INCIDENCE OF CHILD LABOUR, FREE EDUCATION POLICY AND ECONOMIC LIBERALIZATION IN A DEVELOPING ECONOMY

Sarbajit Chaudhuri
Reader
Dept. of Economics
University of Calcutta
56A, B.T. Road
Kolkata 700 050
India.

Address for communication: Dr. Sarbajit Chaudhuri, 23 Dr. P.N. Guha Road, Belgharia, Kolkata 700083, India.
Tel: 91-33-541-0455 (R), 91-33-557-5082 (C.U.) Fax: 91-33-2844-1490 (P)
E-mail: sarbajitch@yahoo.com, sceco@caluniv.ac.in
http://papers.ssrn.com/author=294419

(This version: January 2004)

ABSTRACT: The paper analyzes the implications of a subsidy policy on education and different liberalized trade and investment policies on the incidence of child labour in a developing economy in terms of a three-sector general equilibrium model with informal sector and child labour. The supply function of child labour is endogenously determined. The paper shows that different policies, if undertaken concurrently, may produce mutually contradictory effects, thereby producing little or no impact on the incidence of child labour. The paper provides a theoretical answer as to why the incidence of child labour has not significantly declined in the developing economies in spite of economic development and globalization.

Keywords: Child labour, general equilibrium, informal sector, education subsidy, trade liberalization.

JEL classification: F10, J10, J13, I28.

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1. Introduction:

Child labour is presently a phenomenon pervasive mostly in the transitional societies of the developing economies where multi-class social structures exist and a complex of traditional and pre-capitalist production relations are operative in an articulated capitalist mode of production and exploitation. Working of children in these countries in general are subjected to a process of implacable exploitation characterized by low wages, long hours of work, unclean, unhygienic and unsafe working and living conditions and more importantly deprivation from education which hamper their physical and mental development. According to ILO (2002) one in every six children aged between 5 and 17 - or 246 million children are involved in child labour.[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.

In the recent literature, the supply of child labour has been attributed to factors such as poverty[2], lack of educational facilities and poor quality of schooling, capital market imperfection, parental attitudes including the objectives to maximize present income, reflecting cultural norms and social values[3] etc. However, it is generally agreed that the root cause is abject poverty, which compels people to have large families and children to go out in the job market and earn their own

[1] If the "invisible" workers who perform unpaid and household jobs are included, it is likely that the estimate would shoot up significantly further.

[2] Perceived poverty instead of actual poverty and desire for consumer goods and better living standards may sometimes contribute to the incidence of child labour.

[3] Parental attitudes, reflecting cultural norms, nevertheless play a major role in sending a child to work or to school. Parents' expectations that children will provide for them in their old age may lead to their having larger numbers of children and, where household incomes are limited, there may be a lower level of investment in each child, including in education. Parents may genuinely believe that they are doing the best for their children by allowing or encouraging them to work, not realizing the hazards that the work might entail (ILO 2002).

means of livelihood. To eradicate the incidence of child labour, *World Development Report 1995* called for a multifaceted approach with programmes that increase income security, reduce education costs, and improve the quality schooling. However, policy prescriptions directed towards poverty alleviation are difficult to be implemented properly due to various bottlenecks and vicious circles typical of developing economies; even if implemented, they take a long time to mitigate the problem, so that legal restrictions can be more instrumental to deal with child labour. Legislative fiats to combat child labour range from an outright ban on child labour to social labeling of products. However, a total ban would be counterproductive in the sense that it may adversely affect the welfare of the poor households and force the children to take resort to more hazardous and illegal activities. Moreover, most of the children work in domestic service or informal sector, where labour law enforcement is virtually absent. Social labeling can be applied only to a few products (mostly exported ones), so that the potential effect is limited; it is also difficult to monitor the labeling operations and may have disastrous consequences on the developing economies as the Bangladeshi experience[4] has shown. It is believed that the betterment of educational opportunities and a policy of compulsory education designed for human capital formation can more effectively remove children from work.

The ongoing process of globalization was expected to produce considerable downward pressure on the problem of child labour in the developing countries by reducing the extent of poverty. Over the last two decades there have been many groundbreaking changes in the global scenario. The multilateral agreement and the formation of the World Trade Organization (WTO), resultant of the Uruguay round of discussions, have brought about revolutionary changes in liberalizing international trade across countries whether developed or developing. Radical measures for reducing tariff barriers and completely doing away with non-tariff barriers to ensure freer global trade have already been undertaken in manufacturing commodities. However, the attempt to subject agricultural commodities to disciplines similar to those that govern trade in manufactures has not so far been successful. The WTO is now embarking upon a new round of negotiations on agricultural trade. Multilateral liberalization in the context of the WTO negotiations will

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[4] Owing to the possibility of introduction of the US Harkins Bill, which calls for complete ban on imports of any good that were manufactured wholly or partly by child workers, the employers in the booming garments industry in Bangladesh that had employed a large number of child labourers began removing the child workers drastically. The consequence was a chaotic process that left many children worse off than they had before. See UNICEF (1997).

primarily imply reduced protection against imports and reduced subsidies for domestic production, including reduced export subsidies. If the result of reduced trade barriers and increased international competition are uniform in both developed or developing countries, the prices of the primary agricultural exports of the developing countries are likely to rise because of the probable reduction of the multilateral tariffs by the large trading countries and increase in their import demands. Model simulations of multilateral trade liberalization, e.g. (Hoekman and Anderson, 1999) are quite unanimous in predicting that such liberalization would result in higher world market prices than otherwise for those goods currently being protected and subsidized. During this period the problem of child labour has drawn serious cognizance and calls for different policy measures to curb the evil. It was believed that liberalized economic policies would take the developing countries into higher growth orbits, the benefits of which would definitely percolate down to the bottom of the society, thereby leading to reduction of poverty and poverty-driven child labour incidence. Despite most of the developing economies choosing free trade as their development strategies, empirical evidence suggests that in many of the transition economies the incidence of child labour has been on the rise. For example, a recent study of child labour by Swaminathan (1998) in a city in western India concluded: "The prevalence and absolute expansion of child labor in a period and region of relatively high growth of aggregate output indicates that the nature of economic growth is flawed". Why liberalized trade policies and free education policy have not so far been successful in eradicating the problem is quite puzzling.

In the recent theoretical literature on child labour the notable contributors are Eswaran (1996), Basu and Van (1998), Ranjan (2001), Baland and Robinson (2000), Jafarey and Lahiri (2002) and Dessy (2000). Eswaran (1996) has found an explanation in the need for old age security of the parents behind the incidence of high fertility rate and lower investment on the education of their offspring (and hence the high incidence of child labour) in a backward society where the child mortality rate is quite high. Thus he has suggested improvement in healthcare services and legislation of compulsory education to eradicate child labour from the system. 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. What follows from the Basu and Van (1998)

paper is that labour market interventions that raise adults' wages are expected to mitigate the problem of child labour. There are some papers in the literature focusing on capital market failure. Ranjan (1999), Baland and Robinson (2000) and Jafarey and Lahiri (2002) emphasize the importance of capital-market imperfection as a contributing factor to inefficient child labor. The dynamic implications of capital market imperfection have been studied by Ranjan (2001), with similar conclusions reached by Basu (1999). On the other hand, Dessy (2000) has advocated in favour of imposition of compulsory education as a means to combat the incidence of child labour. Dessy (2000) has shown that in an economy where the benefits of having children are outweighed by rearing costs, a policy of free education with no compulsory education laws, may lead the economy to an underdevelopment trap with high fertility rate and higher incidence of child labour. On the contrary, a compulsory education policy is expected to eradicate the existence of the evil from the system.

Unfortunately, the existing theoretical literature on child does not deal adequately[5] with issues like the supply of child labour and its linkages with the adult labour markets in a multi-sector general equilibrium framework, which is especially crucial when child labour and adult labour are substitutes[6] in different informal sectors of a developing economy. One cannot get the overall effect of a policy on the incidence of child labour in a partial equilibrium framework. This is because, as the Bangladeshi experience has shown, a policy designed to mitigate the problem of child labour in a targeted sector may drive the children into other sectors of the economy and undertake illegal and more hazardous activities. So, one cannot evaluate the success of a particular policy unless one takes into account its effect on the aggregate number of child workers, spread over different sectors of a developing economy. Neither do we find any work where the effect of an education subsidy policy on the supply of child labour has been studied although the traditional wisdom recommends a hike in educational opportunities to eradicate the problem. Also, economists have not so far paid adequate attention to analyze the implications of

[5] The Basu and Van (1998) model, of course, can be easily embedded in a general equilibrium framework. Besides, Jafarey and Lahiri (2002) and Gupta (2002) have examined the efficacy of imposition of trade sanctions on export items of the developing countries produced by child labour as a policy in curbing the incidence of child labour in terms of general equilibrium models.

[6] See footnote 9 in this context.

the liberalized economic policies on the problem of child labour.[7] This attempt should have been made earlier, especially when trade liberalization was expected to exert downward pressures on the incidence of poverty-driven child labour.

The present paper is purported to examine the implications of an education subsidy policy and liberalized economic policies on the incidence of poverty-induced child labour in a general equilibrium setup. We consider a three-sector full-employment model with informal sector and child labour. The economy is divided into two informal and one formal sectors. One of the two informal sectors (sector X) produces an exportable agricultural commodity, while the other (sector Y) produces a non-traded intermediary[8] for the formal manufacturing sector (sector Z). Sector Z is the import-competing sector of the economy and is protected by an import tariff. Child labour is used in the two informal sectors. It is assumed that different economic activities are perfectly substitutable[9] between adult and child labour (see Basu (1999)). The adult workers employed in the two informal sectors of the economy constitute the poorer section of the working population and the supply of child labour comes entirely from these poor families. The supply function of child labour is endogenously determined. In this setup we shall show that a subsidy policy on education and liberalized trade and investment policies may produce mutually

[7] Chaudhuri and Gupta (2004) and Chaudhuri and Dwibedi (2005) are two of the few notable exceptions.

[8] If one considers a vertically integrated production structure, the inclusion of a non-tradable intermediate good-producing sector does not make any sense in a Heckscher-Ohlin-Samuelson framework. If there is any intermediary it must be an internationally traded one. However, in the present model the inclusion of a non-traded intermediary is worthwhile since the wage rates in the final good and intermediate good-producing sectors differ. While in the formal final good-producing sector the employees get the unionized wage, the workers in the intermediary sector receive only the low competitive wage.

[9] In the developing economies child workers are mostly found in the production of carpets, glass, bangles, leather bags, shoes, garments, matchbox and fireworks and cattle feeding. It is sensible to assume that adults can perform all these tasks. First, all these industries exist in countries where there is no child labour. Second, not all the firms producing these goods in countries where child labour exists actually use child labour– after all, this is the justification for 'social labelling'. The 'nimble fingers' argument, which once has been put forward, especially to carpet weaving, is an excuse given by employers and fails to convince researchers (see Burra (1995) and Weiner (1991)). Even if present technologies required the use of child labour and not adult labour in certain production activities, major changes in economic conditions coupled with the mobility of capital across sectors, would certainly result in the adoption of different technologies allowing the substitution of adult for child labour.

incompatible effects on the incidence of child labour. In other words, if all of these policies are undertaken simultaneously, as what the developing countries are doing presently, these may invalidate each other, and fail to deliver the goods. In the extreme case, the net result may even be counterproductive. Thus, the paper provides a theoretical answer as to why the developing economies have not so far been able to successfully combat the problem of child labour despite economic development and globalization.

2. The Model:

We consider a small open dual economy, which is divided into two informal sectors and one formal sector. One of the two informal sectors produces an agricultural product, X, with the help of labour and capital. The informal manufacturing sector uses labour, and capital to produce an internationally non-traded intermediary[10], Y, for the formal manufacturing sector. In the two informal sectors both adult labour and child labour are used and these are perfectly substitutes to each other. Many large industries like carpet weaving, glass manufacturing, leather bag and shoe manufacturing and garment industries have split up into tiny units and shifted the production process to urban slums, in order to utilize the services of children. Some among these industries give subcontract to enterprises, which produce components of the formal sector output, on an informal basis, hiring child labour.

Following Basu and Van (1998), we make the assumption of 'substitution' in the informal sectors, which suggests that adult labour is a perfect substitute for child labour, or more generally, adults can do what children do. It is assumed that an adult worker is equivalent to μ number of child labourers, where $\mu > 1$. Thus, adult and child labour are perfect substitutes subject to a child-equivalent scale correction of μ. So when the adult wage rate is W the child wage rate, W_C, must be (W/μ). Complete mobility of both types of labour between these two sectors ensures that the wage rates must be the same across the informal sectors.

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[10] Empirical evidence suggests that the informal sector units mostly produce intermediate inputs for the formal sector. See for example, Joshi and Joshi (1976), Bose (1978), Papola (1981) and Romatet (1983). However, there are a few theoretical papers like Grinols (1991), Chandra and Khan (1993) and Gupta (1997), which have formalized the urban informal sector as a sector that produces an internationally traded final commodity.

The formal sector is the tariff protected import-competing sector producing a manufacturing good, Z. It uses adult labour, capital and the produced input from the informal sector. Owing to effective wage legislation and unionization of labour, the adult wage rate in the formal sector, W^*, is greater than the competitive informal sector adult wage rate, W.[11]

Production functions in sectors X and Y satisfy constant returns to scale with positive but diminishing returns to each factor. But, fixed-coefficient technology[12] is assumed for sector Z. Markets except the formal sector labour market are perfectly competitive and all inputs are fully employed. Owing to the small open economy assumption prices of the traded goods, X and Z are given internationally. Since Y is non-traded its price is endogenously determined by the demand-supply mechanism. We assume that sectors Y and Z as a whole is more capital intensive[13] than sector X.

The following symbols will be used in the formal presentation of the model.

$a_{Li} =$ labour-output ratio in the i-th sector, $i = X, Y, Z$;

$a_{Ki} =$ capital-output ratio in the i-th sector, $i = X, Y, Z$;

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[11] In a developing economy the supply of child labour comes from the poor working families employed in the informal sectors. Their incomes from non-child labour sources are quite low and uncertain. In the rural areas, workers get employment in the peak season. But in the lean season, employment is not guaranteed, as the demand for labour remains low. It has been observed that the market for child labour remains relatively stable throughout the year as child workers are mainly employed to look after the cattle (see Gupta 2000). Therefore, the poor families often send out their children to work for the purpose of 'consumption smoothing'. In urban areas also there is very little employment security for the workers employed in the informal sectors. The present analysis, unfortunately, cannot take into consideration the aspect of income uncertainty on the part of informal sector workers. However, there is no reason to deny that the incidence of child labour is likely to fall significantly if the poor working families are protected by employment security and social security.

[12] This is a simplifying assumption. As sector Z uses more than two inputs in production, unless fixed-coefficient technology is assumed, the algebra of the model will be seriously complicated by the presence of partial elasticities of substitutions when one considers the effects of any changes in the price system. However, as the system possesses the decomposition property the usual CRS production function may be considered when one analyzes the effects of any changes in the output system.

[13] Chandra and Khan (1993) and Gupta (1997) have also made this assumption. However, in these papers, the Harris-Todaro framework has been considered.

a_{YZ} = per-unit requirement of Y to produce Z;

θ_{ji} = distributive share of the j-th input in the i-th industry, $j = L, K$; and, $i = X, Y, Z$;

λ_{Ki} = proportion of capital used in the i-th sector, $i = X, Y, Z$;

λ_{Li} = proportion of the effective labour endowment used in the i-th sector, $i = X, Y, Z$;

σ_i = elasticity of substitution between labour and capital in the i-th sector, $i = X, Y$;

P_i = world price of the i-th good, $i = X, Z$;

t = ad-valorem rate of tariff on the import of Z;

P_Y = domestically determined price of Y;

W = adult wage rate in the informal sectors;

$W_C (= W / \mu) =$ child wage rate;

W^* = unionized adult wage rate in sector Z;

U = parameter denoting the extent of bargaining power of the trade unions in sector Z;

R = rate of return to capital;

L = adult labour endowment;

l_C = supply of child labour by each poor working family;

L_C = aggregate supply of child labour;

L^* = effective adult labour endowment of the economy (including child labour);

$L_I (= L - a_{LZ} Z) =$ number of adult workers employed in the two informal sectors;

$K =$ aggregate stock of capital of the economy (domestic plus foreign);

E = amount of subsidy on education;

n = number of children in each working family;

'$\wedge$' = proportional change.

2.1 Derivation of Supply Function of Child Labour

We assume that there are L numbers of working families in the economy, 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 sectors constitute the

poorer section. Following the 'Luxury Axiom'[14] of Basu and Van (1998) we assume that there exists a critical level of family (or adult labour) income, $\overline{W}$, from non-child labour sources, 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 can easily assume that each worker in the formal manufacturing sector earns a wage income, W^*, sufficiently greater than this critical level. So, the workers belonging to this group do not send their children to work. On the other hand, adult workers employed in the informal sectors earn W amount of wage income, which is less than $\overline{W}$ and therefore, send many 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. 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. The rest of the children are sent to schools. We also assume that there is only public educational system[15, 16] available to the children in the economy and it is entirely financed by government subsidy on this account. The richer section of the workers does not send their children to the job market. In a society with high fertility rate, poor perception of the parents about future benefits of children's education, low quality of schooling and households' objectives to maximize present income, one of the main motives behind the decision of the poorer households in sending some of their

[14] An empirically testable hypothesis of Basu and Van's model is that child labour arises if adult household income falls below some benchmark level. This hypothesis has been tested by different economists for different countries. Studies by Ray (1999) for India, Ray (2000) for Pakistan and Peru, Addison et al. (1997) for Ghana and Pakistan and Bhalotra (2000) for Pakistan have found the 'Luxury Axiom' of Basu and Van (1998) more or less to be statistically valid.

[15] Governments all over the world devote substantial resources to their education sector. This is especially true in developing countries. In 1995, public spending on education accounted for 15.7% of total government expenditure in developing countries (see Bedi and Garg (2000)). Furthermore, the majority of students in developing countries are educated in publicly funded and publicly managed educational institutions. According to Jimenez and Lockheed (1995), almost 90% of all primary and 70% of all secondary enrollments in developing countries are in public schools.

[16] The paper does not deal with an important aspect of child labour– its relation to education and human capital. However, Basu and Van (1998) also share the same limitation.

offspring to public schools is to derive the immediate benefits of free education policy.[17] In the public education system in the developing economies there are provisions for the children from the poorer families to get stipend, free educational goods and free mid-day meals. It is sensible to assume that higher the subsidy on education, E, the higher would be the free educational facilities and the related benefits, B, associated with child schooling. On the other hand, the larger the number of children sent to schools the higher would be the aggregate benefits accrued to the poor families. We make the simplifying assumption that the money value of such benefits is strictly proportional to the number of children sent to schools. The utility function of the household is given by

$$U = U(C_X, C_Z, (n - l_C))$$

The household derives utility from the consumption of the final goods and from the children's leisure. However, children's leisure here does not imply that the children who are not sent out to work are kept at home. They are sent to schools.[18] The altruistic guardian of the family derives utility from this source because at least some of his children have been kept out from the work hazards. Besides, by sending some of the children to schools, the family secures current income gain from access to the different incentives that the free education scheme provides. For analytical simplicity let us consider the following Cobb-Douglas type of the utility function.

$$U = A(C_X)^{\alpha}(C_Z)^{\beta}(n - l_C)^{\gamma} \qquad (1)$$

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

It satisfies all the standard properties and it is homogeneous of degree 1. The parameter γ denotes the degree of altruism of the guardian towards the well being of his children. The value of

[17] In this context, mention should be made of an empirical paper by Ravallion and Wodon (2000) who have found that the school enrollment subsidy substantially increased the number of school going children from the poorer section of the households in Bangladesh. But the magnitude of decline in the incidence of child labour as a proportion of the total amount of enrollment subsidy was insignificant. This is because parents were clearly substituting other uses of their children's time, so as to secure the current income gain from access to the program with modest impact on earnings from their children's work.

[18] This is a static model. So the aspects of education and human capital formation and its role on the incidence of child labour have not been dealt in this paper. See footnote 16 in this context.

γ crucially depends on the social values and norms of the society towards child labour. In a relatively educationally advanced society the value of γ is likely to be comparatively high.[19]

Ruling out the possibility for any child worker attending school to undertake any part time job, the budget constraint of the representative poor household is given by the following.

$$P_X C_X + P_Z(1+t)C_Z = (W_C l_C + W) + (n - l_C)B(E) \quad (2)$$

where, W is the income of the adult worker, $W_C l_C$ measures the income from child labour and $(n - l_C)B(E)$ is the money value of the benefits derived by the household from sending $(n - l_C)$ number of children to schools. Note that $B'(.)$ is positive. Here the effective child wage rate is $(W_C - B(E))$.[20]

Maximization of the utility function subject to the above budget constraint gives us the following first-order conditions.

$$((\alpha U)/(P_X C_X)) = ((\beta U)/(P_Z(1+t)C_Z)) = ((\gamma U)/(n - l_C)(W_C - B(E))) \quad (3)$$

From (3) we get the following expressions.

$$C_X = \{\alpha(n - l_C)(W_C - B(E))/(\gamma P_X)\} \quad (4)$$

$$C_Z = \{\beta(n - l_C)(W_C - B(E))/(\gamma P_Z(1+t))\} \quad (5)$$

Substitution of the values of C_X and C_Z into the budget constraint and simplification give us the following labour supply function.

$$l_C = \frac{[n\{(\alpha+\beta)W_C - B(E)\} - \gamma W]}{(W_C - B(E))} \quad (6)$$

This is the supply function of child labour by each poor family. We now analyze its properties. First, l_C varies negatively with the adult wage rate, W. A rise in W produces a positive income effect so that the adult worker sends a larger number of children to schools and therefore decides to send a lower number of children to the workplace. An increase in W_C (or an increase in

[19] A comparative static result relating to a change in γ on the incidence of child labour in the economy has been discussed in details in footnote 26.

[20] We assume that $W_C > B(E)$. Otherwise, no children are sent to the job market.

$(W_C - B(E))$), on the other hand, produces a negative price effect, which increases the supply of child labour from the family.

As adult labour and child labour are perfect substitutes in this model subject to a child-equivalent scale correction of μ, the child wage rate, W_C, must be (W/μ) when the adult wage rate is W. Substituting (W/μ) in place of W_C in (6) we get

$$l_C = \frac{[n\{(\alpha+\beta)(W/\mu) - B(E)\} - \gamma W]}{((W/\mu) - B(E))} \tag{6.1}$$

Differentiating (6.1) with respect to W we get

$(dl_C/dW) = [B(E)\gamma(1+\frac{n}{\mu})(\frac{1}{(W/\mu)-B(E)})^2] > 0.$ In this case, the negative price effect of an increase in the adult wage rate, W, taking place through an increase in the effective child wage rate, $((W/\mu) - B(E))$ outweighs the positive income effect so that the net effect would be an increase in the supply of child labour. As a consequence, an increase in the adult wage, W, leads to an increase in the supply of child labour by each poor working family when the two types of labour are perfect substitutes.

There are $L_I (= L - a_{LZ}Z)$ 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

$$L_C = [\frac{[n\{(\alpha+\beta)(W/\mu) - B(E)\} - \gamma W]}{((W/\mu) - B(E))}](L - a_{LZ}Z) \tag{7}$$

2.2 *The General Equilibrium Analysis*

Given the assumption of perfectly competitive markets the usual price-unit cost equality conditions relating to the three sectors of the economy are given by the following three equations.

$$a_{LX}W + a_{KX}R = P_X \tag{8}$$

$$a_{LY}W + a_{KY}R = P_Y \tag{9}$$

$$a_{LZ}W^* + a_{YZ}P_Y + a_{KZ}R = P_Z(1+t) \tag{10}$$

The formal sector faces a unionized labour market. The relationship for the unionized wage rate is specified as:[21]

$$W^* = f(W, U) \tag{11}$$

$f(.)$ satisfies the following properties:

$W^* = W$ for $U = 0, W^* > W$ for $U > 0; f_1, f_2 > 0$. $W^* = W$ for $U = 0, W^* > W$ for $U > 0$; $f_1, f_2 > 0$.

Equation (11) states that in the absence of any bargaining power of the trade unions i.e. when $U = 0,$ the formal and informal sector wage rates are equal. However, the formal sector wage rate, $W^*,$ exceeds the competitive informal sector wage rate, $W,$ when there is at least some power to the trade unions. The unionized wage is scaled upward as the informal wage rate rises. Also with an increase in the bargaining power, the unions bargain for a higher wage.

Using (11), equation (10) may be rewritten as

$$a_{LZ} f(W, U) + a_{YZ} P_Y + a_{KZ} R = P_Z (1 + t) \tag{10.1}$$

Since the intermediary, Y, is used only in the production of Z its full-employment condition is as follows.

$$a_{YZ} Z = Y \tag{12}$$

The capital endowment equation is given by

$a_{KX} X + a_{KY} Y + a_{KZ} Z = K$. Using (12), this may be rewritten as follows.

$$a_{KX} X + (a_{KY} a_{YZ} + a_{KZ}) Z = K \tag{13}$$

As in the two informal sectors child labour and adult labour are perfectly substitutes, the effective adult labour endowment equation of the economy is given by the following.

$$a_{LX} X + a_{LY} Y + a_{LZ} Z = (L + L_C / \mu)$$

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[21] Assuming that each formal sector firm has a separate trade union, the unionized wage function may be derived as a solution to the Nash bargaining game between the representative firm and the representative union in the formal sector industry. This function has been derived in Chaudhuri (2003).

Using (7) and (12) and after simplification this may be rewritten as follows.

$$a_{LX}X + [a_{LY}a_{YZ} + a_{LZ}\{1 + \frac{(n(\alpha+\beta)W - n\mu B(E) - \mu\gamma W)}{(W - \mu B(E))}\}]Z$$

$$= L[1 + \frac{(n(\alpha+\beta)W - n\mu B(E) - \mu\gamma W)}{(W - \mu B(E))}] \qquad (14)$$

In this model there are eight endogenous variables (namely, W, W^*, R, P_Y, X, Y, Z and L_C) and eight independent equations (namely, equations (7), (8), (9), (10.1), (11) and (12) – (14)). The parameters of the system are: $Px, P_Z, K, L, E, t, U, \alpha, \beta, \gamma, \mu$ and n. Equations (8), (9) and (10.1) constitute the price system and the rest of the equations form the output system. We should note that the system possesses the decomposition property since the three unknown input prices, W, R and P_Y, can be determined from the price system alone, independently of the output system. Once the factor prices are known the factor coefficients, $a_{ji}s$, are also known. As W is already known, W^* is obtained from (11). X and Z are simultaneously solved from equations (13) and (14). Given Z the equilibrium value of Y is found from (12). Finally, L_C is obtained from equation (7).

3. Comparative Static Exercises:

The conventional wisdom suggests that an improvement of the educational facilities would bring about a significant reduction in the incidence of child labour. Also it is believed that liberalized trade and investment policies would take the developing countries into higher growth orbits, the benefits of which would percolate down to the poor people, thereby lowering the extent of poverty. Thus these policies were expected to exert downward pressures on the incidence of poverty-induced child labour. In this section of the paper, we shall examine the effectiveness of these policies to control the supply of child labour. Although, different liberalized policies in trade and investment and a free education policy are undertaken simultaneously in a developing economy, to fix our ideas we consider their effects one by one.

Totally differentiating equations (8), (9) and (10.1) and solving by Cramer's rule the following expression can be obtained.[22]

$$\hat{W} = (1/|\theta|)[\hat{P}_X(\theta_{KY}\theta_{YZ} + \theta_{KZ}) - \theta_{KX}T\hat{t}] \tag{15}$$

and

$$\hat{R} = (1/|\theta|)[\theta_{LX}T\hat{t} - \hat{P}_X(\theta_{LY}\theta_{YZ} + \theta_{LZ}E_W)] \tag{16}$$

where $|\theta| = \{\theta_{LX}(\theta_{KY}\theta_{YZ} + \theta_{KZ}) - \theta_{KX}(\theta_{LY}\theta_{YZ} + \theta_{LZ}E_W)\} > 0$ as the industrial sector as a whole (sectors Y and Z taken together) is more capital intensive than the agricultural sector (sector X), $T = (t/(1+t)) > 0, E_W = ((\partial W^*/\partial W)(W/W^*)) > 0$. E_W is the elasticity of the unionized wage rate, W^*, with respect to the informal sector wage rate, W.

So, a policy of trade liberalization in agriculture or a reduction in import tariff unequivocally raises the informal sector wage rate.

Now totally differentiating equations (14) and (13) one can derive[23] the following expressions, respectively.

$$\lambda_{LX}\hat{X} + \{\lambda_{LY} + \lambda_{LZ}(1 + l_C/\mu)\}\hat{Z} = A_1\hat{P}_X - A_2\hat{t} - A_3\hat{E} \tag{17}$$

where $A_1 = (1/|\theta|)[(\lambda_{LX}\theta_{KX}\sigma_X + \lambda_{LY}\theta_{KY}\sigma_Y)(1 - \theta_{LZ}(1 - E_W)$

$$+ \frac{(L - a_{LZ}Z)W}{L^*(W - \mu B)}\{n(\alpha + \beta) - \mu\gamma - l_C\}(\theta_{KY}\theta_{YZ} + \theta_{KZ})] > 0;$$

$$A_2 = (\frac{T}{|\theta|})[(\lambda_{LX}\theta_{KX}\sigma_X + \lambda_{LY}\theta_{KY}\sigma_Y)$$

$$+ \frac{\theta_{KX}(L - a_{LZ}Z)W\{n(\alpha + \beta) - \mu\gamma - l_C)(\theta_{KY}\theta_{YZ} + \theta_{KZ})}{L^*(W - \mu B)}] > 0; \text{ and,}$$

$$A_3 = [\frac{\mu B' E(1 + n)(L - a_{LZ}Z)}{L^*(W - \mu B)}] > 0.$$

$$\lambda_{KX}\hat{X} + (\lambda_{KY} + \lambda_{KZ})\hat{Z} = \hat{K} - A_4\hat{P}_X + A_5\hat{t} \tag{18}$$

where $A_4 = [\{(\lambda_{KX}\theta_{LX}\sigma_X + \lambda_{KY}\theta_{LY}\sigma_Y)/|\theta|\}\{(1 - \theta_{LZ}(1 - E_W)\}] > 0; \text{ and,}$

22, 20 These results have been derived in the Appendix.

$$A_5 = [\{(\lambda_{KX}\theta_{LX}\sigma_X + \lambda_{KY}\theta_{LY}\sigma_Y)/|\theta|\}T] > 0.$$

Solving (17) and (18) by Cramer's rule we get the following expression.

$$\hat{Z} = (1/|\lambda|)[\lambda_{KX}\hat{K} - (\lambda_{LX}A_4 + \lambda_{KX}A_1)\hat{P}_X + (\lambda_{LX}A_5 + \lambda_{KX}A_2)\hat{t} + \lambda_{KX}A_3\hat{E}] \quad (19)$$

where $|\lambda| = [\lambda_{LX}(\lambda_{KY} + \lambda_{KZ}) - \lambda_{KX}(\lambda_{LY} + \lambda_{LZ}(1 + l_C/\mu))]$ (20)

So, $|\lambda| > (<)0$ iff $\{\lambda_{LX}(\lambda_{KY} + \lambda_{KZ}) - \lambda_{KX}(\lambda_{LY} + \lambda_{LZ})\} > (<)\ (\lambda_{KX}\lambda_{LZ}l_C/\mu)$. Alternatively, $|\lambda| > (<)0$ under the following necessary and sufficient condition:

$$[\frac{a_{LX}}{a_{KX}} - \frac{(a_{LY}Y + a_{LZ}Z)}{(a_{KY}Y + a_{KZ}Z)}] > (<)[\frac{(a_{LZ}l_C/\mu)}{(a_{KY}Y + a_{KZ}Z)}] \quad (21)$$

From equation (19) one can now trivially establish the following proposition.[24]

PROPOSITION 1: An inflow of foreign capital or a hike in subsidy on education leads to a contraction (an expansion) of the formal sector (sector Z) both in terms of employment and output if and only if $|\lambda| < (>)0$. On the other hand, sector Z contracts (expands) owing to an increase in the price of agricultural commodity or a reduction in the import tariff iff $|\lambda| > (<)0$.

We shall now try to interpret the necessary and sufficient condition (given by (21)) for $|\lambda|$ to be negative (positive). We should remember that each adult worker employed in the two informal sectors sends l_C number of his children to the job market and the rest are sent to schools. On the other hand, labourers engaged in the formal sector of the economy constitute the richer section of the working class and do not send their children to the job market. In the two informal sectors adult labour and child labour are perfect substitutes. So, the effective adult labour endowment of the economy including child labour is given by $L^*(= L + L_C/\mu)$. The labour-capital ratio in sector X is given by (a_{lX}/a_{KX}). Sector Z uses capital directly as well as indirectly through use of Y as production of one unit of Z requires a_{YZ} units of Y and sector Y also requires capital in its production. Thus, $(a_{KY}Y + a_{KZ}Z)$ gives the direct plus indirect requirement of capital in the production of Z. Sector Y requires labour in its production. So this should be included in the

[24] Intuitive explanations have been provided later.

calculation of labour requirement for sector Z. The effective labour-capital ratio for sector Z is given by $\{(a_{LY}Y + a_{LZ}Z)/(a_{KY}Y + a_{KZ}Z)\}$. The left-hand side of (21) gives the difference between the actual labour-capital ratio of sector X and the effective labour-capital ratio of sector Z. This difference is positive because it is sensible to assume that the agricultural sector (sector X) is more labour intensive vis-à-vis the aggregate industrial sector (i.e. sectors Z and Y taken together). Now turning back to interpreting the right-hand side of (21), we note that $a_{LZ}Z$ number of workers who are engaged in sector Z do not send their offspring to the job market. However, if they were employed in either of the two informal sectors each of them would have sent l_C number of children to work. As these $a_{LZ}Z$ numbers of workers are used in sector Z, the economy is deprived of having $a_{LZ}Zl_C$ number of potential child workers, which is equivalent to $(a_{LZ}Zl_C/\mu)$ units of adult labour. Thus, the right-hand side of (21) gives the ratio between the forgone labour endowment and aggregate amount of capital used in the industrial sectors. Thus, $|\lambda|$ is negative (positive) under the necessary and sufficient condition that the latter ratio must be greater (less) than the difference between the labour-capital ratios of the agricultural and the industrial sectors. We should note that the a_{ji}s depend on the unknown factor prices, which in turn depend on the parameters in the price system like, P_X, P_Z, t and U. The value of l_C, on the other hand, depends on the values of $\mu, \alpha, \beta, \gamma, P_X, P_Z, t$ and U. So, depending on the parameter values $|\lambda|$ would be negative or positive.

Finally, totally differentiating equation (7) using (15), (19) and (20) and simplifying we can derive the following expression.[25, 26]

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[25] See the Appendix for detailed derivations.

[26] It may be an interesting idea to carry out a comparative static exercise with respect γ. The parameter denoting the degree of altruism on the part of the guardian of a poor working family depends crucially on the social values and tradition. Owing to mass literacy and adult education programmes and vigorous public campaign against child labour social values and tradition may change over time and raise the value of γ. From equation (6.1) it is easy to check that an increase in γ lowers the supply of child labour from each poor family, l_C. To find out the effect on the aggregate supply of child labour in the economy after differentiating equation (7) with respect to γ and using (15) and (19) we find that

$$\hat{L}_C = -(\frac{l_C a_{LZ} Z \lambda_{KX}}{L_C|\lambda|})\hat{K}$$

$$+\hat{P}_X(\frac{1}{L_C|\lambda\|\theta|})[\frac{(L-a_{LZ}Z)W(\theta_{KY}\theta_{YZ}+\theta_{KZ})(n(\alpha+\beta)-\mu\gamma-l_C)}{(W-\mu B)}\{\lambda_{LX}(\lambda_{KY}+\lambda_{KZ})$$

$$-\{\lambda_{KX}(\lambda_{LY}+\lambda_{LZ})\}+l_C a_{LZ} Z(1-\theta_{LZ}(1-E_W))\{\lambda_{LX}(\lambda_{KX}\theta_{LX}\sigma_X+\lambda_{KY}\theta_{LY}\sigma_Y)$$

$$+\lambda_{KX}(\lambda_{LX}\theta_{KX}\sigma_X+\lambda_{LY}\theta_{KY}\sigma_Y)\}]$$

$$-\hat{t}(\frac{T}{|\lambda\|\theta|L_C})[\{\frac{\theta_{KX}W(L-a_{LZ}Z)(n(\alpha+\beta)-\mu\gamma-l_C)}{(W-\mu B)}\}\{\lambda_{LX}(\lambda_{KY}+\lambda_{KZ})-\lambda_{KX}(\lambda_{LY}+\lambda_{LZ})\}$$

$$+l_C a_{LZ} Z\{\lambda_{LX}(\lambda_{KX}\theta_{LX}\sigma_X+\lambda_{KY}\theta_{LY}\sigma_Y)+\lambda_{KX}(\lambda_{LX}\theta_{KX}\sigma_X+\lambda_{LY}\theta_{KY}\sigma_Y)\}]$$

$$-\hat{E}[\frac{\mu B'E(L-a_{LZ}Z)}{L_C|\lambda|(W-\mu B)}][(n-l_C)\{\lambda_{LX}(\lambda_{KY}+\lambda_{KZ})-\lambda_{KX}(\lambda_{LY}+\lambda_{LZ})\}+l_C\lambda_{LZ}\lambda_{KX}(1+l_C)]$$

…… (22)

From (22) we find that

(i) $\hat{L}_C > (<)0$ when $\hat{K} > 0$ iff $|\lambda| < (>)0$;

(ii) $\hat{L}_C > (<)0$ when $\hat{E} > 0$ iff $|\lambda| < (>)0$;

Let us now explain these results intuitively. We note that any policy change affects the supply of child labour in two ways: (i) through a change in the size of the informal sector labour force, $(L_I = (L - a_{LZ}Z))$, as these families are considered to be the suppliers of child labour (we call this the *labour reallocation effect*); and, (ii) through a change in l_C (the number of child workers supplied by each poor family), which results either from a change in the adult wage rate, W, or from a change in the benefit derived from sending children to schools, $B(E)$ (this is called the *direct effect*).

$$(dL_C/d\gamma) = -(L_C/\gamma)[\frac{\mu\gamma W}{(W-\mu B)l_C|\lambda|}][\{\lambda_{LX}(\lambda_{KY}+\lambda_{KZ})-\lambda_{KX}(\lambda_{LY}+\lambda_{LZ})\}$$

$$+l_C\lambda_{LZ}\lambda_{KX}(1-1/\mu)]$$

From this expression it follows that $(dL_C/d\gamma) > (<)0$ if and only if $|\lambda| < (>)0$. So, the incidence of child labour declines iff $|\lambda| > 0$. This result may be intuitively explained in terms of *direct effect* and *labour reallocation effect*.

An inflow of foreign capital cannot change the factor prices including the informal sector adult wage rate, W, as the production system possesses the decomposition property. So the supply of child labour from each poor working family, l_C, does not change. However, it produces a *Rybczynski effect* leading to a contraction (expansion) of sector Z and an expansion (contraction) of sector X if and only if $|\lambda| < (>)0$. As sector Z contracts (expands), more (less) adult workers would now be employed in the two informal sectors than before. Consequently, the number of poor families, from which the supply of child labour comes, increases (decreases). This is the *labour reallocation effect*. The supply of child labour in the economy increases (decreases) following an inflow of foreign capital if and only if $|\lambda| < (>)0$.

On the other hand, an increase in the subsidy on education affects the incidence of child labour in two ways. First, it lowers the effective price of child labour, $((W/\mu) - B(E))$. This lowers the supply of child labour from each family, l_C. This is the *direct effect* of the policy, which exerts a downward pressure on the incidence of child labour. Second, an induced effect is generated as the *direct effect* lowers the number of available child labour and hence the effective adult labour endowment of the economy.[27] This causes sector Z to shrink (grow) and the X sector to expand (contract) owing to *Rybczynski effect* if and only if $|\lambda| < (>)0$.[28] If the formal sector contracts, the number of child labour supplying families employed in the informal sectors increases. This is the *labour reallocation effect*, which tends to push up the number of child labour in the society. The incidence of child labour gets a boost when the *labour reallocation effect* outweighs the contractionary *direct effect*. This happens under the necessary and sufficient condition that $|\lambda| < 0$. On the contrary, when $|\lambda| > 0$, a larger number of working families would now be engaged in the formal sector (sector Z) resulting in a decrease in the number of families supplying child labour. Hence, both the direct and induced effects of an education subsidy policy work together to lower the incidence of child labour in the society when $|\lambda| > 0$.

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[27] As child labour and adult labour are substitutes in X and Y sectors, the effective labour force must include child labour subject to a scale correction of μ. Thus, a reduction in the number of child labour lowers the effective adult labour endowment of the economy.

[28] The interpretation of this condition has already been provided.

So the following proposition can now be established.

PROPOSITION 2: An increase in the subsidy on education and /or an inflow of foreign capital will raise (lower) the supply of child labour iff $|\lambda| < (>)0$.

We are now interested to study the consequences of the trade liberalization policies. If trade in agriculture is liberalized in the developed nations, the prices of primary agricultural exports of the developing countries are expected to rise possibly owing to the multilateral tariff reductions by the large trading countries and the consequent increase in their import demands. In the context of the present model trade liberalization in agriculture in the developed countries implies an increase in the price of the export commodity of the developing country, P_X. On the contrary, tariff reform in the case of manufacturing product means a reduction in the import tariff, t, on Z.

From (22) it is easy to check that

(iii) $\hat{L}_C > (<)0$ when $\hat{t} < 0$ iff $|\lambda| > (<)0$; and,

(iv) $\hat{L}_C > (<)0$ when $\hat{P}_X > 0$ iff $|\lambda| > (<)0$.

If the price of the agricultural commodity, P_X, rises or the import tariff on sector Z falls, the informal sector adult wage rate, W, rises following a *Stolper-Samuelson effect* as sector X is more intensive in the use of labour vis-à-vis the industrial sectors as a whole. The child wage rate, W/μ, also rises as a consequence. The supply of child labour from each poor family, l_C, increases (see equation (6.1)). As a consequence, the incidence of child labour rises. This is the *direct effect* of the trade liberalization policies, which exerts an upward pressure on the incidence of child labour. However, as the *direct effect* raises the number of available child labour and hence the effective adult labour endowment of the economy, sector Z expands (contracts) if and only if $|\lambda| < (>)0$. If the formal sector expands, some workers move out of the informal sectors to join the formal sector. Hence, the number of families, supplying child labour, decreases. This is the *labour reallocation effect*, which produces a favourable effect on the incidence of child labour. The net result would a decrease in the aggregate supply of child labour as the *labour reallocation effect* outweighs the *direct effect*. On the contrary, when $|\lambda| > 0$ sector Z contracts. More adult workers are now employed in the two informal sectors, thereby raising the total number of families supplying child labour. Thus, in this case both the *direct effect* and

the *labour reallocation effect* work on the same direction and accentuate the incidence of child labour in the society. This leads to the following proposition.

PROPOSITION 3: Tariff reform in manufacturing import or a policy of trade liberalization in agriculture lowers (raises) the incidence of child labour in the society if and only if $|\lambda| < (>)0$.

A close look at propositions 2 and 3 reveals that when $|\lambda| > 0$, an inflow of foreign capital or a hike in education subsidy lowers the incidence of child labour while a policy of tariff reform and/or trade liberalization in agriculture accentuates the problem. On the contrary, the former policies raise the incidence of child labour while the latter produce the opposite effect when $|\lambda| < 0$. In a developing economy, a subsidy policy on education and trade and investment liberalization policies are undertaken concurrently. In the given setup, we find that if these policies are undertaken concurrently, some of these will work to reduce the incidence of child labour while the others will accentuate the problem, thereby counterbalancing each other's effects, partially, if not fully. Thus, the net effect may be ambiguous irrespective of the sign of $|\lambda|$. This establishes the final proposition of the model.

PROPOSITION 4: If a subsidy policy on education and different trade and investment liberalization policies are adopted in a developing economy concomitantly, the net effect on the incidence of child labour may be uncertain.

4. Concluding Remarks:

Abject poverty and lack of educational facilities are often cited in the literature as the primary factors responsible for the incidence of child labour in the developing economies. Liberalized trade and investment policies and provision of better and free education were often recommended as remedial measures. Trade and investment liberalization programs are supposed to reduce poverty by raising the growth rates of these economies, thereby putting a brake on the incidence of poverty-induced child labour. On the other hand, betterment of educational facilities coupled with allied incentive schemes would also be able to deliver the goods by keeping the children from poor families into schools and refraining them from entering the job market. Over the last two decades, the developing economies have gone in for economic liberalization in a big way. Several drastic measures have been implemented to ensure a freer international trade. Also,

provisions have been made for ensuring free and better educational opportunities. However, what empirical evidence from several countries in transition reveals is not quite encouraging. The incidence of child labour has decreased over the last few decades but not at the expected rate. Even in some high growth-prone areas, the incidence has been on the rise. Why globalization and betterment of educational opportunities have not so far been able to produce the desired results is quite puzzling. The present paper has made an attempt to provide a theoretical answer to the above question in terms of a three-sector general equilibrium model with informal sector and child labour.

The paper has shown that if different trade and investment liberalization programs and a free education policy are undertaken simultaneously in a transition economy, their overall effect on the supply of child labour may not be quite satisfactory as different policies produce mutually opposite effects on the incidence of child labour, thereby nullifying each other's effects, at least partially. For example, when $\lambda > 0,$ an inflow of foreign capital or a hike in education subsidy exerts a downward pressure on the incidence of child labour while a policy of tariff reform or trade liberalization in agriculture accentuates the problem. On the contrary, the former two policies raise the child labour incidence while the latter policies produce the opposite effect when $|\lambda| < 0.$ The actual sign of $|\lambda|$ depends on the parameters of the system. So, taking into account all parameter values, the policymakers of the country should decide which policies ought to be given priority and carried out in order to mitigate the incidence of poverty-induced child labour in the system.

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APPENDIX:

1.

Totally differentiating equations (8), (9) and (10.1) we get the following expressions.

$$\theta_{LX}\hat{W} + \theta_{KX}\hat{R} = \hat{P}_X \quad \text{(A.1)}$$

$$\theta_{LY}\hat{W} + \theta_{KY}\hat{R} - \hat{P}_Y = 0 \quad \text{(A.2)}$$

$$\theta_{LZ}E_W\hat{W} + \theta_{KZ}\hat{R} + \theta_{YZ}\hat{P}_Y = T\hat{t} \quad \text{(A.3)}$$

where $T = (t/(1+t)) > 0$ and $E_W = ((\partial W^*/\partial W)(W/W^*))$. E_W is the elasticity of the unionized wage rate, W^*, with respect to the informal sector wage rate, W.

Solving equations (A.1), (A.2) and (A.3) by Cramer's rule one gets expressions (15) and (16) presented in the text.

2.

Totally differentiating equation (14) one gets the following.

$$\lambda_{LX}\hat{X} + \{\lambda_{LY} + \lambda_{LZ}(1 + l_C/\mu)\}\hat{Z} = \lambda_{LX}\theta_{KX}\sigma_X(\hat{W} - \hat{R}) + \lambda_{LY}\theta_{KY}\sigma_Y(\hat{W} - \hat{R})$$
$$+ \frac{(L - a_{LZ}Z)}{L^*(W - \mu B)^2}[(W - \mu B)\{n(\alpha + \beta)W\hat{W} - \mu\gamma W\hat{W} - n\mu B'E\hat{E}\}$$
$$- \{n(\alpha + \beta)W - n\mu B - \mu\gamma W\}(W\hat{W} - \mu B'E\hat{E})]$$

where $L^* = (L + L_C/\mu)$ is the effective adult labour endowment of the economy. Thus, $\lambda_{Li} = (a_{Li}X_i/L^*)$ for $i = X, Y, Z$. Note that $\hat{a}_{Li} = -\theta_{Ki}\sigma_i(\hat{W} - \hat{R})$ where σ_i is the elasticity of substitution between labour and capital in the i-th sector for $i = X, Y$. But $\sigma_Z = 0$ as we have assumed fixed-coefficient technology for sector Z. Simplification gives

$$\lambda_{LX}\hat{X} + \{\lambda_{LY} + \lambda_{LZ}(1 + l_C/\mu)\}\hat{Z}$$
$$= (\lambda_{LX}\theta_{KX}\sigma_X + \lambda_{LY}\theta_{KY}\sigma_Y)(\hat{W} - \hat{R})$$
$$+ \frac{(L - a_{LZ}Z)}{L^*(W - \mu B)}[W\hat{W}\{n(\alpha + \beta) - \mu\gamma)\} - n\mu B'E\hat{E} - l_C(W\hat{W} - \mu B'E\hat{E})]$$

Using (15) and (16) we write

$$\text{or, } \lambda_{LX}\hat{X} + \{\lambda_{LY} + \lambda_{LZ}(1 + l_C / \mu)\}\hat{Z} = \frac{(\lambda_{LX}\theta_{KX}\sigma_X + \lambda_{LY}\theta_{KY}\sigma_Y)}{|\theta|}[\{1 - \theta_{LZ}(1 - E_W)\}\hat{P}_X - T\hat{t}]$$

$$+ \frac{(L - a_{LZ}Z)W}{L^*(W - \mu B)|\theta|}\{n(\alpha + \beta) - \mu\gamma - l_C\}[(\theta_{KY}\theta_{YZ} + \theta_{KZ})\hat{P}_X - \theta_{KX}T\hat{t}]$$

$$- [\frac{\mu B'E(1 + n)(L - a_{LZ}Z)}{L^*(W - \mu B)}]\hat{E}$$

$$\text{or, } \lambda_{LX}\hat{X} + \{\lambda_{LY} + \lambda_{LZ}(1 + l_C / \mu)\}\hat{Z} = A_1\hat{P}_X - A_2\hat{t} - A_3\hat{E} \qquad \text{(A.4)}$$

$$\text{where } A_1 = (1/|\theta|)[(\lambda_{LX}\theta_{KX}\sigma_X + \lambda_{LY}\theta_{KY}\sigma_Y)(1 - \theta_{LZ}(1 - E_W)$$

$$+ \frac{(L - a_{LZ}Z)W}{L^*(W - \mu B)}\{n(\alpha + \beta) - \mu\gamma - l_C\}(\theta_{KY}\theta_{YZ} + \theta_{KZ})] > 0;$$

$$A_2 = (\frac{T}{|\theta|})[(\lambda_{LX}\theta_{KX}\sigma_X + \lambda_{LY}\theta_{KY}\sigma_Y)$$

$$+ \frac{\theta_{KX}(L - a_{LZ}Z)W\{n(\alpha + \beta) - \mu\gamma - l_C)(\theta_{KY}\theta_{YZ} + \theta_{KZ})}{L^*(W - \mu B)}] > 0; \text{ and,}$$

$$A_3 = [\frac{\mu B'E(1 + n)(L - a_{LZ}Z)}{L^*(W - \mu B)}] > 0.$$

Similarly totally differentiating (13) we obtain

$$\lambda_{KX}\hat{X} + (\lambda_{KY} + \lambda_{KZ})\hat{Z} = \hat{K} + [\frac{(\lambda_{KX}\theta_{LX}\sigma_X + \lambda_{KY}\theta_{LY}\sigma_Y)\{T\hat{t} - \hat{P}_X(1 - \theta_{LZ}(1 - E_W)\}}{|\theta|}]$$

$$= \hat{K} - A_4\hat{P}_X + A_5\hat{t} \qquad \text{(A.5)}$$

$$\text{where } A_4 = [\{(\lambda_{KX}\theta_{LX}\sigma_X + \lambda_{KY}\theta_{LY}\sigma_Y)/|\theta|\}\{(1 - \theta_{LZ}(1 - E_W)\}] > 0; \text{ and,}$$

$$A_5 = [\{(\lambda_{KX}\theta_{LX}\sigma_X + \lambda_{KY}\theta_{LY}\sigma_Y)/|\theta|\}T] > 0.$$

Solving (A.4) and (A.5) by Cramer's rule we get the following expression.

$$\hat{Z} = (1/|\lambda|)[\lambda_{KX}\hat{K} - (\lambda_{LX}A_4 + \lambda_{KX}A_1)\hat{P}_X + (\lambda_{LX}A_5 + \lambda_{KX}A_2)\hat{t} + \lambda_{KX}A_3\hat{E}] \qquad (19)$$

3.

Totally differentiating equation (7) we write

$$L_C\hat{L}_C = \frac{(L-a_{LZ}Z)}{(W-\mu B)}[nW(\alpha+\beta)\hat{W} - n\mu B'E\hat{E} - \mu\gamma W\hat{W} - l_C(W\hat{W} - \mu B'E\hat{E})] - l_C a_{LZ}Z\hat{Z}$$

$$\text{or, } \hat{L}_C = \frac{(L-a_{LZ}Z)}{L_C(W-\mu B)}\{n(\alpha+\beta) - \mu\gamma - l_C)\}W\hat{W} - \mu B'E(n-l_C)\frac{(L-a_{LZ}Z)}{L_C(W-\mu B)}\hat{E}$$

$$-(l_C a_{LZ}Z/L_C)\hat{Z}$$

Using (15) and (19), the above expression can be rewritten as follows.

$$\hat{L}_C = [\frac{(L-a_{LZ}Z)W}{L_C(W-\mu B)|\theta|}\{n(\alpha+\beta) - \mu\gamma - l_C)\}][(\theta_{KY}\theta_{YZ} + \theta_{KZ})\hat{P}_X - \theta_{KX}T\hat{t}]$$

$$-\frac{\mu B'E(n-l_C)(L-a_{LZ}Z)}{L_C(W-\mu B)}\hat{E}$$

$$-(\frac{l_C a_{LZ}Z}{L_C|\lambda|})[\lambda_{KX}\hat{K} - (\lambda_{LX}A_4 + \lambda_{KX}A_1)\hat{P}_X + (\lambda_{LX}A_5 + \lambda_{KX}A_2)\hat{t} + \lambda_{KX}A_3\hat{E}]$$

Rearranging terms one finds

$$\hat{L}_C = -(\frac{l_C a_{LZ}Z\lambda_{KX}}{L_C|\lambda|})\hat{K}$$

$$+\hat{P}_X[\frac{(L-a_{LZ}Z)W\{n(\alpha+\beta) - \mu\gamma - l_C\}(\theta_{KY}\theta_{YZ} + \theta_{KZ})}{L_C(W-\mu B)|\theta|} + \frac{l_C a_{LZ}Z(\lambda_{LX}A_4 + \lambda_{KX}A_1)}{L_C|\lambda|}]$$

$$-\hat{t}[\frac{T\theta_{KX}W(L-a_{LZ}Z)\{n(\alpha+\beta) - \mu\gamma - l_C\}}{L_C(W-\mu B)|\theta|} + \frac{l_C a_{LZ}Z(\lambda_{LX}A_5 + \lambda_{KX}A_2)}{L_C|\theta|}]$$

$$-\hat{E}[\frac{\mu B'E(n-l_C)(L-a_{LZ}Z)}{L_C(W-\mu B)} + \frac{l_C a_{LZ}Z\lambda_{KX}A_3}{L_C|\lambda|}] \qquad \text{(A.6)}$$

Now $[\frac{\mu B'E(n-l_C)(L-a_{LZ}Z)}{L_C(W-\mu B)} + \frac{l_C a_{LZ}Z\lambda_{KX}A_3}{L_C|\lambda|}]$

$$= [\frac{\mu B'E(n-l_C)(L-a_{LZ}Z)}{L_C(W-\mu B)} + \frac{l_C a_{LZ}Z\lambda_{KX}\mu B'(1+n)(L-a_{LZ}Z)}{L_C|\lambda|L^*(W-\mu B)}]$$

$$= [\frac{\mu B' E(L - a_{LZ} Z)}{L_C |\lambda| (W - \mu B)}][(n - l_C)|\lambda| + \lambda_{LZ} l_C \lambda_{KX} (1 + n)]$$

Inserting the value of $|\lambda|$ and after simplification the above expression becomes

$$[\frac{\mu B' E(n - l_C)(L - a_{LZ} Z)}{L_C (W - \mu B)} + \frac{l_C a_{LZ} Z \lambda_{KX} A_3}{L_C |\lambda|}]$$

$$= [\frac{\mu B' E(L - a_{LZ} Z)}{L_C |\lambda| (W - \mu B)}][(n - l_C)\{\lambda_{LX}(\lambda_{KY} + \lambda_{KZ}) - \lambda_{KX}(\lambda_{LY} + \lambda_{LZ})\}$$

$$+ l_C \lambda_{LZ} \lambda_{KX} \{(1 + n) - (n - l_C)/\mu\}] \qquad \text{(A.7)}$$

Again, $[\frac{T\theta_{KX} W(L - a_{LZ} Z)\{n(\alpha + \beta) - \mu\gamma - l_C\}}{L_C (W - \mu B)|\theta|} + \frac{l_C a_{LZ} Z(\lambda_{LX} A_5 + \lambda_{KX} A_2)}{L_C |\theta|}]$

$$= [\frac{T\theta_{KX} W(L - a_{LZ} Z)\{n(\alpha + \beta) - \mu\gamma - l_C\}}{L_C (W - \mu B)|\theta|} + (\frac{l_C a_{LZ} ZT}{|\lambda| L_C |\theta|})\{\lambda_{LX}(\lambda_{KX}\theta_{LX}\sigma_X + \lambda_{KY}\theta_{LY}\sigma_Y)$$

$$+ \lambda_{KX}(\lambda_{LX}\theta_{KX}\sigma_X + \lambda_{LY}\theta_{KY}\sigma_Y) + \frac{\lambda_{KX}\theta_{KX}(L - a_{LZ} Z)W(n(\alpha + \beta) - \mu\gamma - l_C)}{L^*(W - \mu B)}\}]$$

Inserting the value of $|\lambda|$ and after simplification the above expression becomes

$$[\frac{T\theta_{KX} W(L - a_{LZ} Z)\{n(\alpha + \beta) - \mu\gamma - l_C\}}{L_C (W - \mu B)|\theta|} + \frac{l_C a_{LZ} Z(\lambda_{LX} A_5 + \lambda_{KX} A_2)}{L_C |\theta|}]$$

$$= (\frac{T}{|\lambda||\theta| L_C})[\{\frac{\theta_{KX} W(L - a_{LZ} Z)(n(\alpha + \beta) - \mu\gamma - l_C)}{(W - \mu B)}\}\{\lambda_{LX}(\lambda_{KY} + \lambda_{KZ}) - \lambda_{KX}(\lambda_{LY} + \lambda_{LZ})$$

$$+ \lambda_{KX}\lambda_{LZ} l_C (1 - 1/\mu)\}$$

$$+ l_C a_{LZ} Z\{\lambda_{LX}(\lambda_{KX}\theta_{LX}\sigma_X + \lambda_{KY}\theta_{LY}\sigma_Y) + \lambda_{KX}(\lambda_{LX}\theta_{KX}\sigma_X + \lambda_{LY}\theta_{KY}\sigma_Y)\}] \qquad \text{(A.8)}$$

We also write

$$[\frac{(L - a_{LZ} Z)W\{n(\alpha + \beta) - \mu\gamma - l_C\}(\theta_{KY}\theta_{YZ} + \theta_{KZ})}{L_C (W - \mu B)|\theta|} + \frac{l_C a_{LZ} Z(\lambda_{LX} A_4 + \lambda_{KX} A_1)}{L_C |\lambda|}]$$

$$= [\frac{(L - a_{LZ}Z)W\{n(\alpha+\beta) - \mu\gamma - l_C\}(\theta_{KY}\theta_{YZ} + \theta_{KZ})}{L_C(W - \mu B)|\theta|}$$

$$+ \frac{l_C a_{LZ} Z}{|\theta| L_C |\lambda|}\{\lambda_{LX}(1 - \theta_{LZ}(1 - E_W))(\lambda_{KX}\theta_{LX}\sigma_X + \lambda_{KY}\theta_{LY}\sigma_Y)$$

$$+ \lambda_{KX}(\lambda_{LX}\theta_{KX}\sigma_X + \lambda_{LY}\theta_{KY}\sigma_Y)(1 - \theta_{LZ}(1 - E_W))$$

$$+ \lambda_{KX}\frac{(L - a_{LZ}Z)W(n(\alpha+\beta) - \mu\gamma - l_C)(\theta_{KY}\theta_{YZ} + \theta_{KZ})}{L^*(W - \mu B)}\}]$$

Inserting the value of $|\lambda|$ and after simplification the above expression becomes

$$[\frac{(L - a_{LZ}Z)W\{n(\alpha+\beta) - \mu\gamma - l_C\}(\theta_{KY}\theta_{YZ} + \theta_{KZ})}{L_C(W - \mu B)|\theta|} + \frac{l_C a_{LZ} Z(\lambda_{LX}A_4 + \lambda_{KX}A_1)}{L_C|\lambda|}]$$

$$= (\frac{1}{L_C|\lambda\|\theta|})[\frac{(L - a_{LZ}Z)W(\theta_{KY}\theta_{YZ} + \theta_{KZ})(n(\alpha+\beta) - \mu\gamma - l_C)}{(W - \mu B)}\{\lambda_{LX}(\lambda_{KY} + \lambda_{KZ})$$

$$- \{\lambda_{KX}(\lambda_{LY} + \lambda_{LZ}) + \lambda_{KX}\lambda_{LZ}l_C(1 - 1/\mu)\}$$

$$+ l_C a_{LZ} Z(1 - \theta_{LZ}(1 - E_W))\{\lambda_{LX}(\lambda_{KX}\theta_{LX}\sigma_X + \lambda_{KY}\theta_{LY}\sigma_Y)$$

$$+ \lambda_{KX}(\lambda_{LX}\theta_{KX}\sigma_X + \lambda_{LY}\theta_{KY}\sigma_Y)\}] \qquad \text{(A.9)}$$

Using (A.7), (A.8) and (A.9) from (A.6) we finally get

$$\hat{L}_C = -(\frac{l_C a_{LZ} Z\lambda_{KX}}{L_C|\lambda|})\hat{K}$$

$$+ \hat{P}_X(\frac{1}{L_C|\lambda\|\theta|})[\frac{(L - a_{LZ}Z)W(\theta_{KY}\theta_{YZ} + \theta_{KZ})(n(\alpha+\beta) - \mu\gamma - l_C)}{(W - \mu B)}\{\lambda_{LX}(\lambda_{KY} + \lambda_{KZ})$$

$$- \{\lambda_{KX}(\lambda_{LY} + \lambda_{LZ})\} + l_C a_{LZ} Z(1 - \theta_{LZ}(1 - E_W))\{\lambda_{LX}(\lambda_{KX}\theta_{LX}\sigma_X + \lambda_{KY}\theta_{LY}\sigma_Y)$$

$$+ \lambda_{KX}(\lambda_{LX}\theta_{KX}\sigma_X + \lambda_{LY}\theta_{KY}\sigma_Y)\}]$$

$$- \hat{t}(\frac{T}{|\lambda\|\theta|L_C})[\{\frac{\theta_{KX}W(L - a_{LZ}Z)(n(\alpha+\beta) - \mu\gamma - l_C)}{(W - \mu B)}\}\{\lambda_{LX}(\lambda_{KY} + \lambda_{KZ}) - \lambda_{KX}(\lambda_{LY} + \lambda_{LZ})\}$$

$$+ l_C a_{LZ} Z\{\lambda_{LX}(\lambda_{KX}\theta_{LX}\sigma_X + \lambda_{KY}\theta_{LY}\sigma_Y) + \lambda_{KX}(\lambda_{LX}\theta_{KX}\sigma_X + \lambda_{LY}\theta_{KY}\sigma_Y)\}]$$

$$- \hat{E}[\frac{\mu B' E(L - a_{LZ}Z)}{L_C|\lambda|(W - \mu B)}][(n - l_C)\{\lambda_{LX}(\lambda_{KY} + \lambda_{KZ}) - \lambda_{KX}(\lambda_{LY} + \lambda_{LZ})\} + l_C\lambda_{LZ}\lambda_{KX}(1 + l_C)]$$

…… (22)