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Dwibedi, Jayanta and Chaudhuri, Sarbajit
University of Calcutta

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Jayanta Kumar Dwibedi[a,ψ] and Sarbajit Chaudhuri[b]

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Abstract: This paper purports to examine the validity of the common belief that in a developing economy the backward agricultural sector should be subsidized as poorer group of the working population are employed in this sector that send their children out to work out of sheer poverty. A three-sector general equilibrium framework with agricultural dualism and child labour has been employed for the purpose of analysis. It finds that a price subsidy policy to backward agricultural sector is likely to aggravate the child labour incidence while a credit subsidy to advanced agriculture may be effective in reducing the gravity of the problem in the economy. The paper, therefore, questions the desirability of assisting backward agriculture for eradicating child labour in the society.

Keywords: Child labour, general equilibrium, agricultural dualism, subsidy policy.

JEL classification: D15, J10, J13, O 12, O17.

[a] Dept. of Economics, B.K.C. College, Kolkata , India. E-mail: jayantadw@rediffmail.com

[b] Dept. of Economics, University of Calcutta, India. E-mail: sarbajitch@yahoo.com

Address for communication: Dr. Jayanta Kumar Dwibedi,

[ψ] Corresponding author.

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1. Introduction

The incidence of child labour is one of the most disconcerting problems in the transitional societies of developing economies. According to ILO (2002), one in every six children aged between 5 and 17 - or 246 million children are involved in child labour.[1] If the "invisible" workers who perform unpaid and household jobs are included, it is likely that the estimates would shoot up significantly further.

Available empirical evidences suggest that the concentration of child labour is the highest in the rural sector of a developing economy and that child labour is used intensively directly or indirectly in the agricultural sector[2]. In backward agriculture, the production techniques are primitive, use of capital is very low and child labour can almost do whatever adult labour does. Farming in backward agriculture is mostly done by using bullocks and ploughs and the cattle-feeding is entirely done by child labour. Besides, at the time of sowing of seeds and harvest children are often used in the family farms for helping adult members of the family. The advanced agricultural sector on the other hand uses mechanised techniques of production and uses agricultural machineries like tractors, seeders/planters, sprayers and harvesters etc. and therefore does not require child labour in its production process. This type of agricultural dualism is a very common feature of the developing countries. The distinction between advanced and backward agriculture can be made on the basis of inputs used, economies of scale, efficiency and elasticity of substitution. Many of the farmers in the agricultural sector of a developing economy stick to old and unscientific methods of cultivation although in other parts of the economy the introduction of the so called 'Green Revolution' technology brought about revolutionary changes with respect to production technologies and use of modern inputs and the increase in factor productivity. However, the improved technology was designed for the best areas (irrigation, high

[1] Out of 246 million about 170 million child workers were found in different hazardous works. Some 8.4 million children were caught in the worst forms of child labour including slavery, trafficking, debt bondage and other forms of forced labour, forced recruitment for armed conflict, prostitution, pornography and other illicit activities (ILO, June 2002).

[2] According to the ILO (2002) report (figure 4, pp. 36), more than 70 per cent of economically active children in the developing countries are engaged in agriculture and allied sectors.

soil fertility) with chemical-intensive technology. Although, Green Revolution has modernized agricultural technology, it is limited only to a few parts of a developing economy and only rich (large) farmers have been benefited from it. The small and marginal farmers continue to depend on rain-fed backward agricultural technique. Therefore, the adoption of the Green Revolution technology has led to an increase in the extent of agricultural dualism in a developing economy.

The existing theoretical literature on child labour[3], however, has not paid any attention so far to this kind of agricultural dualism and its implications on the problem of child labour. This is important because from the view point of the use of child labour, these two types of agricultural sectors differ and any changes in their output composition will affect the magnitude of child labour use in the agricultural sector. Agriculture in many countries is supported by government's subsidy policies in the form of price support, export subsidy and credit support etc. In a developing country like India, farmers in backward agriculture are given price support to protect them from sharp fall in their produce during the times of over supply in the market. Government's Minimum Support Price mechanism is a very common form of government subsidy policy directed towards backward agriculture to ensure remunerative prices to farmers. Government also provides subsidised credit to encourage mechanised farming and increase productivity. Institutional credit at a subsidised rate is being provided to the farmers for the purchase of different kinds of farm machines like tractors, trailers, power tillers etc. These types of subsidy schemes are designed to benefit the poorer section of the working population who are the potential suppliers of child labour. It is therefore natural to expect that these fiscal measures will raise the earning opportunities of the poor households which in turn will lower the supply of child labour through positive income effect. However, the matter is not as straightforward as it appears to be at the first sight. Apart from their impact on adult wages, these fiscal policies affect the relative output compositions of the two agricultural sectors and the earning opportunities of children as well. Expansion/contraction of any form of agriculture at the cost of the other will affect the demand for child labour and therefore their price. An expansion of backward agriculture resulting from a price subsidy policy given to that sector, for example, will create more demand for child labour and raise the use of child labour in the economy. Even if there is a

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[3] See Basu an Van (1998), Basu (1999), Gupta (2000, 2002), Jaferey and Lahiri (2002), Ranjan (1999, 2001), Baland and Robinson (2000), Chaudhuri (2009), Chaudhuri and Dwibedi (2006, 2007), Dwibedi and Chaudhuri (2009) among others. In the literature the supply of child labour has been attributed to factors such as abject poverty, lack of educational facilities and poor quality of schooling, capital market imperfection, parental attitudes including the objectives to maximize present income etc.

positive income effect due to increase in adult wages, the net effect on child labour is ambiguous. Any policy effect on the child labour incidence, therefore, should be carried out in a multi-sector general equilibrium framework to capture various linkages that may exist in the system.

The present paper is designed to examine the implications of two different types of subsidy policies to the agricultural sectors of an economy on the child labour incidence in a general equilibrium framework. We consider a three-sector full-employment model with child labour. The economy is divided into two agricultural and one manufacturing sectors. One of the two agricultural sectors (sector 1) is the advanced agricultural sector that produces it output by means of adult labour, land and capital. The other agricultural sector, we call it backward agriculture (sector 2), also produces an agricultural commodity using adult labour, land and child labour. Finally, sector 3 produces a manufacturing product with the help of adult labour and capital. In this setup we have examined the consequences of a credit subsidy policy to advanced agricultural sector and a price subsidy policy designed to benefit backward agriculture on the aggregate supply of child labour in the economy. We have found that a price subsidy policy to backward agricultural sector is likely to be counterproductive while a credit subsidy to advanced agriculture may be effective in lessening the prevalence of child labour in the economy. The paper, therefore, questions the desirability of assisting backward agriculture so as to eradicate the problem of child labour in the society.

2. The model

We consider a small open economy with three sectors: two agricultural and one manufacturing sector. Sector 1 is the advanced agricultural sector that produces its output, X_1, by means of adult labour (L), land (N) and capital (K). The other agricultural sector, we call it backward agriculture (sector 2), produces its output, X_2, using adult and child labour (L_C) and land. Sector 2 does not require capital for its production. The land-output ratios in sectors 1, and 2 (a_{N1} and a_{N2}) are assumed to be technologically given. This assumption can be defended as follows. In one hectare of land the number of saplings that can be sown is given. There should be a minimum gap between two saplings and land cannot be substituted by other factors of production. Besides, empirical evidence from developing countries, like India, suggests that the productivity per hectare of land has remained more or less unchanged over a long period of time.[4]

It is sensible to assume that the backward agricultural sector is more adult labour-intensive vis-à-vis the advanced agricultural sector with respect to land. This implies that $\frac{a_{L2}}{a_{N2}} > \frac{a_{L1}}{a_{N1}}$, where a_{ji}s are input-output ratios. Available empirical evidence suggests that the concentration of child labour is the highest in the rural sector of a developing economy and that child labour is used intensively directly or indirectly in backward agriculture that uses primitive production techniques. The advanced agricultural sector, on the other hand, uses mechanised techniques of production and does not require child labour in production. Child labour is therefore specific to backward agriculture. The two agricultural sectors are the two informal sectors in the sense that the adult workers receive competitive wage, W, and these are the two export sectors of the economy. The formal sector (sector 3) is the import-competing sector that produces a manufacturing commodity, X_3 using adult labour and capital. The formal sector faces a unionised labour market where workers receive a contractual wage $\bar{W}$ with $\bar{W} > W$. The adult labour allocation mechanism is the following. Adult workers first try to get employment in the formal sector that offers the higher wage and those who are unable to find employment in the said sector are automatically absorbed in the two informal sectors, as the wage rate there is perfectly flexible. Capital is completely mobile between sectors 1 and 3. Owing to the small open economy assumption all the three commodity prices, P_is, are given internationally. Competitive markets, excepting the formal labour market, constant returns to scale technologies with positive and diminishing marginal productivities of inputs and full-employment of resources are assumed. Commodity 1 is chosen as the numeraire.

The following three equations present the zero-profit conditions relating to the three sectors of the economy.

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[4] In case of India, per hectare wheat production was 2708 kg in 2000-01 and it remained at 2708 kg per hectare even for the year 2006-07. Besides, per hectare food grains production was 1734 kg in 2001-02 and the corresponding figure for the year 2006-07 was 1756 kg indicating fairly constant land-output ratio.

$$Wa_{L1} + Ra_{N1} + r(1 - S_r)a_{K1} = 1 \tag{1}$$

$$Wa_{L2} + W_C a_{C2} + Ra_{N2} = P_2(1 + S_P) \tag{2}$$

$$\overline{W}a_{L3} + ra_{K3} = P_3 \tag{3}$$

where R, r and W_C stand for return to land, return to capital and child wage rate, respectively. S_r is the ad-valorem rate of credit subsidy[5] given to the advanced agricultural sector and S_P stands for the rate of ad-valorem price subsidy given to backward agriculture.

Complete utilization of adult labour, capital, land and child labour imply the following four equations, respectively.

$$a_{L1}X_1 + a_{L2}X_2 + a_{L3}X_3 = L \tag{4}$$

$$a_{K1}X_1 + a_{K3}X_3 = K \tag{5}$$

$$a_{N1}X_1 + a_{N2}X_2 = N \tag{6}$$

$$a_{C2}X_2 = L_C \tag{7}$$

While endowments of adult labour, land and capital are fixed in the economy, the aggregate supply of child labour, L_C, is endogenous and is determined from the utility maximizing behavior of the households.

2.1. Household behaviour

We derive the supply function of child labour from the utility maximizing behaviour of the representative altruistic poor household. There are L numbers of working families, which are classified into two groups with respect to the earnings of their adult members. The adult workers who work in the higher paid formal manufacturing sector comprise the richer section of the working population. On the contrary, labourers who are engaged in the informal agricultural sectors constitute the poorer section. There is now considerable evidence and theoretical reason for believing that, in developing countries, parents send their children to work out of sheer

[5] It is easy to check that a price subsidy policy to advanced agriculture also produces the same effects.

poverty. Following the '*Luxury Axiom*'[6] of Basu and Van (1998), we assume that there exists a critical level of family (or adult labour) income, W^*, such that the parents will send their children out to work if and only if the actual adult wage rate is less than this critical level. We assume that each worker in the formal manufacturing sector earns a wage income, $\bar{W}$, sufficiently higher than this critical level[7]. So, the workers of the formal sector do not send their children to work. On the other hand, adult workers employed in the two agricultural sectors earn W amount of wage income, which is less than the critical wage, W^*, and therefore send some of their children to the job market to supplement low family income.

The supply function of child labour by each poor working family is determined from the utility maximizing behaviour of the representative altruistic household who works in the agricultural sectors. We assume that each working family consists of one adult member and 'n' number of children. The altruistic adult member of the family (guardian) decides the number of children to be sent to the work place (l_C). The utility function of the household is given by

$$U = U(C_1, C_2, C_3, (n - l_C))$$

The household derives utility from the consumption of the three commodities, C_i s and from the children's leisure. For analytical simplicity let us consider the following Cobb-Douglas type of the utility function.

$$U = A(C_1)^{\alpha}(C_2)^{\beta}(C_3)^{\rho}(n - l_C)^{\gamma} \tag{8}$$

with $A > 0$, $1 > \alpha, \beta, \rho, \gamma > 0$; and, $(\alpha + \beta + \rho + \gamma) = 1$.

It satisfies all the standard properties and it is homogeneous of degree 1.

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[6] Basu and Van (1998) have shown that if child labour and adult labour are substitutes (Substitution Axiom) and if child leisure is a luxury commodity to the poor households (Luxury Axiom), unfavourable adult labour market, responsible for low adult wage rate, is the driving force behind the incidence of child labour. According to the Luxury Axiom, there exists a critical level of adult wage rate, and any adult worker earning below this wage rate, considers himself as poor and does not have the luxury to send his offspring to schools. He is forced to send his children to the job market to supplement low family income out of sheer poverty.

[7] We can also quantify this critical value in our model. From equation (10) we can say that $l_C = 0$ if $\bar{W} \geq \frac{n(1-\gamma)W_C}{\gamma}$.

The household maximizes its utility subject to the following budget constraint.

$$P_1C_1 + P_2C_2 + P_3C_3 = (W_C l_C + W) \tag{9}$$

where, W is the income of the adult worker and $W_C l_C$ measures the income from child labour.

Maximizing the utility function subject to the above budget constraint and solving for l_C the following family child labour supply function can be derived.[8]

$$l_C = \{(1-\gamma)n - \gamma(W / W_C)\} \tag{10}$$

From (10) it is easy to check that l_C varies negatively with the adult wage rate, W. A rise in W produces a positive income effect so that the adult worker chooses more leisure for his children and therefore decides to send a lower number of children to the workplace. An increase in W_C, on the other hand, produces a negative price effect, which increases the supply of child labour from each family.[9]

There are $L_I (= L - a_{L3}X_3)$ number of adult workers engaged in the two informal sectors and each of them sends l_C number of children to the workplace. Thus, the aggregate supply function of child labour in the economy is given by

$$L_C = [(1-\gamma)n - \gamma(W / W_C)](L - a_{L3}X_3) \tag{11}$$

2.2. The General Equilibrium Analysis

Using (11), equation (7) can be rewritten as

$$a_{C2}X_2 = [(1-\gamma)n - \gamma(W / W_C)](L - a_{L3}X_3) \tag{7.1}$$

The general equilibrium structure of the economy is represented by equations (1) – (6), (7.1) and (11). There are eight endogenous variables in the system: $W, W_C, R, r, X_1, X_2, X_3$ and L_C and

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[8] See Appendix I for mathematical derivation.

[9] It may be checked that the results of this paper hold for any utility function generating a supply function of child labour that satisfies these two properties.

eight independent equations (namely equations (1) – (6), (7.1) and (11). The parameters in the system are: $P_2, P_3, L, K, N, \bar{W}, \alpha, \beta, \rho, \gamma, n, S_r$ and S_P. Equations (1) – (3) constitute the price system. This is an indecomposable system with three price equations and four factor prices, W, W_C, r and R. So factor prices depend on both commodity prices and factor endowments. Given the child wage rate, sectors 1 and 2 together effectively form a modified Heckscher-Ohlin system as they use both adult unskilled labour and land in their production. Given the world prices and the unionised wage $\bar{W}$, r is determined from equation (3). Now W, W_C, R, X_1, X_2 and X_3 are simultaneously obtained from equation (1), (2), (4) – (6) and (7.1). Finally, L_C is determined from (11).

3. Comparative Statics

The two agricultural sectors receive subsidies from the government. The subsidy schemes are designed to benefit the poorer section of the working population who are the potential suppliers of child labour. The conventional wisdom is that these fiscal measures will raise the adult incomes of the poor households which in turn lower the supply of child labour through positive income effect. This section is aimed at examining the efficacies of the two subsidy policies in mitigating the child labour problem in the economy. Two different subsidies are given to the two agricultural sectors. The advanced agricultural sector receives a credit subsidy at the rate S_r while the backward agricultural sector gets a price subsidy at the rate S_P.

For determining the consequences of the subsidy policies on the child labour incidence after totally differentiating equation (1), (2), (4) –(6) and (7.1) and solving by Cramer's rule the following two propositions can be established[10].

PROPOSITION 1: A credit subsidy policy to advanced agriculture leads to (i) decreases in both adult wage, W, and child wage, W_C; (ii) an increase in the (W / W_C) ratio thereby lowering the supply of child labour by each poor working family; (iii) an expansion (a contraction) of the advanced (backward) agricultural sector; and, (iv) an expansion of the manufacturing sector if

[10] See Appendix II for detailed derivations.

$\{S^1_{KL}\left|\lambda^{12}_{NL}\right| + \lambda_{N2}\lambda_{L1}S^1_{LL}\} \geq 0$ □[11]. On the other hand, a price subsidy policy to backward agriculture produces the exactly opposite effects on the wages, family supply of child labour and the composition of output of the economy.

Proposition 1 can be explained in economic terms in the following fashion. As r is determined from the zero profitability condition for sector 3 (equation (3)) and remains unchanged despite a change in S_r and S_P, sectors 1 and 2 together can effectively be regarded as a *Modified Hechscher-Ohlin subsystem (MHOSS)*. The modification is due to the fact that those two sectors use adult labour and land, apart from the fact that sector 2 uses child labour and sector 1 uses capital as inputs. An increase in S_r (which effectively implies an increase in the price of commodity 1) raises the rate of return to land, R and lowers the adult wage, W following a *Stolper-Samuelson effect,* as sector 2 is more adult labour-intensive than sector 1 with respect to land. This generates a *Rybczynski type effect* and produces an expansionary (a contractionary) effect on sector 1 (sector 2). This is a well-known result in the theory of international trade that a *Stolper-Samuelson effect* contains an element of *Rybczynski effect* if the technologies of production are of the variable coefficient type. As sector 2 contracts the demand for child labour falls as this is specific to this sector. Consequently, the child wage rate falls. It is easy to check that the proportionate fall in child wage rate is greater than that in adult wage so that (W/W_C) rises. This lowers the supply of child labour by each working family, l_C. As S_r increase the effective price of capital net of subsidy falls. But the adult wage rate has also fallen. It can be easily shown that wage-rental ratio falls and producers in sector 1 substitute capital by labour resulting in a decrease in a_{K1}. But as sector 1 has expanded the net effect on the demand for capital in sector 1 is ambiguous. However, it can be proved that capital demand falls in sector 1 under the sufficient condition that $\{S^1_{KL}\left|\lambda^{12}_{NL}\right| + \lambda_{N2}\lambda_{L1}S^1_{LL}\} \geq 0$. If this happens the released capital goes to sector 3 thereby causing it to expand. On the contrary, a price subsidy to backward agriculture produces exactly the opposite effects on factor prices and output

[11] Here S^k_{ji} is the degree of substitution between factors j and i in the kth sector with $S^k_{ji} > 0$ for $j \neq i$; and, $S^k_{jj} < 0$ while λ_{ji} is the allocative share of jth input in ith sector. Besides, $\left|\lambda^{12}_{NL}\right| = (\lambda_{N1}\lambda_{L2} - \lambda_{L1}\lambda_{N2}) > 0$ as the backward agriculture (sector 2) is more adult labour-intensive vis-à-vis the advanced agriculture (sector 1) with respect to land.

composition. The supply of child labour by each poor working families rises and sector 3 contracts under the same sufficient as stated above.

3.1 Agricultural subsidy policies and incidence of child labour

For examining the implications of the subsidy policies on the incidence of child labour in the economy we use the aggregate child labour supply function, which is given by equation (11). We note that any policy affects the supply of child labour in two ways: (i) through a change in the size of the informal sector adult labour force, $(L_I = L - a_{L3}X_3)$, as these families are considered to be the suppliers of child labour; and, (ii) through a change in l_C (the number of child workers supplied by each poor family), which results from a change in the (W / W_C) ratio. Differentiating equation (11) the following proposition can be proved.[12]

PROPOSITION 2: A credit subsidy to the advanced agricultural sector is effective in reducing the gravity of the problem of child labour in the economy either if $\{S^1_{KL}\left|\lambda^{12}_{NL}\right| + \lambda_{N2}\lambda_{L1}S^1_{LL}\} \geq 0$; or if, $S^2_{LC}S^1_{KL} \geq S^2_{CC}S^1_{LL}$. On the contrary, a price subsidy policy directed towards backward agriculture aggravates the child labour problem under anyone of the above two sufficient conditions.

As explained previously, a credit subsidy policy to advanced agriculture raises the (W / W_C) ratio, which in turn lowers the supply of child labour from each poor working family. On the other hand, as the formal sector expands the number of poor working families, which are considered to be the suppliers of child labour, $(L - a_{L3}X_3)$, decreases. So, we have a situation where there is less number of poor families each supplying less number on child labors. So the supply of child labour unambiguously falls. A price subsidy policy to backward agriculture produces exactly the opposite effects thereby raising the supply of child labour in the society.

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[12] This has been derived in Appendix IV.

4. Conclusion remarks

In a developing country the government often tinkers with market mechanism using its tax and subsidy policies for different purposes. It is a common belief that the backward agricultural sector should be subsidized as poorer group of the working population are employed in this sector who send their children out to work out of sheer poverty. If the economic conditions of these people can be improved the social menace of child could automatically be mitigated. The analysis of this paper has challenged this populist belief using a three-sector general equilibrium model with child labour and agricultural dualism. The advanced agriculture is distinguished from backward agriculture as follows. The former uses capital in the form of agricultural machineries that prevents child labour to work on these farms. On the contrary, backward agriculture uses primitive techniques of cultivation and employs child labour in a significant number. Apart from this, backward agriculture uses more labour-intensive (adult labour) technique vis-à-vis advanced agriculture with respect to land. In this backdrop we have examined the consequences of a credit subsidy policy to advanced agricultural sector and a price subsidy policy designed to benefit backward agriculture on the aggregate supply of child labour in the economy. We have found that a price subsidy policy to backward agricultural sector is likely to aggravate the child labour problem while a credit subsidy to advanced agriculture may be effective in reducing the gravity of the problem in the economy. The paper, therefore, questions the desirability of assisting backward agriculture so as to eradicate the problem of child labour in the society.

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Appendix I: Derivation of family supply function of child labour

Maximizing equation (8) with respect to C_1, C_2, C_3 and l_C and subject to the budget constraint (9) the following first-order conditions are obtained.

$$((\alpha U)/(P_1C_1)) = ((\beta U)/(P_2C_2)) = ((\rho U)/(P_3C_3)) = ((\gamma U)/(n-l_C)W_C) \quad \text{(A.1)}$$

From (A.1) we get the following expressions.

$$C_1 = \{\alpha(n-l_C)W_C/(\gamma P_1)\} \quad \text{(A.2)}$$

$$C_2 = \{\beta(n-l_C)W_C/(\gamma P_2)\} \quad \text{(A.3)}$$

$$C_3 = \{\rho(n-l_C)W_C/(\gamma P_3)\} \quad \text{(A.4)}$$

Substitution of the values of C_1, C_2 and C_3 into the budget constraint and further simplifications give us the following child labour supply function of each poor working household.

$$l_C = \{(\alpha+\beta+\rho)n - \gamma(W/W_C)\} \quad \text{(10)}$$

Appendix II: Changes in factor prices

As r is determined from equation (3), it is independent of any changes in S_r and S_P. In other words, we have $\hat{r} = 0$.

Now we totally differentiate equations (1), (2), (4) – (6) and (7.1), collecting terms and arranging in a matrix notation we get the following expression.

$$\begin{bmatrix} \theta_{L1} & \theta_{N1} & 0 & 0 & 0 & 0 \\ \theta_{L2} & \theta_{N2} & \theta_{C2} & 0 & 0 & 0 \\ \bar{S}_{LL} & 0 & \lambda_{L2}S_{LC}^2 & \lambda_{L1} & \lambda_{L2} & \lambda_{L3} \\ \lambda_{K1}S_{KL}^1 & 0 & 0 & \lambda_{K1} & 0 & \lambda_{K3} \\ 0 & 0 & 0 & \lambda_{N1} & \lambda_{N2} & 0 \\ (S_{CL}^2 + \dfrac{\gamma W}{l_C W_C}) & 0 & (S_{CC}^2 - \dfrac{\gamma W}{l_C W_C}) & 0 & 1 & \dfrac{\lambda_{L3}}{(1-\lambda_{L3})} \end{bmatrix} \begin{bmatrix} \hat{W} \\ \hat{R} \\ \hat{W}_C \\ \hat{X}_1 \\ \hat{X}_2 \\ \hat{X}_3 \end{bmatrix} = \begin{bmatrix} H.\hat{S}_r \\ G.\hat{S}_P \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \quad \text{(A.5)}$$

Solving (A.5) by Cramer's rule the following expressions are obtained.

$$\hat{W} = \frac{1}{\Delta}\{\lambda_{L2}S_{LC}^2 A_1 - (S_{CC}^2 - \frac{\gamma W}{l_C W_C})A_2\}\theta_{N2}H\hat{S}_r - \frac{1}{\Delta}\{\lambda_{L2}S_{LC}^2 A_1 - (S_{CC}^2 - \frac{\gamma W}{l_C W_C})A_2\}\theta_{N1}G\hat{S}_P \quad \text{(A.6)}$$

$$\hat{W}_C = -\frac{1}{\Delta}\{\bar{S}_{LL}A_1 - \lambda_{K1}S_{KL}^1 A_3 - (S_{CL}^2 + \frac{\gamma W}{l_C W_C})A_2\}\theta_{N2}H\hat{S}_r$$

$$+\frac{1}{\Delta}\{\bar{S}_{LL}A_1 - \lambda_{K1}S_{KL}^1 A_3 - (S_{CL}^2 + \frac{\gamma W}{l_C W_C})A_2\}\theta_{N1}G\hat{S}_P \quad \text{(A.7)}$$

$$\hat{R} = -\frac{1}{\Delta}\{\lambda_{L2}S_{LC}^2 A_1 - (S_{CC}^2 - \frac{\gamma W}{l_C W_C})A_2\}\theta_{L2}H\hat{S}_r + \frac{1}{\Delta}\{\lambda_{L2}S_{LC}^2 A_1 - (S_{CC}^2 - \frac{\gamma W}{l_C W_C})A_2\}\theta_{L1}G\hat{S}_P$$

(A.8)

where, S_{ji}^k = the degree of substitution between factors j and i in the k th sector, $j,i = L, L_C, K$; and, k = 1,2,3. $S_{ji}^k > 0$ for $j \neq i$; and, $S_{jj}^k < 0$; and, λ_{ji} = proportion of the j th input employed in the i th sector and,

$$\left.\begin{aligned}
&H = \theta_{K1}\frac{S_r}{(1-S_r)} > 0; \\
&G = \frac{S_P}{(1+S_P)} > 0; \\
&\bar{S}_{LL} = (\lambda_{L1}S_{LL}^1 + \lambda_{L2}S_{LL}^2) < 0; \\
&\Delta = [\{\lambda_{L2}S_{LC}^2 A_1 - (S_{CC}^2 - \frac{\gamma W}{l_C W_C})A_2\}(\theta_{L1}\theta_{N2} - \theta_{N1}\theta_{L2}) \\
&\quad +\theta_{N1}\theta_{C2}\{\bar{S}_{LL}A_1 - \lambda_{K1}S_{KL}^1 A_3 - (S_{CL}^2 + \frac{\gamma W}{l_C W_C})A_2\}] < 0 \\
&A_1 = \lambda_{K1}(\lambda_{N2}.\frac{\lambda_{L3}}{1-\lambda_{L3}}) + \lambda_{N1}\lambda_{K3} > 0 \\
&A_2 = \lambda_{K3}(\lambda_{N1}\lambda_{L2} - \lambda_{L1}\lambda_{N2}) + \lambda_{K1}\lambda_{L3}\lambda_{N2} > 0 \\
&A_3 = \frac{1}{1-\lambda_{L3}}(\lambda_{N2}\lambda_{L3}\lambda_{L1} + \lambda_{N1}\lambda_{L3}\lambda_{L1}) = \frac{\lambda_{L3}\lambda_{L1}}{1-\lambda_{L3}} > 0
\end{aligned}\right\} \quad \text{(A.9)}$$

$\left|\lambda_{NL}^{12}\right| = (\lambda_{N1}\lambda_{L2} - \lambda_{L1}\lambda_{N2}) > 0$ as we have assumed that the backward agricultural sector is more adult labour-intensive vis-à-vis the advanced agricultural sector with respect to land both in physical and value sense. The latter implies that $(\theta_{L1}\theta_{N2} - \theta_{N1}\theta_{L2}) < 0$ which in turn shows that $\Delta < 0$.

Now subtraction of (A.7) from (A.6) yields

$$(\hat{W} - \hat{W}_C) = (\hat{W} - \hat{W}_C) = \frac{1}{\Delta}[A_1(\lambda_{L2}S_{LC}^2 + \overline{S}_{LL}) - A_2(S_{CC}^2 + S_{CL}^2) - \lambda_{K1}S_{KL}^1 A_3)]\theta_{N2}H\hat{S}_r$$

$$-\frac{1}{\Delta}[A_1(\lambda_{L2}S_{LC}^2 + \overline{S}_{LL}) - A_2(S_{CC}^2 + S_{CL}^2) - \lambda_{K1}S_{KL}^1 A_3)]\theta_{N1}G\hat{S}_P$$

Using the expression of $\overline{S}_{LL}$ we can further simplify the expression of $(\hat{W} - \hat{W}_C)$ as follows.

$$(\hat{W} - \hat{W}_C) = \frac{1}{\Delta}[A_1\lambda_{L1}S_{LL}^1 - \lambda_{K1}S_{KL}^1 A_3]\theta_{N2}H\hat{S}_r$$

$$-\frac{1}{\Delta}[A_1\lambda_{L1}S_{LL}^1 - \lambda_{K1}S_{KL}^1 A_3]\theta_{N1}G\hat{S}_P \qquad \text{(A.10)}$$

[Note that $(S_{CC}^2 + S_{CL}^2) = 0$ and $(S_{LL}^2 + S_{LC}^2) = 0$, (note that as a_{N2} is constant $S_{CN}^2 = 0$ and $S_{LN}^2 = 0$.]

Using (A.9), from (A.6) – (A.8) and (A.10) we can obtain the following results.

$$\left.\begin{array}{ll}
\text{(i)} & \hat{W} < 0, \hat{R} > 0 \text{ and } \hat{W}_C < 0 \text{ when } \hat{S}_r > 0; \\
\text{(ii)} & \hat{W} > 0, \hat{R} < 0 \text{ and } \hat{W}_C > 0 \text{ when } \hat{S}_P > 0; \\
\text{(iii)} & (\hat{W} - \hat{W}_C) > 0 \text{ when } \hat{S}_r > 0 \\
\text{(iv)} & (\hat{W} - \hat{W}_C) < 0 \text{ when } \hat{S}_P > 0
\end{array}\right\} \qquad \text{(A.11)}$$

Appendix III: Changes in output composition

Solving (A.5) by Cramer's Rule we derive the following expressions as well.

$$\hat{X}_1 = \frac{1}{\Delta}[(S_{CL}^2 + \frac{\gamma W}{l_C W_C})\lambda_{L2} S_{LC}^2 \lambda_{K3} - (S_{CC}^2 - \frac{\gamma W}{l_C W_C})(\overline{S}_{LL}\lambda_{K3} - \lambda_{K1} S_{KL}^1 \lambda_{L3})$$

$$- \frac{\lambda_{L3}}{(1-\lambda_{L3})}\lambda_{L2} S_{LC}^2 \lambda_{K1} S_{KL}^1)]\theta_{N2}\lambda_{N2} H\hat{S}_r$$

$$- \frac{1}{\Delta}[(S_{CL}^2 + \frac{\gamma W}{l_C W_C})\lambda_{L2} S_{LC}^2 \lambda_{K3} - (S_{CC}^2 - \frac{\gamma W}{l_C W_C})(\overline{S}_{LL}\lambda_{K3} - \lambda_{K1} S_{KL}^1 \lambda_{L3})$$

$$- \frac{\lambda_{L3}}{(1-\lambda_{L3})}\lambda_{L2} S_{LC}^2 \lambda_{K1} S_{KL}^1)]\theta_{N1}\lambda_{N2} G\hat{S}_P$$

Or,

$$\hat{X}_1 = \frac{1}{\Delta}[-(S_{CC}^2 - \frac{\gamma W}{l_C W_C})(\lambda_{L1} S_{LL}^1 \lambda_{K3} - \lambda_{K1} S_{KL}^1 \lambda_{L3}) - \frac{\lambda_{L3}}{(1-\lambda_{L3})}\lambda_{L2} S_{LC}^2 \lambda_{K1} S_{KL}^1)]\theta_{N2}\lambda_{N2} H\hat{S}_r$$

$$- \frac{1}{\Delta}[-(S_{CC}^2 - \frac{\gamma W}{l_C W_C})(\lambda_{L1} S_{LL}^1 \lambda_{K3} - \lambda_{K1} S_{KL}^1 \lambda_{L3}) - \frac{\lambda_{L3}}{(1-\lambda_{L3})}\lambda_{L2} S_{LC}^2 \lambda_{K1} S_{KL}^1)]\theta_{N1}\lambda_{N2} G\hat{S}_P \quad \text{(A.12)}$$

$$\hat{X}_2 = -\frac{1}{\Delta}[-(S_{CC}^2 - \frac{\gamma W}{l_C W_C})(\lambda_{L1} S_{LL}^1 \lambda_{K3} - \lambda_{K1} S_{KL}^1 \lambda_{L3}) - \frac{\lambda_{L3}}{(1-\lambda_{L3})}\lambda_{L2} S_{LC}^2 \lambda_{K1} S_{KL}^1)]\theta_{N2}\lambda_{N1} H\hat{S}_r$$

$$+ \frac{1}{\Delta}[-(S_{CC}^2 - \frac{\gamma W}{l_C W_C})(\lambda_{L1} S_{LL}^1 \lambda_{K3} - \lambda_{K1} S_{KL}^1 \lambda_{L3}) - \frac{\lambda_{L3}}{(1-\lambda_{L3})}\lambda_{L2} S_{LC}^2 \lambda_{K1} S_{KL}^1)]\theta_{N1}\lambda_{N1} G\hat{S}_P \quad \text{(A.13)}$$

[We have used the expression of $\overline{S}_{LL}$ and note that $S_{LC}^2 + S_{LL}^2 = 0$ and $S_{CC}^2 + S_{CL}^2 = 0$]

$$\hat{X}_3 = \frac{1}{\Delta}[\{(S_{CC}^2 - \frac{\gamma W}{l_C W_C})\lambda_{L2}\lambda_{K1} S_{KL}^1 - \lambda_{L2} S_{LC}^2 \lambda_{K1} S_{KL}^1\}\lambda_{N1}$$

$$-\{(S_{LC}^2 + \frac{\gamma W}{l_C W_C})\lambda_{L2} S_{LC}^2 \lambda_{K1} - (S_{CC}^2 - \frac{\gamma W}{l_C W_C})(\overline{S}_{LL}\lambda_{K1} - \lambda_{L1}\lambda_{K1} S_{KL}^1)\}\lambda_{N2}]\theta_{N2} H\hat{S}_r$$

$$- \frac{1}{\Delta}[\{(S_{CC}^2 - \frac{\gamma W}{l_C W_C})\lambda_{L2}\lambda_{K1} S_{KL}^1 - \lambda_{L2} S_{LC}^2 \lambda_{K1} S_{KL}^1\}\lambda_{N1}$$

$$-\{(S_{LC}^2 + \frac{\gamma W}{l_C W_C})\lambda_{L2} S_{LC}^2 \lambda_{K1} - (S_{CC}^2 - \frac{\gamma W}{l_C W_C})(\overline{S}_{LL}\lambda_{K1} - \lambda_{L1}\lambda_{K1} S_{KL}^1)\}\lambda_{N2}]\theta_{N1} G\hat{S}_P$$

Or,

$$\hat{X}_3 = \frac{1}{\Delta}[-\lambda_{L2}S_{LC}^2 S_{KL}^1 \lambda_{N1} + (S_{CC}^2 - \frac{\gamma W}{l_C W_C})\{S_{KL}^1 \left|\lambda_{NL}^{12}\right| + \lambda_{N2}\lambda_{L1}S_{LL}^1\}]\lambda_{K1}\theta_{N2}H\hat{S}_r$$

(-) (+) (-)

$$-\frac{1}{\Delta}[-\lambda_{L2}S_{LC}^2 S_{KL}^1 \lambda_{N1} + (S_{CC}^2 - \frac{\gamma W}{l_C W_C})\{S_{KL}^1 \left|\lambda_{NL}^{12}\right| + \lambda_{N2}\lambda_{L1}S_{LL}^1\}]\lambda_{K1}\theta_{N1}G\hat{S}_P \qquad \text{(A.14)}$$

(-) (+) (-)

From (A.12) - (A.14) we get the following

(v) $\hat{X}_1 > 0, \hat{X}_2 < 0$ when $\hat{S}_r > 0$;

$\hat{X}_1 < 0, \hat{X}_2 > 0$ when $\hat{S}_P > 0$;

(vi) $\hat{X}_3 > 0$ when $\hat{S}_r > 0$

under the sufficient condition $\{S_{KL}^1 \left|\lambda_{NL}^{12}\right| + \lambda_{N2}\lambda_{L1}S_{LL}^1\} \geq 0$

(vii) $\hat{X}_3 < 0$ when $\hat{S}_P > 0$ under the same sufficient condition.

(A.15)

Appendix IV: Proof of proposition 3

Totally differentiating equation (11) we get the following

$$\hat{L}_C = -\frac{\gamma W}{l_C W_C}(\hat{W} - \hat{W}_C) - \frac{\lambda_{L3}}{(1-\lambda_{L3})}\hat{X}_3$$

We now substitute the expressions of $\hat{X}_3$ and $(\hat{W} - \hat{W}_C)$ from (A.14) and (A.10) respectively to get the following expression.

$$\hat{L}_C = \frac{1}{\Delta}[-\frac{\gamma W}{l_C W_C}(A_1\lambda_{L1}S_{LL}^1 - \lambda_{K1}S_{KL}^1 A_3)$$

$$-\frac{\lambda_{L3}}{(1-\lambda_{L3})}\{-\lambda_{L2}S_{LC}^2 S_{KL}^1 \lambda_{N1} + (S_{CC}^2 - \frac{\gamma W}{l_C W_C})(S_{KL}^1 \left|\lambda_{NL}^{12}\right| + \lambda_{N2}\lambda_{L1}S_{LL}^1)\}\lambda_{K1}]\theta_{N2}H\hat{S}_r$$

$$-\frac{1}{\Delta}[-\frac{\gamma W}{l_C W_C}(A_1\lambda_{L1}S_{LL}^1 - \lambda_{K1}S_{KL}^1 A_3)$$

$$-\frac{\lambda_{L3}}{(1-\lambda_{L3})}\{-\lambda_{L2}S_{LC}^2 S_{KL}^1 \lambda_{N1} + (S_{CC}^2 - \frac{\gamma W}{l_C W_C})(S_{KL}^1 \left|\lambda_{NL}^{12}\right| + \lambda_{N2}\lambda_{L1}S_{LL}^1)\}\lambda_{K1}]\,\theta_{N1}G\hat{S}_P \qquad (12)$$

From (12) we get the following results.

$\hat{L}_C < 0$ when $\hat{S}_r > 0$ under the sufficient condition $\{S^1_{KL}\left|\lambda^{12}_{NL}\right| + \lambda_{N2}\lambda_{L1}S^1_{LL}\} \geq 0$

$\hat{L}_C > 0$ when $\hat{S}_P > 0$ under the same condition.

Rewriting (12) in a different way it can be checked that the above two res ults also hold under the sufficient condition that $S^2_{LC}S^1_{KL} \geq S^2_{CC}S^1_{LL}$.