We now consider the impact of foreign capital inflow on the total factor income of the economy when the foreign capital income is fully repatriated.<sup>7</sup> It is given by

$$Z = WL + W_S S + rK + r_I K_I \quad \dots \quad \dots \quad \dots \quad \dots \quad (10)$$

Differentiating Equation (10) with respect to  $K_F$  we get

$$(dZ / dK_F) = L(dW / dK_F) + S(dW_S / dK_F) + K(dr / dK_F) + K_I(dr_I / dK_F)$$

We can rewrite as

<sup>7</sup>In case of a small open economy, in the absence of tariffs national income or factor income is considered as a measure of welfare. See the works of Gupta and Gupta (1997); Gupta (1997), etc.

$$(dZ/dK_F) = L(dW/dr_1)(dr_1/dK_F) + S(dW_S/dr)(dr/dK_F) + K(dr/dK_F) + K_I(dr_I/dK_F)$$

Using the Shephard-Samuelson relations we find from competitive equilibrium conditions

$$(dW/dr_1) = -(a_{K_I}/a_{L_I}) \quad \text{and} \quad (dW_S/dr) = -(a_{K_m}/a_{S_m})$$

Therefore

$$(dZ/dK_F) = L(dr_1/dK_F) [(K_I/L) - (a_{K_I}/a_{L_I})] + S(dr/dK_F) [(K/S) - (a_{K_m}/a_{S_m})]$$

$$\text{As } (dr_1/dK_F) < 0 \text{ and } (dr/dK_F) < 0$$

Under sufficient conditions  $(K/S) < (a_{K_m}/a_{S_m})$ <sup>8</sup> and  $(K_I/L) < (a_{K_I}/a_{L_I})$  we find that  $(dZ/dK_F) > 0$

Hence we find that under the given conditions, an increase in foreign capital inflow increases the level of welfare of the economy.

We summarise the results in the form of following proposition.

**Proposition 1.** *Trade liberalisation in the form of an increase in the foreign capital inflow in an economy raises the skilled-unskilled wage gap of the economy. Such an inflow also increases the level of welfare in the presence of the informal sector under some reasonable conditions.*

Finally, we are interested to examine the impact of foreign capital inflow on the output of the informal sector. We have shown that as a result of an increase in  $K_F$ , both  $r$  and  $r_F$  falls. Hence from Equation (9) it implies that  $a_{K_I}$  increases. Given the stock of informal capital,  $K_I$ , we can thus conclude that the output of the informal sector falls.

We can thus write the following proposition

**Proposition 2.** *In an economy with skilled-unskilled division of work force, an increase in foreign capital inflow reduces the output of the informal sector when it produces internationally traded final goods.*

#### 4. THE ALTERNATIVE VERSION OF THE MODEL

Informal sectors of a developing economy mostly produce non-traded intermediary products for the formal sectors of the economy, instead of final traded goods. Empirical evidences also support this fact.<sup>9</sup> In order to capture this characteristic

<sup>8</sup>This assumption is feasible in context of a developing economy, like India, where we generally expect  $a_{K_m}$  to be quite high and methods of production are highly capital intensive. It is to be noted that  $K$  is shared between sectors  $m$  and  $y$ . So it is reasonable to assume that unit requirement of capital per unit of skilled labour is higher than the average capital-skilled labour endowment of the economy.

<sup>9</sup>In India, for example, many of the large industries like leather bag and shoe manufacturing industries, garments industries etc. use the intermediate inputs, which are produced by the informal sectors of the economy. For example, in Kolkata the informal segment of the economy carries out leather-tanning process for the shoe and bag manufacturing industries. Similarly, for the garment industry the dyeing and stitching of garments are done by the informal sector of the economy on a subcontracting basis.



of developing countries, we have modified the basic version of our model and tried to examine the impact of trade liberalisation on the skilled-unskilled wage gap of the economy, within this framework. In this version of our model one can assume that the product produced by the informal segment of the economy is used both by the sector  $x$  and the sector  $m$ , as an intermediate product.<sup>10</sup> But for the sake of simplicity, we assume that the product of sector  $i$  is used as an intermediate input by sector  $x$  to produce its product. Thus, sector  $x$  uses skilled labour, foreign capital and intermediate product,  $i$ , to produce its product. It implies that the competitive equilibrium condition of sector  $x$  is modified in the extended version of the model as

$$P_x = a_{Sx} W_S + a_{Kfx} r_F + a_{Ix} P_i \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (1a)$$

Since the product  $I$  is used as an intermediate product on a subcontracting basis, its price,  $P_i$ , is endogenously determined and its demand-supply equation is given as

$$a_{Ix} X = I \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (9a)$$

Again for the sake of simplicity it is assumed that the unit requirement of informal sector input by the formal sector,  $x$ , is fixed i.e. the input-output coefficient,  $a_{Ix}$  is fixed.<sup>11</sup>

To simplify matters, in the present model we assume that the informal sector uses the same capital that is used by the formal part of the economy, instead of sector specific capital. We refer to it as domestic capital. Equation (4) of the basic model is thus transformed as

$$P_i = a_{Li} W + a_{Ki} r \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (4a)$$

Equation (7) of the basic model is thus modified in the extended version of the model, as the capital is perfectly mobile among sector  $y$ ,  $m$  and  $i$  instead of  $y$  and  $m$ .

$$a_{Ky} Y + a_{Ki} I + a_{Km} M = K \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (7a)$$

Thus in the extended version of the model, we have nine equations with nine endogenous variables  $r$ ,  $r_F$ ,  $W_S$ ,  $W$ ,  $P_i$ ,  $X$ ,  $Y$ ,  $I$  and  $M$  which implies the system is determinable.

<sup>10</sup>In that case results will remain unaffected.

<sup>11</sup>It implies that fixed amount of the product of the sector  $i$  is needed as an intermediate product by the sector  $x$  to produce one unit of its product. It rules out the possibility of substitution between the non-traded intermediary and other factors of production in sector  $x$ . It is a reasonable assumption from the point of view of the nature of subcontracting between the formal and informal firms, as experienced in India. In industries like shoe making and garments, large formal sector shift their production to small informal sector firms under the system of subcontracting. So the production is done in the informal sector firms while the formal sector firms do packaging and marketing. One pair of shoes produced in the informal sector does not change in quantity when it is marketed by the formal sector as a final commodity. Thus there remains a fixed proportion between the use of intermediary and the quantity of final commodity produced and marketed by the formal sector.

In context of this model, we want to examine the impact of trade liberalisation i.e. larger foreign capital inflow into the economy on the level of skilled-unskilled wage gap. In other words, we want to examine the movement of  $(W_S/W)$  as a result of increase in  $K_F$  i.e.

$$(\hat{W}_S - \hat{W}) / \hat{K}_F$$

After total differentiation of Equation (8) we get

$$\lambda_{Ly} \hat{Y} + \lambda_{Li} \hat{I} = -(\lambda_{Ly} \hat{a}_{Ly} + \lambda_{Li} \hat{a}_{Li}) \quad \dots \quad \dots \quad \dots \quad \dots \quad (8a)$$

where  $\lambda_{ij}$  implies the share of  $i$ th input in the product of  $j$ th sector. Assuming that the production function of sector  $y$  is Cobb-Douglas<sup>12</sup> production function, we can write the elasticity of substitution as

$$\sigma_y = (\hat{a}_{Ky} - \hat{a}_{Ly}) / (\hat{W} - \hat{r}) = 1$$

and by using the Equation (3), (for details see the Appendix), the above equation can be further transformed as

$$\lambda_{Ly} \hat{Y} + \lambda_{Li} \hat{I} = (\lambda_{Ly} \theta_{Ky} + \lambda_{Li} \theta_{Ki}) (\hat{W} - \hat{r}) \quad \dots \quad \dots \quad \dots \quad (8.1)$$

Similarly Equation (5) can be rewritten as (see the Appendix for details)

$$\lambda_{Sx} \hat{X} + \lambda_{Sm} \hat{M} = \lambda_{Sx} \theta_{Kfx} (\hat{W}_S - \hat{r}_F) + \lambda_{Sm} \theta_{Km} (\hat{W}_S - \hat{r}) \quad \dots \quad \dots \quad (5.2)$$

Differentiating Equations (3) and (4a) we get

$$\hat{W} = -(\theta_{Ky} / |\theta|) \hat{P}_i$$

$$\hat{r} = (\theta_{Ly} / |\theta|) \hat{P}_i$$

where  $|\theta| = \{(\theta_{Ki} / \theta_{Li}) - (\theta_{Ky} / \theta_{Ly})\}$

In a developing economy like India, the agricultural sector has already experienced mechanisation in the form of Green Revolution whereas the informal sector is mainly a labour absorbing sector, thus it can be assumed that  $(\theta_{Ki} / \theta_{Li}) < (\theta_{Ky} / \theta_{Ly})$

Therefore  $|\theta| < 0$ .

<sup>12</sup>This is just a simplifying assumption. See Chaudhuri and Gupta (2004).

Elasticity of substitution of the production function is given as

$$\sigma_y = (\hat{a}_{Ky} - \hat{a}_{Ly}) / (\hat{W} - \hat{r}) = 1$$

since the production function is a Cobb-Douglas production function

Therefore  $\sigma_y = 1$ .

Similarly the value of  $\hat{W}_S$  and  $\hat{r}_F$  are obtained from Equations (2) and (1a) respectively

$$\hat{W}_S = -\{(\theta_{Km}\theta_{Ly})/(|\theta|\theta_{Sm})\}\hat{P}_i$$

$$\hat{r}_F = -[\{\theta_{Ix}\theta_{Sm}|\theta| - \theta_{Sx}\theta_{Km}\theta_{Ly}\}/\{|\theta|\theta_{Sm}\theta_{KFx}\}]\hat{P}_i$$

Thus

$$(\hat{W}_S - \hat{r}) = \{-(\theta_{Km}\theta_{Ly})/(|\theta|\theta_{Sm}) - (\theta_{Ly})/(|\theta|)\}\hat{P}_i$$

$$= (-\hat{P}_i\theta_{Ly})/|\theta|\theta_{Sm}$$

$$= B\hat{P}_i$$

where  $B = \{(-\theta_{Ly})/|\theta|\theta_{Sm}\}$

and

$$(\hat{W}_S - \hat{r}_F) = -\{(\theta_{Km}\theta_{Ly})/(|\theta|\theta_{Sm})\}\hat{P}_i + \{(\theta_{Ix}\theta_{Sm}|\theta| - \theta_{Sx}\theta_{Km}\theta_{Ly})/(|\theta|\theta_{Sm}\theta_{KFx})\}\hat{P}_i$$

$$= -\{(\theta_{Km}\theta_{Ly}\theta_{KFx} - \theta_{Ix}\theta_{Sm}|\theta| + \theta_{Sx}\theta_{Km}\theta_{Ly})/(|\theta|\theta_{Sm}\theta_{KFx})\}\hat{P}_i$$

$$= A\hat{P}_i$$

where

$$A = -\{(\theta_{Km}\theta_{Ly}\theta_{KFx} - \theta_{Ix}\theta_{Sm}|\theta| + \theta_{Sx}\theta_{Km}\theta_{Ly})/(|\theta|\theta_{Sm}\theta_{KFx})\}$$

and

$$(\hat{W} - \hat{r}) = -\{\hat{P}_i(\theta_{Ky} + \theta_{Ly})\}/|\theta|$$

$$= -\hat{P}_i/|\theta|$$

Substituting the value of  $(\hat{W} - \hat{r})$  in Equation (8.1), the equation can be finally transformed as

$$\lambda_{Ly}\hat{Y} + \lambda_{Li}\hat{I} = -(\lambda_{Ly}\theta_{Ky} + \lambda_{Li}\theta_{Ki})\hat{P}_i/|\theta| \quad \dots \quad \dots \quad \dots \quad (8.2)$$

(see Appendix for detailed derivations)

Similarly by putting the values of  $(\hat{W}_S - \hat{r})$  and  $(\hat{W}_S - \hat{r}_F)$  in Equation (5.2) we get

$$\lambda_{Sx}\hat{X} + \lambda_{Sm}\hat{M} = (\lambda_{Sx}\theta_{KFx}A + \lambda_{Sm}\theta_{Km}B)\hat{P}_i \quad \dots \quad \dots \quad \dots \quad (5.3)$$

$$= C\hat{P}_i$$

where  $C = (\lambda_{Sx}\theta_{KFx}A + \lambda_{Sm}\theta_{Km}B)$

Using Equation (6) we can solve for  $(\hat{X})$  and then by substituting the value of  $(\hat{X})$  in Equation (5.3) the above equation can be further transformed and from that we can express  $\hat{M}$  in terms of  $\hat{P}_i$  (see the Appendix for details)

$$\hat{M} = \{C\hat{P}_i - \lambda_{Sx}(\hat{K}_F - \theta_{Sx}A\hat{P}_i)\} / \lambda_{Sm}$$

Again by differentiating Equation (7a) it can be written as

$$\lambda_{Ky}\hat{Y} + \lambda_{Ki}\hat{I} + \lambda_{Km}\hat{M} = (\hat{P}_i / |\theta|)(\lambda_{Ky}\theta_{Ly} + \lambda_{Ki}\theta_{Li}) - \lambda_{Km}\theta_{Sm}B\hat{P}_i \quad \dots \quad (7.2)$$

Pre-multiplying Equation (8.2) by  $\lambda_{Ky}$  and Equation (7.2) by  $\lambda_{Li}$  and then subtracting Equation (7.2) from (8.2) after some mathematical manipulation and by incorporating the value of  $\hat{M}$  we get

$$\hat{I}|\lambda| = \alpha\hat{P}_i - \{(\lambda_{Sx}\lambda_{Km}\lambda_{Ly}\hat{K}_F) / \lambda_{Sm}\} \dots \dots \dots \quad (7.3)$$

where

$$\begin{aligned} \alpha &= [D/|\theta| + E + \{(\lambda_{Km}\lambda_{Ly}C) / (\lambda_{Sm})\} + \{(\lambda_{Sx}\lambda_{Km}\lambda_{Ly}\theta_{Sx}A) / (\lambda_{Sm})\}] \\ D &= -(\lambda_{Ly}\lambda_{Ky}\theta_{Ky} + \lambda_{Li}\lambda_{Ky}\theta_{Ki} + \lambda_{Ki}\lambda_{Ly}\theta_{Li} + \lambda_{Ly}\lambda_{Ky}\theta_{Ly}) \\ E &= (\lambda_{Km}\lambda_{Ly}\theta_{Sm}B) \\ |\lambda| &= (\lambda_{Ky}\lambda_{Li} - \lambda_{Ki}\lambda_{Ly}) \end{aligned}$$

As  $(\lambda_{Ky} / \lambda_{Ly}) > (\lambda_{Ki} / \lambda_{Li})$

Therefore  $|\lambda| > 0$

On the basis of the assumption that the rural sector of the economy is much more capital-intensive than the urban informal sector of the economy, it can be concluded that  $|\theta| < 0$  and  $A > 0$ . Since  $|\theta| < 0$  and all  $\theta_{ij}$ s and  $\lambda_{ij}$ s are positive. Therefore  $B > 0$ ,  $C > 0$ ,  $E > 0$  and  $D < 0$ .

Since  $a_{Ix}$  is fixed, it implies  $\hat{X} = \hat{I}$

Therefore by incorporating the value of  $\hat{I} = (\hat{K}_F - \theta_{Sx}A\hat{P}_i)$  in the Equation (7.3) we get

$$\begin{aligned} \hat{P}_i / \hat{K}_F &= \{|\lambda| + (\lambda_{Sx}\lambda_{Km}\lambda_{Ly}) / (\lambda_{Sm})\} / \{\alpha + |\lambda|\theta_{Sx}A\} \\ \hat{P}_i / \hat{K}_F &> 0 \end{aligned}$$

Putting the value of  $\hat{P}_i$  in the expression (as obtained from Equation (3)) we get  $(\hat{W} / \hat{K}_F) = -[\theta_{Ky} \{|\lambda| + (\lambda_{Sx}\lambda_{Km}\lambda_{Ly}) / (\lambda_{Sm})\}] / [|\theta|\alpha + |\lambda|\theta_{Sx}A]$

Similarly, by incorporating the value of  $\hat{P}_i$  in the expression (as obtained from Equation (2)) we get

$$(\hat{W}_S / \hat{K}_F) = -\{(\theta_{Km} \theta_{Ly}) / (\theta | \theta_{Sm})\} [ \{|\lambda| + (\lambda_{Sx} \lambda_{Km} \lambda_{Ly}) / (\lambda_{Sm})\} / \{\alpha + |\lambda| \theta_{Sx} A\} ]$$

Subtracting  $(\hat{W}_S / \hat{K}_F)$  from  $(\hat{W} / \hat{K}_F)$  we get

$$\begin{aligned} & (\hat{W}_S - \hat{W}) / \hat{K}_F \\ & = G \{ (\theta_{Sm} \theta_{Ky} - \theta_{Km} \theta_{Ly}) / (\theta | \theta_{Sm}) \} \end{aligned}$$

where  $G = [ \{|\lambda| + (\lambda_{Sx} \lambda_{Km} \lambda_{Ly}) / (\lambda_{Sm})\} / \{\alpha + |\lambda| \theta_{Sx} A\} ]$

Since  $|\lambda| > 0, \alpha > 0, A > 0, |\theta| < 0$

Therefore  $G > 0$

Thus

$$(\hat{W}_S - \hat{W}) / \hat{K}_F > 0$$

iff  $(\theta_{Km} / \theta_{Sm}) > (\theta_{Ky} / \theta_{Ly})$

In this model, it has been assumed that the sector  $m$  uses skilled labour to produce its product whereas the sector  $y$ , which produces agricultural products, absorbs the unskilled labour to produce its product. The assumption  $(\theta_{Km} / \theta_{Sm}) > (\theta_{Ky} / \theta_{Ly})$  implies that for sector  $m$  capital per unit of skilled labour is higher than capital per unit of unskilled labour for sector  $y$ . Generally the sector that is dependent on skilled labour invests more on capital than the sector that is dependent on unskilled labour. In other words, capital used per unit of skilled labour is generally higher than the capital used per unit of unskilled labour. The reason is that the skilled workers are more trained and also more familiar, compared to that of the unskilled workers, to work with modern machineries and equipments. So the sector that uses skilled labour find it profitable to invest more on capital equipments per unit of skilled labour than the sector that uses unskilled labour. This is true in both physical and value terms. Thus it can be concluded that the skilled-unskilled wage gap of the economy rises with an increase in the foreign capital inflow.

We now consider the impact of foreign capital inflow on the total factor income of the economy when the foreign capital income is fully repatriated. It is given by

$$Z = WL + rK + SW_S \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (12)$$

Differentiating Equation (12) with respect to  $K_F$  we get

$$\begin{aligned} (dZ/dK_F) &= L (dW/dK_F) + K (dr/dK_F) + S (dW_S/dK_F) \\ &= (dr/dK_F) [K + L (dW/dr) + S (dW_S/dr)] \end{aligned}$$

Since we already know from competitive conditions (using Shephard-Samuelson relations) that

$$(dW/dr) = -(a_{Ky}/a_{Ly}) \text{ and } (dW_S/dr) = -(a_{Km}/a_{Sm})$$

therefore

$$\begin{aligned} (dZ/dK_F) &= (dr/dK_F) [K - L (a_{Ky}/a_{Ly}) - S (a_{Km}/a_{Sm})] \\ &= (dr/dK_F) [K - \{(K_y/L_y) L + (K_m/S_m) S\}] \\ &= (dr/dK_F) [K - K \{(K_y/K)/(L_y/L)\} - K \{(K_m/K)/(S_m/S)\}] \\ &= (dr/dK_F) K [1 - \{(\lambda_{Ky}/\lambda_{Ly}) + (\lambda_{Km}/\lambda_{Sm})\}] \end{aligned}$$

If we assume that the sum of the share of formal capital,  $K$ , with respect to the share of unskilled labour in sector  $Y$  and the share of formal capital,  $K$ , with respect to the share of skilled labour in sector  $M$  (in physical terms) is less than 1, i.e.  $\{(\lambda_{Ky}/\lambda_{Ly}) + (\lambda_{Km}/\lambda_{Sm})\} < 1$ , we find  $(dZ/dK_F) < 0$  as  $(dr/dK_F) < 0$

We summarise the results in the form of following proposition.

**Proposition 3.** *Trade liberalisation in the form of foreign capital inflow in an economy widens the skilled-unskilled wage gap of the economy, in the presence of an informal sector that produces an intermediate product on a subcontracting basis, if the following assumptions are satisfied (i) the rural sector of the economy is much more capital intensive than that of informal sector, and (ii) sector  $m$  uses more capital per unit of skilled labour as compared to the capital used by sector  $y$  per unit of unskilled labour. The foreign capital inflow with full repatriation of foreign capital income also reduces the level of welfare of the economy in the presence of informal sector provided the condition  $\{(\lambda_{Ky}/\lambda_{Ly}) + (\lambda_{Km}/\lambda_{Sm})\} < 1$  is satisfied.*

#### 4. CONCLUDING REMARKS

The paper has analysed the impact of liberalisation on the skilled-unskilled wage gap as well as on the level of welfare of the economy, in the presence of an informal sector. It has been considered both as final goods-producing and as intermediate goods-producing sector.

In the first part of the model we have considered that the informal sector of the model produces a final good, so that its price is internationally determined. While in the second part of the paper the informal sector produces an intermediate product for the formal sector,  $x$ , so its price is endogenously determined. In either case we observe that liberalisation widens the skilled-unskilled wage gap of the economy under reasonable conditions. But with an increase in the foreign capital inflow, the level of welfare of the economy increases, when the informal sector produces a final product. On the other hand, when the informal sector produces an intermediate product on a subcontracting basis, the level of welfare of the economy falls.

Although some economists have analysed the problem of impact of the foreign capital inflow on skilled-unskilled wage gap, the importance of the present exercise is that we have introduced the role of the informal sector to analyse the problem. For example, Ghosh and Gupta (2001) have considered a Harris-Todaro framework and analysed the same problem in the absence of the informal sector and obtained contrary to our results. However, for a developing economy one cannot ignore the role of the informal sector. Once it is introduced, one can obtain interesting results and empirically more valid results, for less developed countries. Our model can be considered as a generalisation of the Acharyya and Marjit's (2000) model. Here we have considered the issue of the foreign capital inflow, and also both the final goods-producing and intermediate goods-producing informal sectors, while Acharyya and Marjit (2000) have considered only intermediate goods-producing informal sector. Moreover, in our paper we have considered a four-sector division of the economy to capture more clearly the features of a developing economy.

Our paper would have been more interesting if both final goods-producing and intermediate goods-producing sectors were considered simultaneously to analyse the problem. Apart from this, one can take into account the environmental aspects associated with the expansion of the informal sector. We want to take up all these issues for our future research agenda.

## APPENDIX

### Basic Model

#### *Proof of Proposition 1*

Totally differentiating Equation (5.1) and (7.1) and rearranging in matrix form we get

$$\begin{pmatrix} \psi'(r)K_F + a'_{Sm}M & a_{Sm} \\ Ma'_{Km} + a'_{Ky}Y + a_{Ky}Y' & a_{Km} \end{pmatrix} \begin{pmatrix} dr \\ dM \end{pmatrix} = \begin{pmatrix} -\psi dK_F \\ 0 \end{pmatrix}$$

The value of determinant matrix is given by

$$\Delta = \psi'(r)K_F a_{Km} + a'_{Sm}M a_{Km} - a'_{Km}M a_{Sm} - a'_{Ky}Y a_{Sm} - a_{Ky}Y' a_{Sm} \quad (i)$$

Since all the input-output ratios are positive and  $\psi'(r) > 0$ ,  $a'_{Sm} > 0$ ,  $a'_{Km} < 0$ ,  $a'_{Ky} < 0$  and  $Y' < 0$ .

Therefore

$$\Delta > 0.$$

Now using Cramer's rule we have

$$(dr/dK_F) = -\{\psi(r) a_{Km}\} / \Delta$$

$$\text{or } (dr/dK_F) < 0$$

Similarly

$$(dM/dK_F) = \{\psi(a'_{Km}M + a'_{Ky}Y + a_{Ky}Y)\} / \Delta$$

$$\text{or } (dM/dK_F) < 0$$

In order to examine the impact of liberalisation on the skilled-unskilled wage gap of the economy ( $W_S/W$ ), we have to compare the change in  $W_S$  and  $W$  due to increase in  $K_F$ .

$$\text{i.e. } \log W_S - \log W = \log y$$

Totally differentiating Equations (2) and (3), using the envelope conditions and then dividing the equations by  $P_m$  and  $P_y$ , respectively we get

$$(dP_m/P_m) = (a_{Sm} W_S/P_m) (dW_S/W_S) + (a_{Km}r/P_m) (dr/r) \quad \dots \quad \text{(ii)}$$

$$(dP_y/P_y) = (a_{Ly}W/P_y) (dW/W) + (a_{Ky}r/P_y) (dr/r) \quad \dots \quad \text{(iii)}$$

It is to be noted that in the above derivations, by the envelope conditions we get

$$W_S da_{Sm} + r da_{Km} = 0$$

$$\text{and } W da_{Ly} + r da_{Ky} = 0$$

Again, since  $P_m$  and  $P_y$  are exogenously given

$$(dP_m/P_m) = (dP_y/P_y) = 0$$

Therefore Equation (ii) and Equation (iii) can be transformed as

$$0 = \theta_{Sm} \hat{W}_S + \theta_{Km} \hat{r} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \text{(iv)}$$

$$0 = \theta_{Ly} \hat{W} + \theta_{Ky} \hat{r} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \text{(v)}$$

where

$$\hat{W}_S = (dW_S/W_S), \hat{W} = (dW/W) \quad \text{and} \quad \hat{r} = (dr/r)$$

Thus we get

$$\hat{W} = -(\theta_{Ky}/\theta_{Ly}) \hat{r}$$

$$\text{and } \hat{W}_S = -(\theta_{Km}/\theta_{Sm}) \hat{r}$$

Subtracting  $\hat{W}$  from  $\hat{W}_S$  we get

$$(\hat{W}_S - \hat{W}) = \hat{r} [(\theta_{Ky}/\theta_{Ly}) - (\theta_{Km}/\theta_{Sm})]$$



From sufficient conditions we get

$$(\theta_{Ky} / \theta_{Ly}) < (\theta_{Km} / \theta_{Sm})$$

and  $(\hat{r} / \hat{K}_F) < 0$  (already proved)

therefore

$$(\hat{W}_S - \hat{W}) / \hat{K}_F > 0$$

### The Alternative Version of the Model

#### Proof of the Proposition 3

Differentiating Equation (3) and Equation (4a), using the envelope conditions and also using hat mathematics we can rewrite the equations as

$$0 = \theta_{Ly} \hat{W} + \theta_{Ky} \hat{r}$$

$$\hat{P}_i = \theta_{Li} \hat{W} + \theta_{Ki} \hat{r}$$

(Since  $P_y$  is exogenously given, therefore  $P_y = 0$ )

By Cramer's rule we get

$$\hat{W} = -(\theta_{Ky} / |\theta|) \hat{P}_i \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (i)$$

and

$$\hat{r} = (\theta_{Ly} / |\theta|) \hat{P}_i \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (ii)$$

where

$$\begin{aligned} |\theta| &= (\theta_{Ly} \theta_{Ki} - \theta_{Ky} \theta_{Li}) \\ &= (\theta_{Ki} / \theta_{Li}) - (\theta_{Ky} / \theta_{Ly}) \end{aligned}$$

Since the rural sector is more capital intensive than the informal sector

therefore  $(\theta_{Ki} / \theta_{Li}) < (\theta_{Ky} / \theta_{Ly})$

i.e.  $|\theta| < 0$

Similarly differentiating Equation (2), using the envelope condition and also using hat mathematics we get

$$\theta_{Sm} \hat{W}_S + \theta_{Km} \hat{r} = 0$$

Putting the value of  $\hat{r}$  (Equation (ii)) we get

$$\hat{W}_S = -\{(\theta_{Km} \theta_{Ly}) / (|\theta| \theta_{Sm})\} \hat{P}_i \quad \dots \quad \dots \quad \dots \quad \dots \quad (iii)$$

Similarly from Equation (1a) and by using the value of  $\hat{W}_S$  (Equation (iii)) we get

$$\hat{r}_F = -[\{\theta_{Lx} |\theta| \theta_{Sm} - \theta_{Sx} \theta_{Km} \theta_{Ly}\} / \{\theta_{Sm} |\theta| \theta_{KFx}\}] \hat{P}_i \quad \dots \quad \dots \quad (iv)$$

By using the value of  $\hat{W}_S$  (Equation (iii)),  $\hat{r}_F$  (Equation (iv)),  $\hat{r}$  (Equation (ii)) we can calculate

$$\begin{aligned} (\hat{W}_S - \hat{r}_F) &= -\{\theta_{Km}\theta_{Ly} / \theta_{Sm}|\theta|\}\hat{P}_i + \{(\theta_{Lx}\theta_{Sm}|\theta| - \theta_{Sx}\theta_{Km}\theta_{Ly}) / (\theta_{Sm}|\theta|\theta_{KFx})\}\hat{P}_i \\ &= -\{(\theta_{Km}\theta_{Ly}\theta_{KFx} - \theta_{Lx}\theta_{Sm}|\theta| + \theta_{Sx}\theta_{Km}\theta_{Ly}) / (\theta_{Sm}|\theta|\theta_{KFx})\}\hat{P}_i \\ &= A\hat{P}_i \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \end{aligned} \quad (v)$$

where

$$A = -\{(\theta_{Km}\theta_{Ly}\theta_{KFx} - \theta_{Lx}\theta_{Sm}|\theta| + \theta_{Sx}\theta_{Km}\theta_{Ly}) / (\theta_{Sm}|\theta|\theta_{KFx})\} \quad \dots \quad \dots \quad (vi)$$

therefore  $A > 0$

and

$$\begin{aligned} (\hat{W}_S - \hat{r}) &= \{-\theta_{Km}\theta_{Ly} / (\theta_{Sm}|\theta|) - (\theta_{Ly}) / (|\theta|)\}\hat{P}_i \\ &= (-\hat{P}_i\theta_{Ly}) / (\theta_{Sm}|\theta|) = B\hat{P}_i \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \end{aligned} \quad (vii)$$

where

$$B = \{-\theta_{Ly} / (\theta_{Sm}|\theta|)\} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (viii)$$

therefore  $B > 0$

and

$$(\hat{W} - \hat{r}) = -\{\hat{P}_i(\theta_{Ky} + \theta_{Ly})\} / (|\theta|) = -\hat{P}_i / |\theta| \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (ix)$$

Differentiating Equation (8) we get

$$\lambda_{Ly}\hat{Y} + \lambda_{Li}\hat{I} = -(\lambda_{Ly}\hat{a}_{Ly} + \lambda_{Li}\hat{a}_{Li}) \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (x)$$

where  $\lambda_{ij}$  represent the share of  $i$ th input in the product of  $j$ th sector. We know that the elasticity of substitution of the sector  $y$  is given by

$$\begin{aligned} \sigma_y &= (\hat{a}_{Ky} - \hat{a}_{Ly})(\hat{W} - \hat{r}) \\ \text{or } \sigma_y(\hat{W} - \hat{r}) &= (\hat{a}_{Ky} - \hat{a}_{Ly}) \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (xi) \end{aligned}$$

By applying envelope theorem, Equation (3) can be rewritten as

$$\begin{aligned} Wda_{Ly} + rda_{Ky} &= 0 \\ \text{or } \theta_{Ly}\hat{a}_{Ly} + \theta_{Ky}\hat{a}_{Ky} &= 0 \end{aligned}$$

Therefore  $\hat{a}_{Ky} = -(\theta_{Ly} / \theta_{Ky})\hat{a}_{Ly}$

Thus

$$\begin{aligned} \hat{a}_{Ky} - \hat{a}_{Ly} &= -(\theta_{Ly} / \theta_{Ky})\hat{a}_{Ly} - \hat{a}_{Ly} \\ &= -\hat{a}_{Ly}(\theta_{Ly} + \theta_{Ky}) / (\theta_{Ky}) \\ &= -(\hat{a}_{Ly} / \theta_{Ky}) \end{aligned}$$

Replacing  $(-\hat{a}_{Ly} / \theta_{Ky})$  in place of  $(\hat{a}_{Ky} - \hat{a}_{Ly})$  in Equation (xi) we get

$$\sigma_y(\hat{W} - \hat{r}) = -\hat{a}_{Ly} / \theta_{Ky}$$

therefore  $\sigma_y(\hat{W} - \hat{r})\theta_{Ky} = -\hat{a}_{Ly}$

Since the production function is a Cobb- Douglas production, therefore  $\sigma_y = 1$   
Thus,

$$(\hat{W} - \hat{r})\theta_{Ky} = -\hat{a}_{Ly}$$

Similarly with the help of Equation (4a) we get the value of  $\hat{a}_{Li}$

$$-\hat{a}_{Li} = \theta_{Ki}(\hat{W} - \hat{r})$$

Substituting the value of  $\hat{a}_{Ly}$  and  $\hat{a}_{Li}$  in Equation (x) we get

$$\lambda_{Ly}\hat{Y} + \lambda_{Li}\hat{I} = (\lambda_{Ly}\theta_{Ky} + \lambda_{Li}\theta_{Ki})(\hat{W} - \hat{r})$$

Putting the value of  $(\hat{W} - \hat{r})$  (Equation (ix)) we get

$$\lambda_{Ly}\hat{Y} + \lambda_{Li}\hat{I} = -\{(\lambda_{Ly}\theta_{Ky} + \lambda_{Li}\theta_{Ki})\hat{P}_i\} / |\theta| \quad \dots \quad \dots \quad \dots \quad \text{(xii)}$$

Similarly by differentiating Equation (5) and by incorporating the value  $-\hat{a}_{Sx}$  and  $-\hat{a}_{Sm}$  (as obtained from Equation (1a) and (2)) we get

$$\lambda_{Sx}\hat{X} + \lambda_{Sm}\hat{M} = \lambda_{Sx}\theta_{KFx}(\hat{W}_S - \hat{r}_F) + \theta_{Km}\lambda_{Sm}(\hat{W}_S - \hat{r}) \quad \dots \quad \dots \quad \text{(xiii)}$$

Putting the value of  $(\hat{W}_S - \hat{r}_F)$  (Equation (v)) and  $(\hat{W}_S - \hat{r})$  (Equation (vii)) in Equation (xiii) we get

$$\begin{aligned} \lambda_{Sx}\hat{X} + \lambda_{Sm}\hat{M} &= (\lambda_{Sx}\theta_{KFx}A + \theta_{Km}\lambda_{Sm}B)\hat{P}_i \\ &= C\hat{P}_i \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \text{(xiv)} \end{aligned}$$

where  $C = (\lambda_{Sx}\theta_{KFx}A + \theta_{Km}\lambda_{Sm}B)$



where

$$\begin{aligned} |\lambda| &= [\lambda_{Ky}\lambda_{Li} - \lambda_{Ly}\lambda_{Ki}] \\ D &= [-\lambda_{Ky}\lambda_{Ly}\theta_{Ky} - \lambda_{Ky}\lambda_{Li}\theta_{Ki} - \lambda_{Ly}\lambda_{Ky}\theta_{Ly} - \lambda_{Ly}\lambda_{Ki}\theta_{Li}] \\ E &= \lambda_{Ly}\lambda_{Km}\theta_{Sm}B \end{aligned}$$

Since  $B > 0$ ,  $(\lambda_{Ky} / \lambda_{Ly}) > (\lambda_{Ki} / \lambda_{Li})$ , therefore  $|\lambda| > 0$ ,  $D < 0$  and  $E > 0$ .

Putting the value of  $\hat{M}$  in Equation (xxi) we get

$$\begin{aligned} \hat{I}|\lambda| &= D(\hat{P}_i / |\theta|) + E\hat{P}_i + \{(\lambda_{Ly}\lambda_{Km}C\hat{P}_i) / \lambda_{Sm}\} - \{\lambda_{Sx}\lambda_{Km}\lambda_{Ly}\} / \lambda_{Sm} \hat{K}_F \\ &+ \{(\lambda_{Sx}\lambda_{Km}\lambda_{Ly}\theta_{Sx}A) / \lambda_{Sm}\} \hat{P}_i \\ \hat{P}_i &= [D/|\theta| + E + \{(\lambda_{Ly}\lambda_{Km}C) / (\lambda_{Sm})\} + \{(\lambda_{Sx}\lambda_{Km}\lambda_{Ly}\theta_{Sx}A) / (\lambda_{Sm})\}] \\ &- \{(\lambda_{Sx}\lambda_{Km}\lambda_{Ly}) / \lambda_{Sm}\} \hat{K}_F \\ \hat{I}|\lambda| &= \alpha \hat{P}_i - \{(\lambda_{Sx}\lambda_{Km}\lambda_{Ly}) / \lambda_{Sm}\} \hat{K}_F \quad \dots \quad \dots \quad \dots \quad \dots \quad (xxii) \end{aligned}$$

where  $\alpha = [D/|\theta| + E + \{(\lambda_{Ly}\lambda_{Km}C) / (\lambda_{Sm})\} + \{(\lambda_{Sx}\lambda_{Km}\lambda_{Ly}\theta_{Sx}A) / (\lambda_{Sm})\}]$

Since  $D < 0$ ,  $E > 0$ ,  $C > 0$ ,  $A > 0$  and  $|\theta| < 0$ , therefore  $\alpha > 0$

Since  $a_{Lx}$  is fixed, therefore  $\hat{a}_{Lx} = 0$

Thus  $\hat{I} = \hat{X}$  (from Equation (9a))

By replacing the value  $\hat{I} = (\hat{K}_F - \theta_{Sx}A\hat{P}_i)$  in Equation (xxii) we get

$$\hat{K}_F|\lambda| - |\lambda|\theta_{Sx}A\hat{P}_i = \alpha\hat{P}_i - \{(\lambda_{Sx}\lambda_{Km}\lambda_{Ly}) / \lambda_{Sm}\} \hat{K}_F$$

Therefore

$$\hat{P}_i / \hat{K}_F = [|\lambda| + \{(\lambda_{Sx}\lambda_{Km}\lambda_{Ly}) / (\lambda_{Sm})\}] / \{\alpha + |\lambda|\theta_{Sx}A\} \quad \dots \quad \dots \quad (xxiii)$$

Since  $|\lambda| > 0$ ,  $\alpha > 0$  and  $A > 0$

Therefore  $(\hat{P}_i / \hat{K}_F) > 0$

Now we consider the value of  $(\hat{W} / \hat{K}_F)$

Putting the value of  $\hat{P}_i$  (from Equation (xxiii)) in the equation

$$\hat{W} = -(\theta_{Ky} / |\theta|)\hat{P}_i$$

We get

$$\hat{W} = -[\{\theta_{Ky} / |\theta|\} [|\lambda| + \{(\lambda_{Sx}\lambda_{Km}\lambda_{Ly}) / (\lambda_{Sm})\}] / \{\alpha + |\lambda|\theta_{Sx}A\}] \hat{K}_F$$

Therefore

$$(\hat{W} / \hat{K}_F) = -[\theta_{Ky} \{|\lambda| + (\lambda_{Sx} \lambda_{Km} \lambda_{Ly}) / (\lambda_{Sm})\}] / [|\theta| \alpha + |\lambda| |\theta_{Sx} A] \quad \dots \quad (\text{xxiv})$$

Similarly we get

$$(\hat{W}_S / \hat{K}_F) = -\{(\theta_{Km} \theta_{Ly}) / |\theta| \theta_{Sm}\} [\{|\lambda| + (\lambda_{Sx} \lambda_{Km} \lambda_{Ly}) / (\lambda_{Sm})\} / \{\alpha + |\lambda| \theta_{Sx} A\}] \quad (\text{xxv})$$

therefore  $(\hat{W}_S - \hat{W}) / \hat{K}_F = (\hat{W}_S / \hat{K}_F) - (\hat{W} / \hat{K}_F)$

$$\begin{aligned} &= [\{|\lambda| + (\lambda_{Sx} \lambda_{Km} \lambda_{Ly}) / (\lambda_{Sm})\} / \{\alpha + |\lambda| \theta_{Sx} A\}] \\ &= [-\{(\theta_{Km} \theta_{Ly}) / (|\theta| \theta_{Sm})\} + \{\theta_{Ky} / |\theta|\}] \\ &= G [\{\theta_{Sm} \theta_{Ky} - \theta_{Km} \theta_{Ly}\} / \{|\theta| \theta_{Sm}\}] \end{aligned}$$

where  $G = [\{|\lambda| + (\lambda_{Sx} \lambda_{Km} \lambda_{Ly}) / (\lambda_{Sm})\} / \{\alpha + |\lambda| \theta_{Sx} A\}]$

since  $|\lambda| > 0$ ,  $\alpha > 0$ ,  $A > 0$

therefore  $G > 0$  and  $|\theta| < 0$

In this economy it has already been assumed that

$$(\theta_{Km} / \theta_{Sm}) > (\theta_{Ky} / \theta_{Ly})$$

therefore

$$(\hat{W}_S - \hat{W}) / \hat{K}_F > 0$$

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