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Kozo Kiyota
(Yokohama National University)

Naka 2-1, Kunitachi, Tokyo 186-8601, Japan
Phone: +81-42-580-9076 Fax: +81-42-580-9102
URL: http://www.econ.hit-u.ac.jp/~cces/index.htm
E-mail: cces@econ.hit-u.ac.jp

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Kozo Kiyota†

Faculty of Business Administration, Yokohama National University

Abstract

The empirical literature on trade liberalization reflects two puzzles. First, the effect of trade liberalization on economic growth is ambiguous. Second, the effect of trade liberalization by developing countries on their income distribution is ambiguous. This paper attempts to explain these two puzzles at the same time, based on a multiple-cone neoclassical growth model. The model shows that countries that are labor abundant in a global sense may see a rise in income inequality and a decline in per capita GDP and per capita consumption with liberalization if they are capital abundant in a local sense. The results suggest that the two puzzles can be explained by the existence of global and local factor abundances.

Key words: Trade Liberalization; Medium-run Growth; Income Distribution; Multiple-cone Model; Stolper–Samuelson Theorem
JEL classification code: F1, O41

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†Address: Faculty of Business Administration, Yokohama National University, 79-4 Tokiwadai, Hodogaya, Yokohama 240-8501, Japan; Phone: +81-45-339-3770; Fax: +81-45-339-3707; E-mail: kiyota [at] ynu.ac.jp

1 Introduction

The empirical literature on trade liberalization reflects two puzzles. First, the effect of trade liberalization on economic growth is ambiguous. A number of theoretical studies such as Baldwin (1992) have argued that trade liberalization leads to dynamic gains from greater capital accumulation as well as static efficiency gains. This in turn implies that trade liberalization has a positive effect on economic growth.[1] However, empirical studies have found that this theoretical prediction does not necessarily hold. Whereas some studies such as Edwards (1998) and Frankel and Romer (1999) stressed the positive relationship between trade liberalization and economic growth, other studies such as Rodriguez and Rodrik (2000) presented skeptical views about the methodologies and measurements used in previous studies.[2] Therefore, "the nature of the relationship between trade policy and economic growth remains very much an open question. The issue is far from having been settled on empirical grounds" (Rodriguez and Rodrik, 2000, p. 266).

The second puzzle is that the effect of trade liberalization by developing countries on their income distribution is ambiguous. The Stolper–Samuelson Theorem states that protection raises the real factor price of a country's scarce factor and lowers that of its abundant factor (Stolper and Samuelson, 1941). In other words, trade liberalization lowers the factor price of a country's scarce factor and increases that of its abundant factor. Given the fact that developing countries are generally more labor abundant than are industrialized countries, the Stolper–Samuelson Theorem suggests that trade liberalization leads to a decrease in the rental–wage ratio with an increase in the price of a labor-intensive good and a decrease in the price of a capital-intensive good. Because the rental–wage ratio can be interpreted as a proxy for income inequality,[3] a decrease in the rental–wage ratio implies a decrease in income inequality between workers and the owners of capital. Contrary to the Stolper–Samuelson Theorem, however, there is "a large amount of evidence from several developing countries regarding their exposure to globalization and the parallel evolution of inequality" (Goldberg and Pavcnik, 2007, p. 39).[4]

To solve the first puzzle, a number of studies such as Wacziarg and Welch (2003) attempt to refine the empirical framework. However, little attention has been paid to the theoretical framework. The second puzzle is partly explained by Davis (1996), who focused on multiple factor price equalization (FPE) sets, or multiple cones of diversification. The key insight of his analysis is in the distinction between global and local factor abundances. Global factor abundance is defined as the relative factor abundance of countries in factor space. On the other hand, local factor abundance is defined as the relative factor abundance within the country's cone of diversifica-

[1] Note that, in his critical review of Baldwin (1992), Mazumdar (1996) showed that whether trade liberalization leads to growth depends on the kind of good that is imported. Section 3 discusses Mazumdar's claim in more detail.

[2] Note that Edwards (1998) examined the effects of openness on total factor productivity growth whereas Frankel and Romer (1999) and Rodriguez and Rodrik (2000) examined the effects on per capita gross domestic product (GDP) growth. Winters (2004) provided an excellent literature review of the issues.

[3] See, for example, Jones (1975) and Davis (1996). In order to make the interpretation clear, this paper uses the rental–wage ratio rather than the wage–rental ratio.

[4] According to Goldberg and Pavcnik (2007, p. 40), "while inequality has many different dimensions, all existing measures for inequality in developing countries seem to point to an increase in inequality."

tion. Based on a static multiple-cone model, Davis found that trade liberalization could expand income inequality. However, his analysis lacked dynamic aspects. Therefore, the link between trade liberalization, economic growth, and income distribution is unclear. It remains an open question how the link can be modeled comprehensively.

This paper attempts to explain these two puzzles at the same time, based on a multiple-cone neoclassical growth model. The model combines the elements of Davis's (1996) view of local factor abundance together with the elements of Deardorff's (2001) model of trade and growth. Following previous studies such as Mazumdar (1996), growth in this paper refers to medium-run growth rather than long-run growth. Therefore, an increase in per capita GDP is interpreted as a positive effect of trade policy on medium-run economic growth.

Before starting, some terminological matters need to be clarified. That is, the model of this paper consists of industrialized countries and developing countries. The industrialized countries are capital abundant whereas the developing countries are labor abundant in a global sense. The developing countries are further divided into two groups. One comprises locally capital-abundant developing countries that are labor abundant in a global sense but capital abundant in a local sense. The other comprises locally labor-abundant developing countries that are labor abundant in both global and local senses. Table 1 summarizes the country classification.

=== Table 1 ===

Figure 1 illustrates the distinction between the global and local factor abundances, based on the Lerner diagram of a three-good, two-cone model. The two factors are capital and labor. The three goods are labor-, middle-, and capital-intensive goods. The two cones are $[\tau_1, \tau_2]$ and $[\tau_3, \tau_4]$, where τ_j $(j = 1, ..., 4)$ represents the capital–labor ratio and $\tau_1 < \tau_2 < \tau_3 < \tau_4$. Countries that locate in the cone $[\tau_3, \tau_4]$ are more capital abundant than countries that locate in the cone $[\tau_1, \tau_2]$. To simplify the discussion, I assume that "the world is "even" in the sense that there are an equal number of factors and goods in each cone" (Schott, 2003, p. 689). To simplify the terminology, industrialized countries are referred to as high-income countries, locally capital-abundant countries as middle-income countries, and locally labor-abundant countries as low-income countries. I use E_H to denote the factor endowments of a high-income country that locates in the cone $[\tau_3, \tau_4]$. I use E_M, and E_L to denote the factor endowments of middle- and low-income countries, respectively. Both E_M and E_L locate in the cone $[\tau_1, \tau_2]$.

=== Figure 1 ===

The high-income country is globally capital abundant in the sense that it locates in the capital-abundant cone $[\tau_3, \tau_4]$ and thus it can produce the capital-intensive as well as the middle-intensive goods. On the other hand, the middle- and low-income countries are globally labor abundant in the sense that they locate in the labor-abundant cone $[\tau_1, \tau_2]$ and thus they can produce the labor- as well as middle-intensive goods. Note, however, that the middle-income country is relatively capital abundant, whereas the low-income country is relatively labor abundant within the cone $[\tau_1, \tau_2]$. Therefore, the middle-income country is globally labor abundant but locally capital abundant, whereas the low-income country is labor abundant in both global and local senses. This distinction is explained in more detail in Section 3.

This paper focuses on the trade policy of developing countries to explain the two puzzles noted. The contribution of this paper is that it clarifies simultaneously the effects of trade liberalization on income distribution, per capita GDP, and per capita consumption, an issue that has not been explored in previous studies. The model shows that countries that are labor abundant in a global sense may see a rise in income inequality and a decline in per capita GDP and per capita consumption accompanying liberalization if they are capital abundant in a local sense. Therefore, the two puzzles can be attributed to the existence of multiple cones and the differences in factor abundance among countries within the same cone.

This paper is structured as follows. First, I present a three-good, two-cone Heckscher–Ohlin (HO) growth model in Section 2 and discuss some implications for income distribution, economic growth, and per capita consumption. Section 3 introduces the concept of local factor abundance into the HO growth model and examines the effects of trade policy by a developing country. Concluding remarks are provided in Section 4.

2 Model

2.1 Setup

The two-good HO growth and trade model was first developed by Oniki and Uzawa (1965). Deardorff (1974) developed a simplified version based on a single-cone model, introducing a small open economy assumption. Deardorff (2001) further extended the analysis from a two-good to a multiple-good model, introducing multiple cones. Following Galor (1996), in which savings result from wages rather than total income, Deardorff (2001) showed that the multiple-cone model became consistent with the existence of multiple steady states. My paper builds upon Deardorff (2001).

This section focuses on the basic features of the model and discusses some implications for income distribution, per capita GDP, and per capita consumption. The implications of this section hold irrespective of whether developing countries are locally capital abundant or locally labor abundant. Therefore, this section focuses on the case of global factor abundance. The distinction between global and local factor abundances is introduced in Section 3.

Suppose that there are three goods (a labor-intensive good Y_1, a middle-intensive good Y_2, and a capital-intensive good Y_3) and two factors (labor L and capital K). The capital intensities of the goods are $k_1 < k_2 < k_3$, where $k_i = K_i/L_i$. Assume that one of the three goods is classified as an investment good used for capital accumulation whereas the other two goods are classified as consumption goods used for consumption. However, the capital intensity of the investment good is unknown. Therefore, the labor-, middle-, or capital-intensive goods could be the investment good.

I denote total capital and labor in the economy as K and L, respectively. I denote the production function of industry $i(=1,2,3)$ as $Y_i = F_i(K_i, L_i)$, where $L_1+L_2+L_3 = L$ and $K_1+K_2+K_3 = K$. Let $p_i(>0)$ denote the price of good Y_i. Assume that the production function of good i is linear homogeneous: $y_i = Y_i/L_i = F_i(K_i, L_i)/L_i = F_i(K_i/L_i, 1) = f_i(k_i)$. Assume that the production functions have the standard properties of a neoclassical production function: $\lim_{k_i \to 0} f_i'(k_i) = \infty$,

$\lim_{k_i \to \infty} f_i'(k_i) = 0$, $f_i'(k_i) > 0$, and $f_i''(k_i) < 0$.

I use $W(>0)$ and $R(>0)$ to denote the nominal wage and the nominal rental rate, respectively. Assume that capital accumulation comes from savings S. Note that both savings and capital must be measured in the same units. If savings are measured differently from capital, then savings and capital are not comparable directly. In turn, this means that the price of the investment good p_I should be the numéraire. Let $\tilde{p}_i(=p_i/p_I)$ be the price of good Y_i normalized by the price of the investment good. Similarly, let $w(=W/p_I)$ and $r(=R/p_I)$ denote the wage and rental rate, respectively, normalized by the price of the investment good. Let $\tilde{z}_i(=\tilde{p}_i y_i)$ denote the value of production per worker in industry i. In addition, assume that all markets are perfectly competitive and, thus, firms earn zero profit: $\tilde{p}_i y_i - w - r k_i = 0$.

Based on this setup, Deardorff (2001) showed that the relationship between the capital–labor ratio and sectoral output could be constructed as in Figure 2. The per capita production functions $\tilde{z}_1$ and $\tilde{z}_2$ are connected by their common tangent AB. Similarly, the per capita production functions $\tilde{z}_2$ and $\tilde{z}_3$ are connected by their common tangent CD.[5] Perpendiculars $A\tau_1$ and $B\tau_2$ are dropped from the points of tangency to the horizontal axis. Similarly, let $\tau_3(p_2, p_3)$ and $\tau_4(p_2, p_3)$ denote the capital–labor ratios dropped from the points of tangencies for $p_2 f_2(k)$ and $p_3 f_3(k)$ to the horizontal axis. Capital–labor ratios $\tau_1, \ldots \tau_4$ are referred to as "knots." Both the labor- and the middle-intensive goods are produced in the interval $[\tau_1, \tau_2]$, whereas both the middle- and the capital-intensive goods are produced in the interval $[\tau_3, \tau_4]$. The interval is called an FPE set, which is analogous to the cone of diversification, or "cone" in the Lerner Diagram.

=== Figure 2 ===

Consider a small open economy where the price of goods is exogenously given and fixed. This in turn implies that $\tau_i \ \forall i$ are also fixed for given prices. The maximized per capita GDP of this economy is described as envelope $OABCDE$ in Figure 2. I denote this per capita GDP function by $z(k) = (\tilde{p}_1 Y_1 + \tilde{p}_2 Y_2 + \tilde{p}_3 Y_3)/L$:

$$z(k) = \begin{cases} \tilde{p}_1 f_1(k) & \text{if} \quad 0 \le k < \tau_1; \\ \bar{w}_1 + \bar{r}_1 k & \text{if} \quad \tau_1 \le k \le \tau_2; \\ \tilde{p}_2 f_2(k) & \text{if} \quad \tau_2 < k < \tau_3; \\ \bar{w}_2 + \bar{r}_2 k & \text{if} \quad \tau_3 \le k \le \tau_4; \\ \tilde{p}_3 f_3(k) & \text{if} \quad k > \tau_4, \end{cases} \tag{1}$$

where $\bar{w}_1$ and $\bar{r}_1$ are the wage and rental rate within the cone between τ_1 and τ_2 and thus are constant. Similarly, $\bar{w}_2$ and $\bar{r}_2$ are the wage and rental rates within the cone between τ_3 and τ_4 and are also constant.

Some of the important properties of this model are summarized as follows. First, the slope of the common tangent indicates the rental rate r, whereas its intercept indicates the wage w.[6]

[5] To simplify the discussion, this paper excludes the cases of no common tangent or multiple common tangents.

[6] See Hahn and Matthews (1964) for the proof.

Therefore, factor prices are written as follows:

$$r(k) = \frac{\partial z(k)}{\partial k} = \begin{cases} \tilde{p}_1 f_1'(k) & \text{if} \quad 0 \leq k < \tau_1; \\ \bar{r}_1 = \tilde{p}_1 f_1'(\tau_1) = \tilde{p}_2 f_2'(\tau_2) & \text{if} \quad \tau_1 \leq k \leq \tau_2; \\ \tilde{p}_2 f_2'(k) & \text{if} \quad \tau_2 < k < \tau_3; \\ \bar{r}_2 = \tilde{p}_2 f_2'(\tau_3) = \tilde{p}_3 f_3'(\tau_4) & \text{if} \quad \tau_3 \leq k \leq \tau_4; \\ \tilde{p}_3 f_3'(k) & \text{if} \quad k > \tau_4; \end{cases} \tag{2}$$

and

$$w(k) = \begin{cases} \tilde{p}_1 f_1(k) - \tilde{p}_1 k f_1'(k) & \text{if} \quad 0 \leq k < \tau_1; \\ \bar{w}_1 = \tilde{p}_1 f_1(\tau_1) - \tilde{p}_1 \tau_1 f_1'(\tau_1) = \tilde{p}_2 f_2(\tau_2) - \tilde{p}_2 \tau_2 f_2'(\tau_2) & \text{if} \quad \tau_1 \leq k \leq \tau_2; \\ \tilde{p}_2 f_2(k) - \tilde{p}_2 k f_2'(k) & \text{if} \quad \tau_2 < k < \tau_3; \\ \bar{w}_2 = \tilde{p}_2 f_2(\tau_3) - \tilde{p}_2 \tau_3 f_2'(\tau_3) = \tilde{p}_3 f_3(\tau_4) - \tilde{p}_3 \tau_4 f_3'(\tau_4) & \text{if} \quad \tau_3 \leq k \leq \tau_4; \\ \tilde{p}_3 f_3(k) - \tilde{p}_3 k f_3'(k) & \text{if} \quad k > \tau_4. \end{cases} \tag{3}$$

Second, per capita GDP is an increasing function of k. From equation (2), I have:

$$\frac{\partial z(k)}{\partial k} = r(k) > 0. \tag{4}$$

That is, as an economy accumulates capital (relative to labor), per capita GDP also increases.

Third, from equations (2) and (3), factor prices take the following relationships:

$$\frac{\partial w(k)}{\partial k} \begin{cases} > 0 & \text{if } k \text{ locates outside the cones;} \\ = 0 & \text{if } k \text{ locates inside the cones;} \end{cases} \tag{5}$$

and

$$\frac{\partial r(k)}{\partial k} \begin{cases} < 0 & \text{if } k \text{ locates outside the cones;} \\ = 0 & \text{if } k \text{ locates inside the cones.} \end{cases} \tag{6}$$

The rental–wage ratio $r(k)/w(k)$ is interpreted as a proxy for income inequality. Equations (5) and (6) imply the following general monotonic relationship between the rental–wage ratio and capital–labor ratio (Jones, 1974):

$$\frac{\partial \{r(k)/w(k)\}}{\partial k} \begin{cases} < 0 & \text{if } k \text{ locates outside the cones;} \\ = 0 & \text{if } k \text{ locates inside the cones.} \end{cases} \tag{7}$$

Figure 3 illustrates the relationship between the rental–wage ratio and the capital–labor ratio. If an economy locates outside the cones, capital accumulation raises the wage, lowers the rental ratio, and therefore lowers income inequality. On the other hand, if the economy locates inside the cones, capital accumulation has no effect on factor prices or income inequality.

=== Figure 3 ===

2.2 Growth in the small open economy

Now assume that population growth is $\dot{L} = nL(> 0)$, where $\dot{L} = dL/dt$. Assume that capital accumulation is $\dot{K} = S - \delta K$, where $\dot{K} = dK/dt$, S is savings, and $\delta(> 0)$ is the depreciation rate. Suppose that savings come from the wage: $S = swL$, where s $(0 < s \leq 1)$ is the savings rate.[7] Savings are equal to the demand for the investment good that is used for capital accumulation. The rest of the income is used for the consumption goods. The dynamics of the capital–labor ratio are written as follows:

$$\dot{k} = S/L - (n+\delta)k = sw(k) - (n+\delta)k \quad \text{or} \quad \frac{\dot{k}}{k} = s\frac{w(k)}{k} - (n+\delta). \tag{8}$$

Let k^* denote the capital–labor ratio at the steady state (i.e., $\dot{k} = 0$).

Based on this setup, Deardorff (2001) has provided a geometric explanation whereby developing countries converge to a low steady state, whereas industrialized countries converge to a high steady state, which is shown in Figure 4. If the $(n+\delta)k$ line crosses the wage curve inside the two cones, there exist three steady states: k_1^*, k_2^*, and k_3^*.[8] If the initial endowment of an economy is in the interval $(0, k_2^*)$, the economy converges to a low steady state k_1^*. Therefore, its wage and per capita GDP will be $\bar{w}_1$ and z_1^*, respectively. If, on the other hand, the initial endowment of an economy is greater than k_2^*, the economy converges to a high steady state k_3^*. Its wage and per capita GDP will be $\bar{w}_2$ and z_3^*, respectively. Because k_2^* is an unstable equilibrium, it is not examined in this paper.

=== Figure 4 ===

Note that the failure of a single FPE set is regarded as one of the important reasons why the HO model sometimes performs poorly in empirical analysis (e.g., Davis, Weinstein, Bradford, and Shimpo (1997)). Thus, the present paper does not assume that all countries are in a single FPE set. In other words, as in Figure 4, I consider the case where some countries are in a low steady state whereas others are in a high steady state. Countries in a high steady state k_3^* are referred to as industrialized countries because they have a high per capita GDP z_3^*. Similarly, countries in a low steady state k_1^* are referred to as developing countries because they have a low per capita GDP z_1^*.

[7] This assumption was introduced by Galor (1996) to explain the existence of multiple steady states and extended by Deardorff (2001) to incorporate international trade. Overlapping generations can be one possible justification for this assumption. For more detail, see Deardorff (2001).

[8] The multiple equilibria arise because savings come from wages rather than income. If savings are proportional to income, the per capita savings curve is a curve involving a proportional downward shift of the per capita GDP function. Because of the concavity of the GDP function, as in the Solow one-sector model, the savings curve crosses the wage curve only once. With Galor's assumption of savings resulting from wages, the wage curve becomes constant within the cones, which causes the multiple intersections with the $(n+\delta)k$ line. In addition, it is possible to obtain multiple equilibria from the savings out of the rental rate. However, note that in this case the savings curve will be a decreasing function of capital accumulation.

This paper focuses on countries whose capital–labor ratios locate within the cones (i.e., incomplete specialization: $\tau_1 \leq k^* \leq \tau_2$ or $\tau_3 \leq k^* \leq \tau_4$). From equations (3) and (8):

$$s\bar{w}_j - (n+\delta)k^* = 0 \qquad j = 1,2. \tag{9}$$

Therefore:

$$\frac{\partial k^*}{\partial s} = \frac{\bar{w}_j}{n+\delta} > 0 \qquad j = 1,2. \tag{10}$$

Savings have positive effects on capital accumulation if the economy locates inside one of the cones. Let c^* denote per capita consumption at the steady state. Because the income is used for either consumption or savings:

$$c^*(k^*) = z(k^*) - S/L = z(k^*) - (n+\delta)k^*. \tag{11}$$

This in turn means:

$$\frac{\partial c^*(k^*)}{\partial k^*} = \frac{\partial z(k^*)}{\partial k^*} - (n+\delta) = \bar{r}_j - (n+\delta) \begin{cases} > 0 & \text{if} \quad \bar{r}_j > n+\delta; \\ = 0 & \text{if} \quad \bar{r}_j = n+\delta; \\ < 0 & \text{if} \quad \bar{r}_j < n+\delta \end{cases} \qquad j = 1,2. \tag{12}$$

The relationship between steady-state per capita consumption and the capital–labor ratio depends upon the relationship between $\bar{r}_j$ and $n+\delta$.

2.3 Trade patterns

Assume that the preferences of the economy are homothetic. Let d_i and t_i denote the value of per capita domestic demand for good i (either a consumption good or an investment good) and the net export of good i, respectively: $t_i = \tilde{z}_i - d_i$. Assume that trade is balanced: $t_1 + t_2 + t_3 = 0$. The per capita net export of the consumption good is $t_i = \tilde{z}_i - c_i$ whereas that of the investment good is $t_i = \tilde{z}_i - S/L$.

Deardorff (2000) showed that trade patterns for the three-good, two-cone model can be presented as in Figure 5. The steady state of developing countries is located inside the cone $[\tau_1, \tau_2]$ and, therefore, these countries export the labor-intensive good and import the capital-intensive good. The steady state of industrialized countries is located inside the cone $[\tau_3, \tau_4]$ and, therefore, they export the capital-intensive good and import the labor-intensive good. Whether the middle-intensive good is exported by industrialized or developing countries depends upon their steady-state capital–labor ratios.

=== Figure 5 ===

2.4 Changes in the price of goods

For a small open economy, a protective tariff causes a change in the domestic price of imports. Therefore, to examine the effects of trade policy, it is important to clarify the effects of price

changes on the steady state. Because developing countries are not able to produce the capital-intensive good, the changes in its price do not have any effects on the domestic prices of the labor- and middle-intensive goods or on factor prices in developing countries. Thus, the following analysis examines the changes in the prices of the labor- and middle-intensive goods.

Note that Uzawa (1961) found that if the investment good sector was more capital intensive than the consumption good sector, the steady state could be unstable in the sense that the initial capital–labor ratio may not converge to the steady-state capital–labor ratio or there may exist multiple steady-state capital–labor ratios. However, this paper would not rule them out to examine multiple equilibria.

Suppose that the price of the middle-intensive good increases while holding the price of the labor- and capital-intensive goods constant. Assume that this increase is not large enough to cause a single FPE in the world. In other words, the world consists of two FPE sets before and after the change in the price. Regardless of whether the labor-(or capital-)intensive good is the investment good, however, the following lemmas are obtained at the steady state.

LEMMA 1: *An increase in the price of the middle-intensive good decreases per capita GDP and increases income inequality for developing countries.*
PROOF. See Appendix A1.

LEMMA 2: *An increase in the price of the middle-intensive good 1) decreases per capita consumption if $\bar{r}_1 > n+\delta$; 2) increases per capita consumption if $\bar{r}_1 < n+\delta$; and 3) has no effect on per capita consumption if $\bar{r}_1 = n+\delta$ for developing countries.*
PROOF: See Appendix A1.

Next, suppose that the price of the labor-intensive good increases, holding the price of the middle- and capital-intensive goods constant. Similarly to the case of the price change in the middle-intensive good, the following lemmas are obtained at the steady state.

LEMMA 3: *An increase in the price of the labor-intensive good increases per capita GDP and decreases income inequality for developing countries.*
PROOF: See Appendix A2.

LEMMA 4: *An increase in the price of the labor-intensive good 1) increases per capita consumption if $\bar{r}_1 > n+\delta$; 2) decreases per capita consumption if $\bar{r}_1 < n+\delta$; and 3) has no effect on per capita consumption if $\bar{r}_1 = n+\delta$ for developing countries.* PROOF: See Appendix A2.

3 Local Factor Abundance and Trade Policy

3.1 Local factor abundance and trade patterns

This section introduces the local factor abundance into the model. As discussed in Section 1, the local factor abundance means that developing countries locate in the same cone but have

different steady-state capital–labor ratios because, for example, they have different savings rates. Suppose that the developing countries are divided into two groups. One group has a high savings rate. Countries in this group have a relatively high steady-state capital–labor ratio (i.e., they are locally capital abundant) and, therefore, have a relatively high steady-state per capita GDP among the developing countries. The other group has a low savings rate. Countries in this group have a relatively low steady-state capital–labor ratio (i.e., they are locally labor abundant) and, therefore, have a relatively low steady-state per capita GDP among the developing countries.

To simplify the terminology, industrialized countries are referred to as high-income countries. The locally capital-abundant countries are referred to as middle-income countries. The locally labor-abundant countries are referred to as low-income countries. The classification of countries is summarized in Table 1. I denote the savings rates of the high-, middle-, and low-income countries by s_H, s_M, and s_L, respectively. I denote the steady-state capital–labor ratios of the high-, middle-, and low-income countries by k_H^*, k_M^*, and k_L^*, respectively. For analytical simplicity, assume that the high- and middle-income countries have the same savings rates ($s_H = s_M = s$). This, in turn, means that the middle-income countries have the same behavioral parameters as the high-income countries.

Figure 6 presents the global and local factor abundances in the three-good, two-cone model. Because savings come from wages, the high-income countries converge to the higher steady state k_H^*, whereas the middle-income countries converge to the lower steady state k_M^*. In addition, owing to the different savings rates, the low-income countries converge to further lower steady state k_L^*. These are dynamic equilibria analogous to the static equilibria in Figure 1.

=== Figure 6 ===

Assume that the difference in savings rates between the middle- and low-income countries is large enough to generate the different trade patterns between these countries. Figure 7 shows these patterns. The low-income countries export the labor-intensive good and import the middle-intensive and capital-intensive goods. The middle-income countries export the middle-intensive good and import the labor-intensive and capital-intensive goods. The high-income countries export the capital-intensive good and import the labor-intensive and middle-intensive goods.

=== Figure 7 ===

3.2 Effects of trade policy

In this model, there are three types of protection utilized by a developing country. First, the low- and middle-income countries restrict the imports of the capital-intensive good from the high-income countries. Second, the low-income countries restrict the imports of the middle-intensive good from the middle-income countries. Third, the middle-income countries restrict the imports of the labor-intensive good from the low-income countries. For analytical simplicity, following Deardorff (2001), I assume that tariff revenue is used for consumption.[9]

[9]This assumption implies that the tariff revenue is not saved such that the savings are a constant fraction of the wages. If tariff revenue is used for savings, trade policy causes changes in prices and savings. The increase in

First, consider the case where the middle- and low-income countries restrict the imports of the capital-intensive good from the high-income countries. At the steady state, I obtain the following propositions.

PROPOSITION 1: *The imposition of protection by a low- or middle-income country on the imports of the capital-intensive good from high-income countries has no effect on the former's per capita GDP if the capital-intensive good is the consumption good. On the other hand, protection lowers per capita GDP if the capital-intensive good is the investment good.*
PROOF: See Appendix A3.

PROPOSITION 2: *The imposition of protection by a low- or middle-income country on the imports of the capital-intensive good from high-income countries has no effect on the former's per capita consumption if a capital-intensive good is the consumption good. If the capital-intensive good is the investment good, per capita consumption: 1) decreases when* $\bar{r}_1 > n + \delta$*; 2) increases when* $\bar{r}_1 < n + \delta$*; and 3) is constant when* $\bar{r}_1 = n + \delta$.
PROOF: See Appendix A3.

PROPOSITION 3: *The imposition of protection by a low- or middle-income country on the imports of the capital-intensive good from high-income countries has no effect on the former's income inequality irrespective of whether the capital-intensive good is the consumption good or the investment good.*
PROOF: See Appendix A3.

The intuition behind Proposition 3 is that the price of the capital-intensive good p_3 either has no effect on the price of other goods or causes proportional increases in factor prices. The proportional increases do not affect the rental–wage ratio and, therefore, income inequality is not affected.

Note that trade liberalization has the opposite effect to protection. Three findings stand out from Propositions 1–3. First, trade liberalization by a developing country is not harmful to its per capita GDP growth. If the capital-intensive good is the investment good, trade liberalization raises per capita GDP. If the capital-intensive good is not the investment good, then trade liberalization has no effect on per capita GDP.

Second, the effect of trade liberalization by a developing country on its consumption is ambiguous in the sense that the effect depends upon the relationship between $\bar{r}_1$ and $n + \delta$. If $\bar{r}_1 > n + \delta$, trade liberalization has a positive effect on per capita consumption. However, if $\bar{r}_1 < n + \delta$, trade liberalization has a negative effect on per capita consumption. This in turn implies that the effect on per capita consumption is different from the effect on economic growth. If the capital-intensive good is the investment good and if $\bar{r}_1 > n + \delta$, trade liberalization raises per capita GDP and per capita consumption at the same time.

Finally, a change in the price of the capital-intensive good does not have any effects on the rental–wage ratio in the low- and middle-income countries. Because developing and industrialized countries operate in different cones, developing countries import the capital-intensive good

savings causes the increase in per capita GDP. The effect on consumption becomes more complex. However, income inequality is not affected by the changes in savings so long as the steady state locates in the cone of diversification.

that is produced outside the developing countries' cone. Therefore, an increase in the price of the capital-intensive good either has no effect on the price of goods produced in the developing countries or it causes proportional changes. Thus, the rental–wage ratio is not affected by the change in the price of the capital-intensive good.

Next, consider the case where a low-income country restricts imports from the middle-income countries. At the steady state, the following propositions are obtained.

PROPOSITION 4: *The imposition of protection by a low-income country on imports of the middle-intensive good from the middle-income countries raises the low-income country's income inequality and lowers its per capita GDP.*
PROOF: The imposition of protection by a low-income country on the imports of the middle-intensive good from the middle-income countries results in increases in the price of the middle-intensive good in the low-income country. Then, Proposition 4 is immediately derived from Lemma 1. ■

PROPOSITION 5: *The imposition of protection by a low-income country on the imports of the middle-intensive good from the middle-income countries: 1) lowers the low-income country's per capita consumption if* $\bar{r}_1 > n + \delta$*; 2) raises its per capita consumption if* $\bar{r}_1 < n + \delta$*; and 3) has no effect on per capita consumption if* $\bar{r}_1 = n + \delta$.
PROOF: As for the proof of Proposition 4, the imposition of protection by a low-income country on the imports from the middle-income countries results in an increase in the price of the middle-intensive good in the low-income country. Thus, Proposition 5 is immediately derived from Lemma 2. ■

Finally, consider the case where a middle-income country restricts imports from the low-income countries. At the steady state, the following propositions are obtained.

PROPOSITION 6: *The imposition of protection by a middle-income country on the imports of the labor-intensive good from the low-income countries lowers the middle-income country's income inequality and raises its per capita GDP.*
PROOF: The imposition of protection by a middle-income country on the imports of the labor-intensive good from the low-income countries results in an increase in the price of the labor-intensive good in the middle-income country. Then, Proposition 6 is immediately derived from Lemma 3. ■

PROPOSITION 7: *The imposition of protection by a middle-income country on the imports of the labor-intensive good from the low-income countries: 1) raises the middle-income country's per capita consumption if* $\bar{r}_1 > n + \delta$*; 2) lowers its per capita consumption if* $\bar{r}_1 < n + \delta$*; and 3) has no effect on per capita consumption if* $\bar{r}_1 = n + \delta$.
PROOF: As for the proof of Proposition 6, the imposition of protection by a middle-income country on imports from low-income countries results in an increase in the price of the labor-intensive good in the middle-income country. Thus, Proposition 7 is immediately derived from Lemma 4. ■

Figure 8 presents the imposition of protection by a middle-income country on the imports of the labor-intensive good from the low-income countries. For illustrative purposes, Figure 8 assumes that s is unity so that the wage curve can be treated as the per capita savings curve. An increase in p_1 causes an upward shift of the sectoral per capita production function of the labor-intensive good $\tilde{z}_1$ if Y_1 is not the investment good (Figure 8 (a)). If Y_1 is the investment good, an increase in p_1 causes a downward shift of the sectoral per capita production functions of the middle-intensive good $\tilde{z}_2$ and the capital-intensive good $\tilde{z}_3$ (Figure 8 (b)). This causes an increase in the steady-state capital–labor ratio from k_A^* to k_B^* and thus raises the per capita GDP from z_A^* to z_B^*.

=== Figure 8 ===

In addition, the increase in p_1 results in a downward–right shift of the rental–wage ratio curve, which decreases the steady-state rental–wage ratio from $\bar{r}_{1A}/\bar{w}_{1A}$ to $\bar{r}_{1B}/\bar{w}_{1B}$. Although both low- and middle-income countries are globally labor abundant, the effects of trade policy on economic growth and income distribution between these countries differ because of the local factor abundance.

Trade liberalization has the opposite effects to protection. Therefore, Proposition 6 states that trade liberalization by a middle-income country in relation to imports from the low-income countries *increases* the middle-income country's income inequality while *decreasing* its per capita GDP. Moreover, Propositions 5 and 7 states that the effect of trade liberalization by a developing country (either the middle- or the low-income country) on its per capita consumption is ambiguous.

Note that Propositions 4–7 hold irrespective of whether the imported good is the consumption or investment good. This result is different from Mazumdar (1996), who showed that trade liberalization would increase growth only if it lowered the price of the investment good. This is for the following two reasons. First, Mazumdar (1996) considered an economy in which factor intensities were the same between two sectors, whereas this paper considers an economy in which factor intensities are different. Second, Mazumdar (1996) assumed that savings come from income rather than wages, whereas the model in this paper assumes that savings come from wages. If two sectors have different factor intensities and savings come from wages, the change in the price of the consumption and investment goods have the same effects on factor prices regardless of the type of goods. The results of this paper do not depend upon what kinds of goods are imported.

Table 2 summarizes the effect of trade liberalization by a developing country. Propositions 1–7 together imply that the effects of trade liberalization by a developing country on economic growth and inequality depend upon which goods the country imports and from where they are imported. If a cross-country regression study does not take into account such differences, it is not surprising that the effects of trade liberalization by developing countries on their economic growth and income distribution become ambiguous.

=== Table 2 ===

In addition, Table 2 indicates that these propositions are "robust" in the sense that the effects on income inequality depend upon neither the relationship between $\bar{r}_1$ and $n+\delta$ nor the kind of good, that is, whether the import is a numéraire good. The effect on economic growth does not depend upon the relationship between $\bar{r}_1$ and $n+\delta$. Thus, it is not surprising that cross-country regressions generate ambiguous results. The existence of multiple cones and the difference in factor endowments within the same cone could be a possible explanation of these puzzles.

4 Concluding Remarks

The empirical literature on trade liberalization reflects two puzzles. First, the effect of trade liberalization on economic growth is ambiguous. Second, the effect of trade liberalization by developing countries on their income distribution is ambiguous. This paper attempts to explain the two puzzles at the same time, based on a multiple-cone neoclassical growth model.

My model combines the elements of Davis's (1996) view of static multiple equilibria together with the elements of Deardorff's (2001) model of trade and growth. I focus on new aspects that are not explored in these previous studies: income distribution, per capita GDP, and per capita consumption. My model shows that if developing countries locate in different steady states within the same FPE set, or the same diversification cone, trade liberalization by a developing country could increase its income inequality while decreasing its per capita GDP and per capita consumption. My results suggest that the existence of multiple cones and the multiple steady states within the same cone, or the existence of global and local factor abundances, can be a possible explanation of these puzzles.

Note that although my paper clarifies the two empirical puzzles at the same time, it does not examine the welfare effects involved. In addition, identifying the local factor abundance of developing countries is an important empirical question. These issues will be explored in the next stage of my research.

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Table 1. Country Classification

	Global factor abundance	Local factor abundance	Classification	Trade
Industrialized countries	Globally capital abundant	(Not examined in this paper)	High-income countries	Export capital-intensive good and import middle- and labor-intensive goods
Developing countries	Globally labor abundant	Locally capital abundant	Middle-income countries	Export middle-intensive good and import capital- and labor-intensive goods
		Locally labor abundant	Low-income countries	Export labor-intensive good and import middle- and capital-intensive goods

Table 2. Effects of Trade Liberalization

Trade liberalization	Income inequality	Per-capita GDP	Per-capita consumption	Source
Liberalization by the low- and middle-income countries on imports from the high-income countries	No effect	1) Increase if the import is the numeraire good 2) No effect otherwise	1) Increase if $r > n+\delta$ 2) Decrease if $r < n+\delta$ 3) No change if $r = n+\delta$	Propositions 1-3
Liberalization by the low-income countries on imports from the middle-income countries	Decrease	Increase	1) Decrease if $r > n+\delta$ 2) Increase if $r < n+\delta$ 3) No change if $r = n+\delta$	Propositions 4 and 5
Liberalization by the middle-income countries on imports from the low-income countries	Increase	Decrease	1) Increase if $r > n+\delta$ 2) Decrease if $r < n+\delta$ 3) No change if $r = n+\delta$	Propositions 6 and 7

Figure 1. Global and Local Factor Abundance

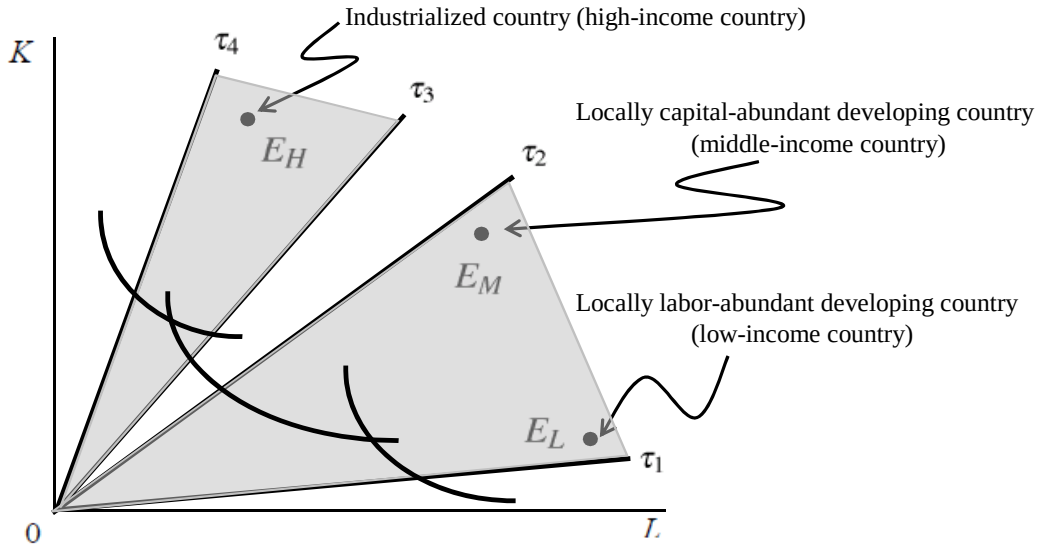


Figure 2. Relationship between Per-capita GDP and Capital-labor Ratio in the Three-good Two-cone Model

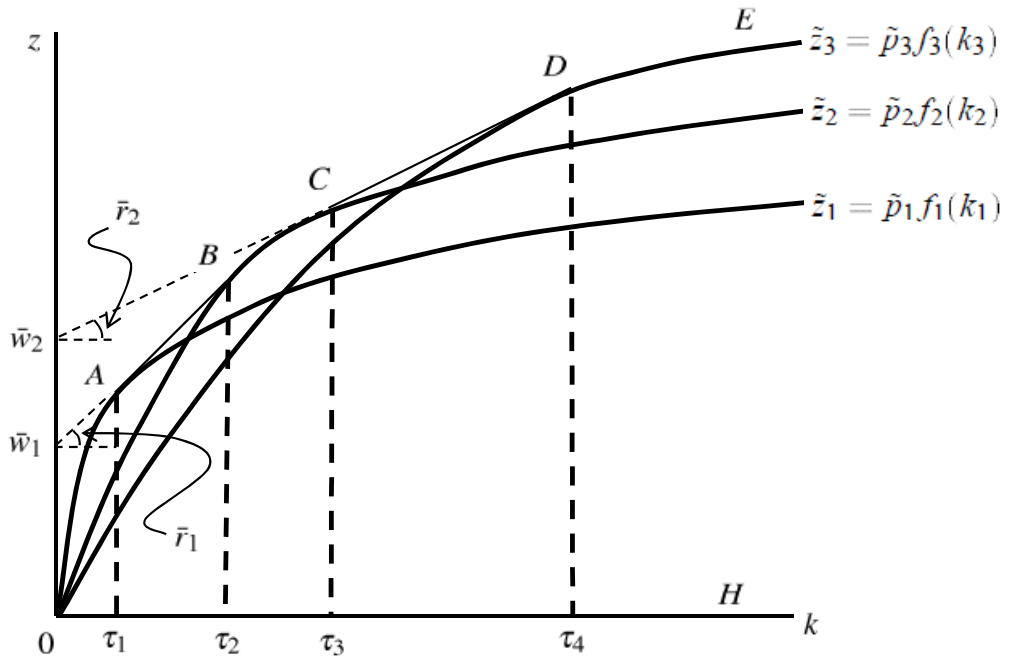


Figure 3. Relationship between Rental-Wage Ratio and Capital-labor Ratio in the Three-good Two-cone Model

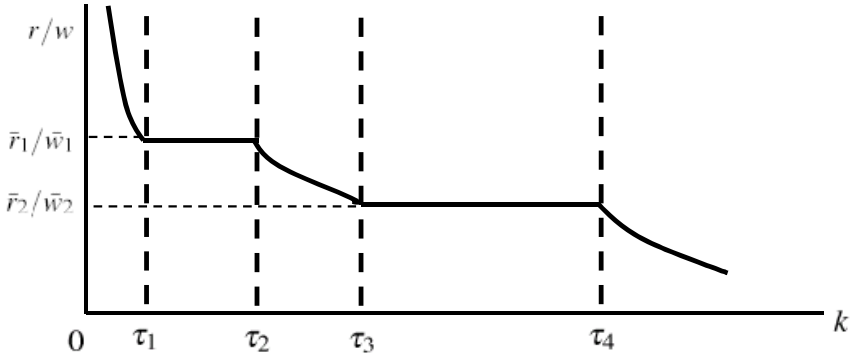


Figure 4. Multiple Equilibria in the Three-good Two-cone Model

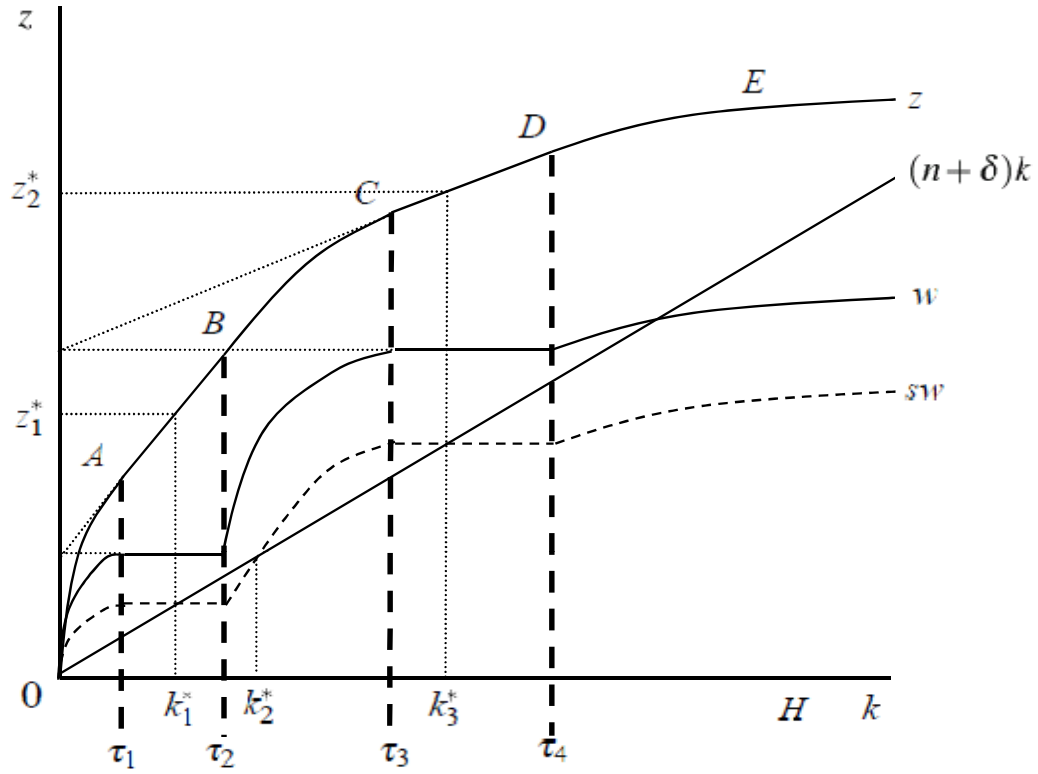


Figure 5. Patterns of Trade for the Three-good Two-cone Model

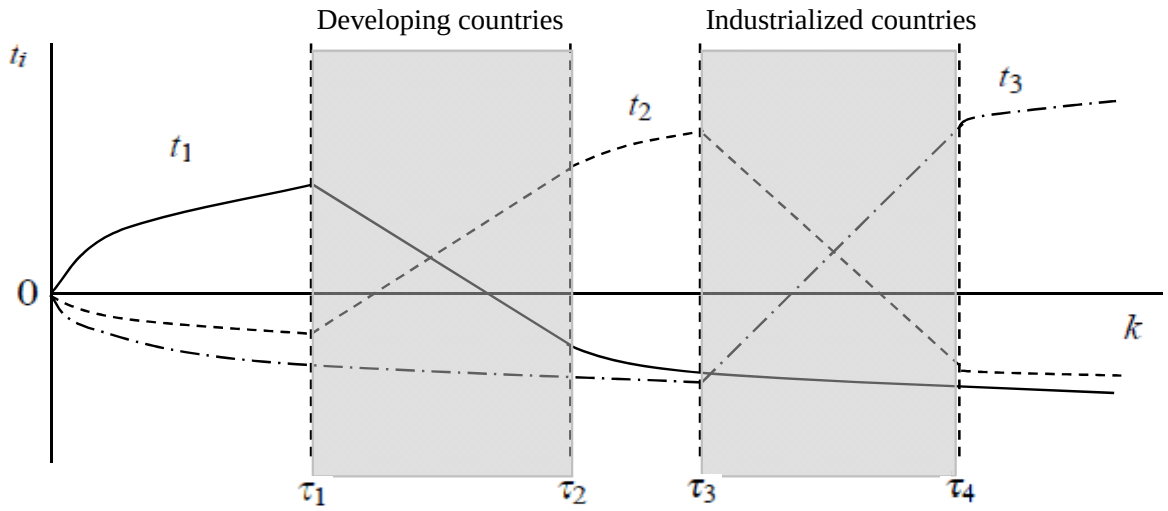


Figure 6. Global and Local Factor Abundances in the Three-good Two-cone Multiple-cone Model

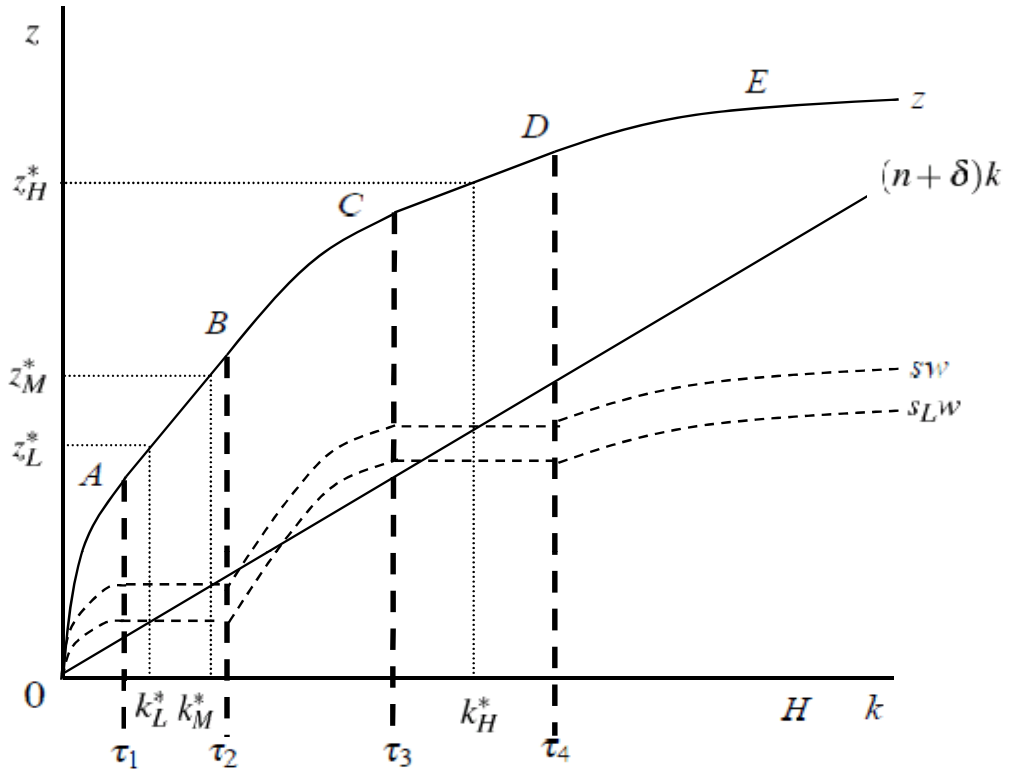


Figure 7. Patterns of Trade for the Three-good Two-cone Model: Global and Local Factor Abundances

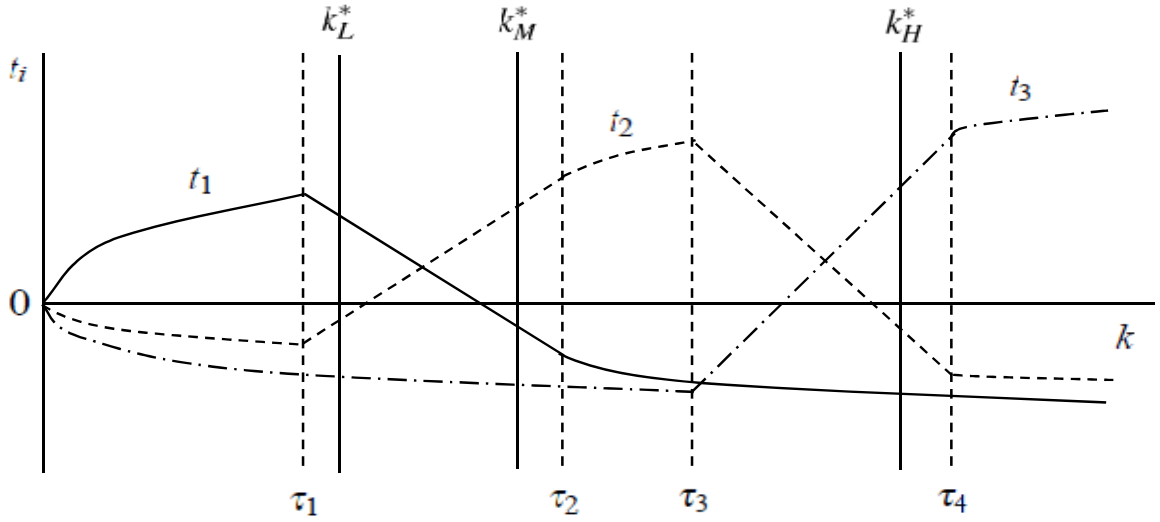
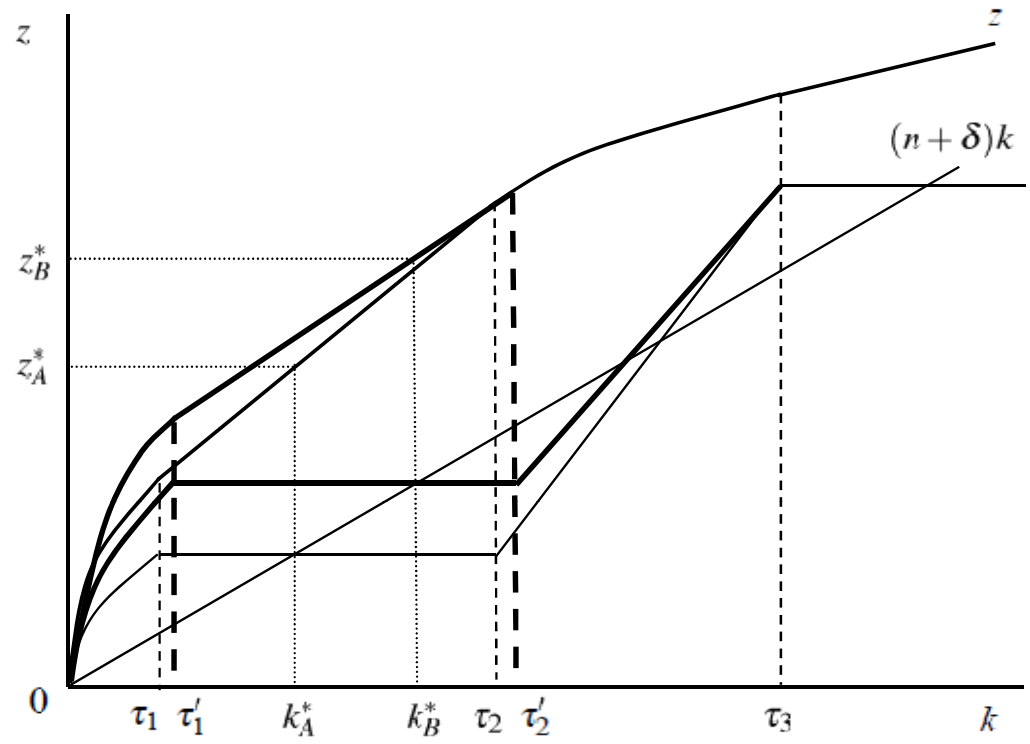


Figure 8. Protection by A Middle-income Country on Imports from Low-income Countries
(a) Y_1 is <u>not</u> the investment good



Note: For illustrative purposes, s = 1 is assumed.

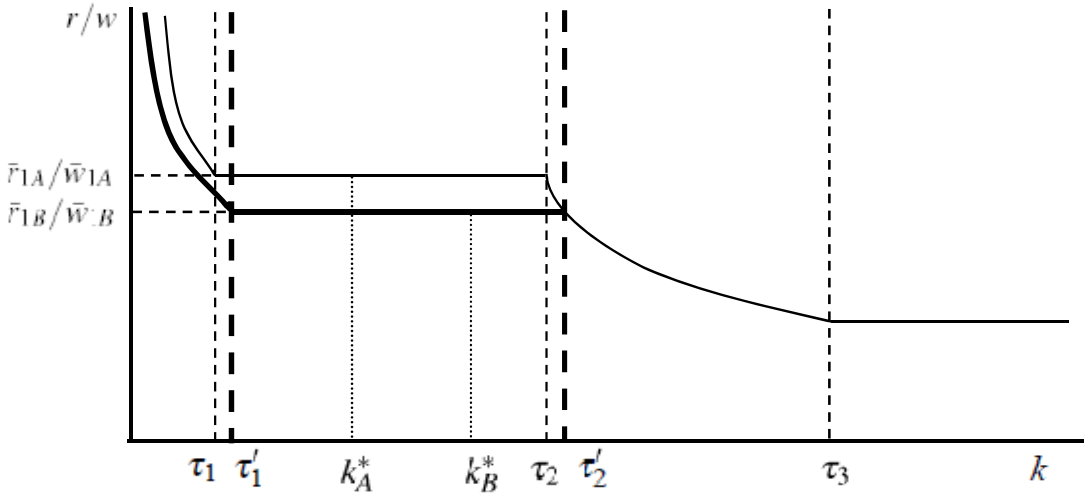
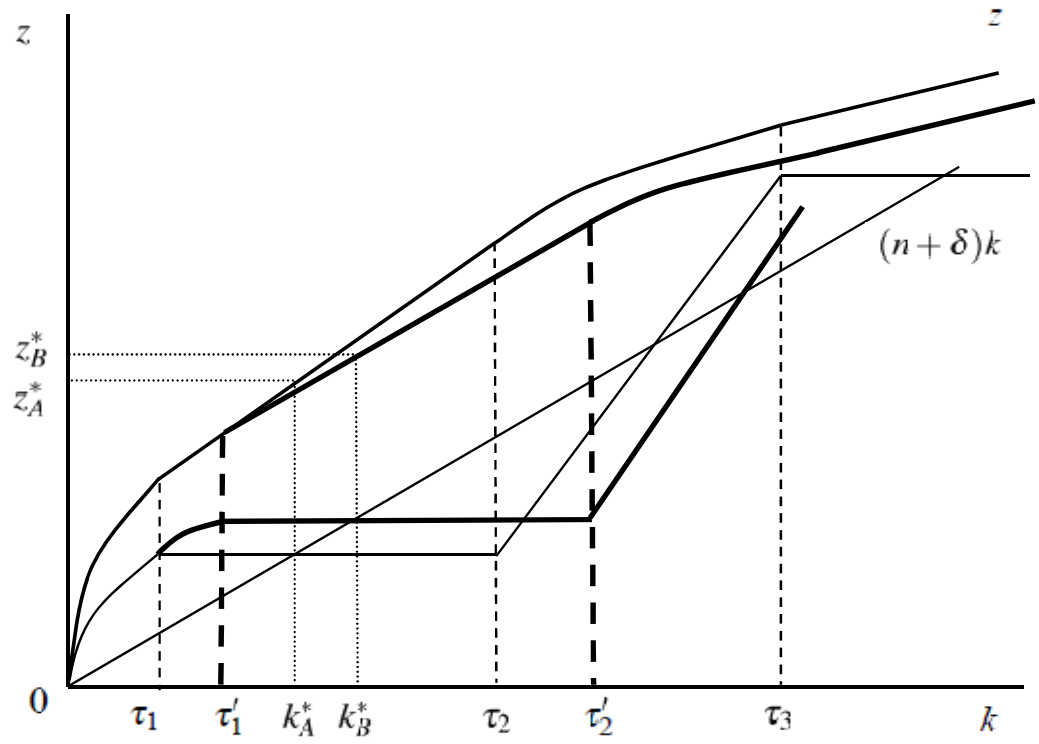


Figure 8. Protection by A Middle-income Country on Imports from Low-income Countries
(b) Y_1 is the investment good



Note: For illustrative purposes, $s = 1$ is assumed.