CHILD LABOUR AND TRADE LIBERALIZATION*

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The paper analyses the implications of trade liberalization on the incidence of child labour in a two-sector general equilibrium framework. The supply function of child labour has been derived from the utility-maximizing behaviour of the working families. The paper finds that the effect of trade liberalization on the incidence of child labour crucially hinges on the relative factor intensities of the two sectors.
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1. Introduction

The incidence of child labour is a slur on the fair face of the globalized world. Although child labour has been prevalent from as early as the eighteenth century (mainly in rural farming), and gained a boost during the industrial revolution in the nineteenth century, the problem has attracted serious cognizance only since the process of globalization has led to calls for different policy measures to curb the evil. In the past fifty years, the magnitude of child labour has been declining throughout the world. Today, child labour is 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. India is one of the countries in which the degree of child labour is greatest.

An accurate measure of working children is difficult to obtain, since there is no single, clear-cut definition of child labour under international law. Most of the empirical surveys classify "child labour" as pertaining to those children under 12 years of age who work on a regular basis for which they are paid, or whose work results in output destined for the market (Basu, 1999). According to the Bureau of Statistics of the ILO, in 1995 at least 120 million of the world's children aged 5–14 were performing full-time paid work. The participation rates for children aged 10–14 in 1995 was 13.02% for the world as a whole, and 14.37% for India (ILO, 1996). Although the estimates are satisfactory if compared with the 1950 estimates of 27.57% and 35.43%, respectively, the magnitude of child labour in absolute terms remains quite alarming. If the "invisible" workers who perform unpaid and household jobs are included, it is likely that the estimates would shoot up significantly further.

In the conventional literature, the supply of child labour has been attributed to factors such as failure of the educational system, the objectives of households to maximize present

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income, a dualistic economy characteristic of developing countries with the coexistence of formal and informal sectors, etc. However, it is beyond any doubt 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 means of livelihood. To eradicate the incidence of child labour, the *World Development Report* (World Bank, 1995) called for a multifaceted approach, with programmes that would increase income security, reduce costs of education and improve the quality of schooling.

There have been many ground-breaking changes in the global scenario over the last two decades. The multilateral agreement and the formation of the World Trade Organization (WTO), following the GATT Uruguay Round of discussions in 1995, have brought about revolutionary changes in international trade liberalization across both developed and developing countries. 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 that use capital or skilled labour intensively. During this period the problem of child labour has attracted serious attention and resulted in calls for a number of policy measures to curb the evil. It was believed that liberalized trade policies would take the developing countries into higher growth orbits, the benefits of which would percolate down to the bottom of the society, thereby resulting in a reduction of poverty and the incidence of poverty-driven child labour. Despite the fact that most of the developing economies have adopted free trade as their development strategy, 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 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); Basu (1999, 2002); Ranjan (1999); Baland and Robinson (2000); Jafarey and Lahiri (2002) and Dessy (2000). In a backward society where the child mortality rate is quite high, Eswaran (1996) has found an explanation for the incidence of high fertility rates and lower investment in the education of their offspring (and hence the high incidence of child labour) in parents' need for old age security. He has therefore suggested improving the health care services and legislating for 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), then unfavourable adult labour markets, responsible for low adult wage rates, are 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 to be poor and not to have the luxury of sending his children to school; he is forced to send them to the job market to supplement low family income out of sheer poverty. It follows from the Basu–Van (1998) paper that labour market interventions that raise adults' wages are expected to mitigate the problem of child labour.

Some papers in the literature focus 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 labour. On the other hand, Dessy (2000) has advocated the imposition of compulsory education as a means to combat the incidence of child labour. He has shown that, in an economy where the benefits of

having children are outweighed by costs of rearing them, a policy of free education with no compulsory education laws may lead the economy into an underdevelopment trap with a high fertility rate and a greater incidence of child labour. On the other hand, a compulsory education policy could be expected to eradicate the existence of the evil from the system.

Unfortunately, the existing theoretical literature on child labour does not deal adequately with issues such as the supply of child labour and its linkages with the adult labour markets in a multi-sector general equilibrium framework,[1] which is especially crucial when child labour and adult labour are substitutes in different informal sectors of a developing economy.[2] One cannot derive the overall effect of a policy on the incidence of child labour in a partial equilibrium framework. This is because, as the recent Bangladeshi experience has shown,[3] a policy designed to mitigate the problem of child labour in a targeted sector may drive the children into other sectors of the economy to 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 an economy. Also, no attempt has so far been made to analyse the implications of the liberalized trade policies on the problem of child labour. This should have been attempted earlier, especially when trade liberalization was expected to exert downward pressures on the incidence of poverty-driven child labour.

The present paper aims to examine the implications of trade liberalization policy on the incidence of child labour in a general equilibrium setup. We consider a two-sector full-employment model with child labour. It is assumed that different economic activities are perfectly substitutable between adult and child labour (see Basu, 1999).[4] Also, all types of labour are perfectly mobile between the two sectors; so wage rates are equal across the two sectors. The supply function for child labour has been derived from the utility-maximizing behaviour of the working families.[5] We have analysed how a reduction of the tariff rate affects the supply of child labour and found that the effect of tariff reform hinges crucially on the relative factor intensities of the two sectors and the parameter values of the system.

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[1] The Basu–Van (1998) model, of course, can be easily embedded in a general equilibrium framework. Basu (2002) also focuses on the analysis of multiple general equilibria with child labour.

[2] See footnote 5 in this context.

[3] Owing to the possible introduction of the US Harkins Bill, which calls for a complete ban on imports of any good manufactured wholly or partly by child workers, employers in the booming garments industry in Bangladesh, who had employed a large number of child labourers, began to remove significant numbers of child workers. The result was a chaotic process that left many children worse off than they had been before.

[4] In the developing economies child workers are found mostly in firms producing carpets, glassware, bangles, leather bags, shoes, garments, matchboxes/fireworks and in cattle-feeding. It is logical to assume that adults can perform all these tasks. First, all these industries exist as well 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 was once put forward, especially for carpet weaving, is merely an excuse given by employers and fails to convince researchers (see Burra, 1995 and Weiner, 1991). Even if present technologies did require the use of child labour rather than 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 to allow the substitution of adult workers for children.

[5] This model is not applicable to the problems of street-children in urban areas where child labourers themselves are the decision-makers.

The paper is organized in the following way. Section 2 describes the model: Section 2.1 analyses the behaviour of the representative adult worker and derives the supply function of child labour; Section 2.2 describes the working of the general equilibrium model of the economy; the effect of trade liberalization on the incidence of child labour has been analysed in Section 2.3. Concluding remarks are made in the final section.

2. The model

We consider a small open economy with two sectors producing an exportable commodity X and an importables Z, using labour and capital. There are two types of labour in the model: adult labour and child labour. Following Basu and Van (1998), we assume that adult labour is a perfect substitute for child labour. It is assumed that an adult worker is equivalent to β number of child workers, where $\beta > 1$. Each adult worker earns a wage of W. The child wage rate, W_C, must be (W/β) when the adult wage rate is W.

Complete mobility of both types of labour and capital between the two sectors is assumed, and this ensures that the wage rates and rental on capital must be the same across these sectors.

Sector 2 is the tariff-protected import-competing sector, producing a commodity Z. Production functions in sectors X and Z satisfy constant returns to scale with positive but diminishing returns to each factor. Markets are perfectly competitive and all factors of production are fully employed. Each firm maximizes profit. Owing to the small open economy assumption, commodity prices are given internationally. For the moment we do not make any assumption regarding the relative factor intensities of the two sectors.

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

a_{Li}: labour–output ratio in the ith sector, $i = X, Z$
a_{Ki}: capital–output ratio in the ith sector, $i = X, Z$
θ_{ji}: distributive share of the jth input in the ith industry, $j = L, K$ and $i = X, Z$
λ_{ji}: proportion of the jth input employed in the ith sector, $j = L, K$ and $i = X, Z$
P_i: world price of the ith good, $i = X, Z$
t: *ad valorem* tariff rate on the import of Z
T: total tariff revenue of the government
M: volume of imports of commodity Z
W: adult wage rate
$W_C (= W/\beta)$: child wage rate
R: rate of return to capital
C_X: consumption of commodity X by each working family
C_Z: consumption of commodity Z by each working family
L: adult labour endowment
L_C: aggregate supply of child labour
K: domestic capital stock of the economy
$\wedge$: proportional change

2.1 Supply function of child labour

In this section we want to derive the supply function of child labour from the utility-maximizing behaviour of the representative adult worker who sends his children to work.

The utility function of the representative adult worker is given by

$$U = W(C_X, C_Z) - V(L_C).$$

The worker derives utility from the consumption of the final goods and disutility from child labour. For analytical simplicity, let us consider the following specific algebraic form of the utility function:

$$U = (C_X)^\alpha + (C_Z)^\alpha - (L_C)^\alpha \qquad \text{with} \qquad 0 < \alpha < 1 \tag{1}$$

This satisfies all the standard properties. Also, it is additive and symmetric. It is homogeneous of degree α and has the constant elasticity of substitution between any two arguments.

The worker maximizes this utility function subject to the budget constraint

$$P_X C_X + P_Z(1 + t)C_Z = \{[(W/\beta)L_C + Y]/L\}, \tag{2}$$

where (Y/L) is the own income of the adult worker and is given by

$$(Y/L) = [(WL + RK + T)/L]. \tag{3}$$

Here it is assumed that workers are the owners of capital. So the income from capital is distributed equally among the workers. Besides, each worker receives a fraction of the tariff revenue as income transfer from the government.

The following first-order conditions are satisfied in equilibrium:

$$(C_X/C_Z)^{(\alpha-1)} = [P_X/P_Z(1 + t)], \tag{4}$$

$$(C_X/L_C)^{(\alpha-1)} = [P_X/(W/\beta)], \tag{5}$$

$$(C_Z/L_C)^{(\alpha-1)} = [(P_Z(1 + t)/(W/\beta)]. \tag{6}$$

Using (5) and (6), we have

$$P_X C_X + P_Z C_Z(1 + t) = [P_X^{(\alpha/\alpha-1)} + (P_Z(1 + t))^{(\alpha/\alpha-1)}] (\beta/W)^{(1/\alpha-1)} L_C. \tag{7}$$

This means that in equilibrium total expenditure on final goods is proportional to the supply of child labour given the product prices, the wage rate and the tariff rate.

Using (2), (3) and (7), we have

$$L_C = \{[L + (R/W)K + (T/W)]/[(P_X)^{\alpha/\alpha-1} + (P_Z(1 + t))^{\alpha/\alpha-1}] [(\beta)^{1/\alpha-1}(W)^{\alpha/1-\alpha}] - (1/\beta)\}. \tag{8}$$

This is the aggregate supply function of child labour. We now analyse its properties. First, the supply of child labour varies positively with rental rate on capital, R, the capital stock, K, and the adult labour endowment, L. L_C also varies positively with the tariff revenue, T; and T in turn varies positively with the tariff rate, t, if the import demand is inelastic. Here income effect on child labour supply is positive. Given the product prices, equilibrium consumption of either commodity is proportional to the supply of child

labour. Since both commodities are non-inferior, the supply of child labour varies positively with the adult workers' aggregate income, Y. Second, L_C varies negatively with the wage rate, W. Note that here adult labour and child labour are perfect substitutes. So (W/β) is the child wage rate. Hence a rise in W produces a negative price effect. Finally, L_C varies positively with the tariff rate, t. An increase in t lowers $[P_Z(1 + t^{(\alpha/\alpha-1)})]$ because $(\alpha/\alpha - 1) < 0$. So L_C rises, given the other parameters. The increase in the tariff rate raises the domestic price of commodity Z. So consumption of commodity Z is substituted by the consumption of commodity X. Since the relative consumption of X with respect to child labour (C_X/L_C) remains unchanged, L_C also rises.

In the subsequent sections of the paper the following general form of the aggregate child labour function will be used for analytical purpose. However, all the properties satisfied by the specific functional form given by equation (8) will be retained.

$$L_C = f(W, \ R, \quad t, \quad L, \quad K, \quad T) \tag{8.1}$$
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2.2 The general equilibrium analysis

Given the assumption of perfectly competitive markets, the usual price–unit cost equality conditions relating to the two sectors of the economy are given by the following two equations:

$$a_{LX}W + a_{KX}R = P_X, \tag{9}$$

$$a_{LZ}W + a_{KZ}R = P_Z(1 + t). \tag{10}$$

The capital endowment equation, which shows capital market equilibrium, is given by

$$a_{KX}X + a_{KZ}Z = K. \tag{11}$$

There are L homogeneous working families, each consisting of one adult member and a certain number of children. The number of children going to the job market from each family is decided by the adult member of the family; actually, it is determined from the utility-maximizing behaviour of the family. The aggregate supply function of child labour in general form is that given above in (8.1).

The effective labour endowment of the economy consists of both adult and child labour; and the labour market equilibrium is given by

$$a_{LX}X + a_{LZ}Z = L + (L_C/\beta). \tag{12}$$

In this model there are five endogenous variables (W, R, X, Z and L_C) and five independent equations. The parameters in the system are P_X, P_Z, β, L, K and t. Equations (9) and (10) constitute the price system, and (8.1), (11) and (12) form the output system. Note that the system possesses the decomposition property since the two unknown input prices, W and R, can be determined from the price system alone, independently of the output system. Once the factor prices are known, the factor coefficients, a_{ij}s, are known too. Also, the amount of child labour, L_C, is obtained from (8.1). Finally, X and Z are solved from (11) and (12).

2.3   Comparative static exercises

It is believed that liberalized trade 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 are expected to exert downward pressures on the incidence of poverty-induced child labour. In this section of the paper we shall examine the impact of trade liberalization on the incidence of child labour. In the present setup, trade liberalization means a reduction in the import tariff on commodity Z.

Totally differentiating (9) and (10) and solving by Cramer's rule, the following expressions can be obtained:

$$\hat{w} = -(1/|\theta|)\theta_{KX} S \hat{t} \tag{13}$$

and

$$\hat{R} = (1/|\theta|)\theta_{LX} S \hat{t} \tag{14}$$

where $|\theta| = \theta_{LX}\theta_{KZ} - \theta_{KX}\theta_{LZ}$ and $S = [t/(1+t)] > 0$.

Differentiating (8.1) with respect to t, the following expression is obtained:

$$(\mathrm{d}L_C/\mathrm{d}t) = (\partial L_C/\partial W)(\mathrm{d}W/\mathrm{d}t) + (\partial L_C/\partial R)(\mathrm{d}R/\mathrm{d}t) + (\partial L_C/\partial t) + (\partial L_C/\partial T)(\mathrm{d}T/\mathrm{d}t) \tag{15}$$
$$(-) \qquad\qquad (+) \qquad\qquad (+) \qquad\quad (+)$$

Here $(\partial L_C/\partial t)$ represents the price effect of the change in the tariff rate that is taking place via the change in the relative price of the importables. However, a change in the tariff rate causes a change in the tariff revenue and $(\partial L_C/\partial T)(\mathrm{d}T/\mathrm{d}t)$ represents the effect resulting from the change in tariff revenue. The combined effect is positive if $(\mathrm{d}T/\mathrm{d}t) \geq 0$, i.e. if the import demand is not elastic.[6] It is negative if $(\mathrm{d}T/\mathrm{d}t) < 0$; and $|((\partial L_C/\partial T)(\mathrm{d}T/\mathrm{d}t)| > (\partial L_C/\partial t)$. The sign and magnitude of $(\mathrm{d}T/\mathrm{d}t)$ depend on the values of the parameters of the system.[7]

Depending on the relative factor intensities between the sectors, the following two cases arise.

Case 1: $|\theta| = \theta_{LX}\theta_{KZ} - \theta_{KX}\theta_{LZ} > 0$

This means that the import-competing sector is more capital intensive than the export sector. From (13) and (14), it follows that $\hat{W} > 0$ and $\hat{R} < 0$ when $\hat{t} < 0$. So $(\mathrm{d}W/\mathrm{d}t) < 0$ and $(\mathrm{d}R/\mathrm{d}t) > 0$. Therefore from (15) it follows that $(\mathrm{d}L_C/\mathrm{d}t) > 0$ if $(\mathrm{d}T/\mathrm{d}t) \geq 0$.[8]

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[6] This is only a sufficient condition, not a necessary one.

[7] See the Appendix for derivation of the expression for $(\mathrm{d}T/\mathrm{d}t)$.

[8] This is only a *sufficient* condition for $(\mathrm{d}L_C/\mathrm{d}t)$ to be positive. However $(\mathrm{d}L_C/\mathrm{d}t)$ can be positive even when $(\mathrm{d}T/\mathrm{d}t)$ is negative.

Case 2: $|\boldsymbol{\theta}| = \boldsymbol{\theta}_{LX}\boldsymbol{\theta}_{KZ} - \boldsymbol{\theta}_{KX}\boldsymbol{\theta}_{LZ} < 0$

In other words, the import-competing sector is more labour intensive than the export sector. This may be the trade pattern for a newly industrialized economy.[9] From (13) and (14) it follows that $\hat{w} < 0$ and $\hat{R} > 0$ when $\hat{t} < 0$. So when $|\boldsymbol{\theta}| < 0$, $(\mathrm{d}W/\mathrm{d}t) > 0$ and $(\mathrm{d}R/\mathrm{d}t) < 0$. Therefore from (15) it follows that $(\mathrm{d}L_C/\mathrm{d}t)$ can be negative; i.e., a reduction in t may be counterproductive if the direct effect of a reduction in t is outweighed by indirect income effects via changes in W and R and by the tariff revenue effect.[10] Combining the effects in the above two cases, we arrive at the following proposition.

Proposition 1: *A reduction in import tariff may have an adverse effect on the incidence of child labour if the tariff-protected import-competing sector is less capital intensive than the export sector. However, it may reduce the pervasiveness of child labour when the import-competing sector is more capital intensive.*

Trade liberalization, in the form of reduction of tariff rates, has two types of effect on the supply of child labour. One is the price effect, which lowers the effective price of the importables. The other is the income effect, which takes place through changes in factor prices (and hence through changes in factor incomes of the household) and through a change in tariff revenue, which is transferred to the households by the government. When the import-competing sector is more capital intensive than the export sector, the aggregate income of each household decreases if $(\mathrm{d}T/\mathrm{d}t) \geq 0$, i.e. if the import demand is not elastic. Thus, under the sufficient condition that the demand for importables is not elastic, both price and income effects of trade liberalization move in the same direction, thereby reducing the incidence of child labour in the economy. However, it should be noted that this result might hold for elastic import demand function as well if the elasticity is not sufficiently high. On the other hand, a reduction in t lowers W and raises R when the import-competing sector is more labour intensive. In this case the price and the income effects of trade liberalization move in opposite directions. The supply of child labour is increased if the direct price effect is outweighed by the indirect income effect including the tariff revenue effect.

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[9] In case I, we considered a small open economy, which exports its labour-intensive commodity and imports the commodity that is intensive in the use of capital. In the traditional literature on trade and development, a developing economy has been depicted with this pattern of trade. However, of late the situation has changed a lot. There are many developing economies today that have adopted an export-oriented growth strategy where the alternative pattern of trade is equally plausible. According to the *World Development Report* (World Bank, 1991), most less developed countries are net importers of food, but some of them are net exporters of specific food items. For example, the erstwhile Soviet Union, Egypt, Nigeria, Iran, Iraq, South Korea, Brazil, Cuba, Mexico, etc., are major importers of wheat and have so far operated under a tariff-quota-subsidy system of trade restrictions. See also Raghavan (1991) and Marjit and Gupta (1995) in this context. At the same time, there are many newly industrializing economies that have grown to be large manufacturing exporters; see Beladi and Marjit (1996, p. 932). India is a typical example in this context. In the present case we would like to investigate the robustness of the result of case I under the alternative trade pattern for a developing economy.

[10] The tariff revenue effect is also a part of the income effect. Because the tariff revenue of the government is distributed among the working families as lump-sum payments, it is also a part of the aggregate income of each family. Any change in the tariff rate, t, affects the aggregate tariff revenue of the government (unless the import demand is unitary elastic), and hence the transfer payments made to the working families. As a consequence, the supply of child labour by each family, and hence the aggregate supply, would be affected. This we may call the "tariff revenue effect" to distinguish it from other components of the income effect, which arise because of changes in factor incomes resulting from a change in the tariff rate.

3. 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 have often been recommended as remedial measures. Trade and investment liberalization programmes 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.

Over the last two decades the developing economies have gone in for trade liberalization in a big way. Several drastic measures have been implemented to ensure a freer international trade. However, what empirical evidence from several countries in transition reveals is not very encouraging. The incidence of child labour has decreased over the last few decades, but not as much as expected. In some high-growth-prone areas, the incidence has even been on the rise. Why trade liberalization has not so far been able to produce the desired results is quite puzzling. The present paper has made an attempt to analyse the effect of trade liberalization in terms of a simple two-sector general equilibrium model.

We have shown that the effect of trade liberalization on the incidence of child labour depends crucially on the relative factor intensities of the two sectors and the values of parameters of the system. If the tariff-protected import-competing sector is capital intensive, a reduction of import tariff may lower the supply of child labour in the given setup. On the other hand, if the import-competing sector is more labour intensive than the export sector, removal of the protectionist policy may increase the incidence of child labour.

Finally, it should be mentioned that this paper concentrates only on poverty-driven child labour. While poverty has often been assumed to be the cause for paid child labour, other types of child labour are likely to arise depending on such factors as capital and labour market imperfections; trade-offs between returns to general human capital acquired through education and returns to specific human capital acquired through, say, working on the family farm; and deficiencies of educational opportunities.

On the whole, the recent theoretical literature, including the present paper, tends to neglect the different types of child labour and to focus on just one of its causes. Empirical papers such as Bhalotra (2000), Bhalotra and Heady (2000), Bommier and Lambert (2000) and Jensen (1999) have pointed out that there is a need for more analyses distinguishing between different types of child work. Future theoretical research should address this aspect.

Appendix

The aggregate tariff revenue of the government is given by

$$T = tP_Z M = tP_Z(C_Z L - Z) = tP_Z L(C_Z - Z/L).$$

From (4) and (6) we get, respectively,

$$C_X = C_Z[P_X/P_Z(1 + t)]^{1/(\alpha-1)} \tag{A1}$$

and

$$L_C = C_Z[W/\beta P_Z(1 + t)]^{1/(\alpha-1)}. \tag{A2}$$

Now the budget constraint of each working family is given by

$$P_X C_X + P_Z(1 + t)C_Z = (1/L)[(W/\beta)L_C + WL + RK + T].$$

Using (A1) and (A2), we get

$$P_X C_Z[P_X/P_Z(1 + t)]^{1/(\alpha-1)} + P_Z(1 + t)C_Z = (W/\beta L)C_Z[W/\beta P_Z(1 + t)]^{1/(\alpha-1)} \\ + W + R(K/L) + tP_Z(C_Z - Z/L),$$

or

$$C_Z = \frac{(1/L)[WL + RK - tP_Z Z]}{\{P_X[P_X/P_Z(1 + t)]^{1/(\alpha-1)} + P_Z - (W/\beta L)[W/\beta P_Z(1 + t)]^{1/(\alpha-1)}\}} \tag{A3}$$

Now, $T = tP_Z L(C_Z - Z/L)$. Using (A3), this becomes

$$T = \left(\frac{t P_Z(WL + RK - tP_Z Z)}{P_X(P_X/P_Z)^{1/(\alpha-1)}(1 + t)^{1/(1-\alpha)} + P_Z - (1/\beta L)(\beta P_Z)^{1/(1-\alpha)}(W)^{\alpha/(\alpha-1)}(1 + t)^{1/(1-\alpha)}}\right) - tP_Z Z \tag{A4}$$

Differentiating (A4) with respect to t, we get

$$\frac{dT}{dt} = \left\{ \frac{P_Z}{B}\left[(WL + RK - tP_Z Z) + t\left(L\frac{dW}{dt} + K\frac{dR}{dt} - P_Z\left(Z + t\frac{dZ}{dt} \right) \right) \right] - P_Z\left(Z + t\frac{dZ}{dt} \right) \right.$$

$$-\left(\frac{t P_Z}{(1 - \alpha)B^2} \right)(WL + RK - tP_Z Z)(1 + t)^{\alpha/(1-\alpha)}\left[P_X\left(\frac{P_X}{P_Z} \right)^{1/(\alpha-1)} \right.$$

$$\left. \left. -\frac{1}{\beta L}(\beta P_Z)^{1/(1-\alpha)}(W)^{\alpha/(\alpha-1)} + \frac{\alpha}{\beta L}(\beta P_Z)^{1/(\alpha-1)}(1 + t)(W)^{1/(\alpha-1)}\left(\frac{dW}{dt} \right) \right] \right\} \tag{A5}$$

where $B = [P_X(P_X/P_Z)^{1/(\alpha-1)}(1 + t)^{1/(1-\alpha)} + P_Z - (1/\beta L)(\beta P_Z)^{1/(1-\alpha)}(W)^{\alpha/(\alpha-1)}(1 + t)^{1/(1-\alpha)}]$.

The expression for (dZ/dt) is obtained after totally differentiating (11) and (12) and solving by Cramer's rule. As t decreases, the domestic price of Z, i.e. $P_Z(1 + t)$, decreases, which in turn causes the factor prices to change. The input–output coefficients, i.e. $a_{ji}s$, will also change, as these are functions of the factor price ratios. Given the product mix, there will be a shortage of capital (labour) if sector Z is more capital (labour) intensive than sector X. In both cases, sector Z contracts following Rybczynski-type effects. However, the sign of (dT/dt) is ambiguous, depending on the values of parameters such as α, L, P_X, P_Z, β and t.

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