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INCOME DISTRIBUTION AND MULTIPLE EQUILIBRIA*

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Abstract

The post-war growth experiences of developing countries lead to the idea that income distribution may affect economic growth and cause multiple equilibria. In this paper, a theoretical model is used to illustrate the possibility that equality makes a country human-capital abundant, which enables industrialization and higher economic growth. On the other hand, in unequal developing countries where the majority of the people manage to survive at minimum consumption level, human capital investment such as schooling is not feasible. Such countries become unskilled labor abundant and suffer further from low economic growth. In addition, the two-good framework shows that protecting infant industries with dynamic externality might enhance economic growth.

Key words: income distribution; economic growth; human capital; comparative advantage; learning-by-doing.
JEL Classification: O15, F11, O41

I. *Introduction*

Recently, it is often advocated that equal income distribution accelerates the economic growth of developing countries. This argument is derived from empirical studies (Alesina and Rodrik, 1991; Persson and Tabellini, 1992, 1994) and the rapid economic growth of the relatively equal East Asian countries such as Japan and Taiwan (World Bank, 1993). Much research effort has been devoted to further explain this issue (Partrigdge, 1997).

Murphy, Shleifer and Vishny (1989) proposed a theoretical model based on the notion that equality can enhance economic growth by enlarging the domestic demand for manufactured goods. Alesina and Perotti (1993) explained this phenomenon using the positive effect of equality on political stability. On the other hand, the theory of social choice of the voters was adopted in the models by Alesina and Rodrick (1991), Perotti (1993) and Persson and Tabellini (1992, 1994). Galor and Zeira (1993) suggested that equality enhances growth

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through rapid human capital accumulation. Owen and Weil (1998) theoretically analyzed how different initial wealth distributions can cause multiple equibria through liquidity constraints on education.

This paper examines the effect of distribution on growth through human capital accumulation on the lines of Galor and Zeira (1993). This paper, however, differs from other studies in the sense that the employed model is a two-good growth model. This type of model constitutes a framework that helps clarify the following two points in addition to the effect of distribution on growth.

First, this model serves to explain that an economy generally experiences industrialization from agricultural economy when it grows rapidly. Secondly, this model shows that protecting infant industries with dynamic externality can enhance economic growth. Even when an economy does not have comparative advantages in the manufacturing sector, protecting it can accelerate its growth rate and raise the welfare of the economy.

The logic behind the above arguments is as follows. In an equal developing country, a large segment of the population has access to education and the country becomes human-capital abundant. Therefore, such a country has a comparative advantage in terms of the production of human-capital intensive goods such as manufactured goods. As the production of manufactured goods exhibits externality and raises the general productivity through learning-by-doing, the country then experiences an increase in productivity and average income. Higher incomes raise the educational level in the subsequent period, leading to accelerated industrialization and economic growth (virtuous circle). On the other hand, in an unequal economy, only a small number of wealthy people can afford education, which makes the economy unskilled labor abundant. As a result, this type of economy specializes in the production of agricultural goods, overall productivity stagnates and growth rate declines (vicious circle). Therefore, an economy becomes industrialized as it grows, and protecting its manufacturing sector enhances economic growth. The model described examines how income distribution changes as the economy grows, and shows that distribution might change, as described by the inverted-U hypothesis of Kuznets (1955).

The considered framework extends a basic trade model of a small open economy with two goods and two factors in two aspects. First, the factor endowments are determined endogenously, depending on income distribution. Secondly, the overlapping generations model and endogenous growth theory are used to derive the model dynamic, in order to examine the growth rate. The static equilibrium of the model is examined in section 2, and the dynamic equilibrium in section 3. Section 4 examines the policy implications, and the final section is summary and conclusion.

II. *The Static Equilibrium*

A small country that trades two goods at exogenously given world prices is studied. The goods are Z (agricultural goods) and M (manufactured goods), which are produced using two factors: A_tL (unskilled labor) and A_tH (human capital). The factors are not traded, and A_t denotes the productivity level of factors. Production technology exhibits constant returns to scale and time-invariant. Manufactured goods are assumed to be relatively human-capital intensive, while agricultural goods, unskilled labor-intensive. The economy produces both goods or specializes in the production of one of the goods, depending on the state of its comparative advantage. Let the upper bound of the incomplete specialization cone be denoted by $\left(\overline{\frac{A_tH_t}{A_tL}}\right)$, and the lower bound by $\left(\underline{\frac{A_tH_t}{A_tL}}\right)$. Then, incomplete specialization results when factor endowment is in $\left[\left(\underline{\frac{A_tH_t}{A_tL}}\right), \left(\overline{\frac{A_tH_t}{A_tL}}\right)\right]$. Otherwise, the economy specializes in manufactured goods if factor endowment is larger than $\left(\overline{\frac{A_tH_t}{A_tL}}\right)$, and in agricultural goods if it is smaller than $\left(\underline{\frac{A_tH_t}{A_tL}}\right)$. These equilibria are examined in the following separate sections.

1. The case of incomplete specialization

In the case of incomplete specialization, the equilibrium can be illustrated by the following three stages.

1.1 The determination of wage rates and input coefficients

In the first stage, incomplete specialization implies that the unit cost of each good must be equal to its world price. Namely,

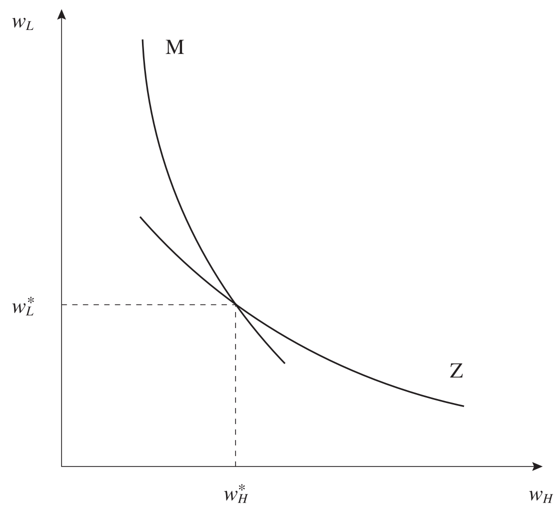
$$w_H a_{HM}(w_H, w_L) + w_L a_{LM}(w_H, w_L) = P_M \tag{1}$$

and

$$w_H a_{HZ}(w_H, w_L) + w_L a_{LZ}(w_H, w_L) = P_Z, \tag{2}$$

where P_M and P_Z are respectively the world price of goods M and Z, w_H and w_L are the rewards

FIG. 1



to human capital and low-skilled labor, and $a_{jj'}(w_H, w_L)$ denotes the unit input coefficient of factor j for good j'. Note that w_H, w_L and $a_{jj'}(w_H, w_L)$ are measured with the efficiency unit of inputs, namely, $\frac{1}{A_t}$. The production technology is described by these unit input coefficients. Given P_M and P_Z, these equations give the equilibrium w_H, w_L and $a_{jj'}(w_H, w_L)$.

1.2 Utility maximization and determination of factor supplies

In the second stage, given the wage rates determined in the first stage, altruistic individuals maximize their utility by choosing their levels of consumption and the degree of their children's education, which subsequently determines the aggregate supply of human capital. In each period t=0, 1, 2, $\cdots\infty$, agents are born and live for two periods. Each agent gains one child at the beginning of the second period, and therefore the population is constant.

In the first period, individuals have no endowment of labor or goods. Their education is financed by their parents and they gain human capital. In the second period, they are endowed with one unit of unskilled labor, and work by supplying their labor inelastically. They spend their wage to consume and to educate their children. Some of the adults provide for the education of their children as bequest, because agents are assumed to be altruistic and to care also about their children's income. Agents born in period t receive h_t units of education and gain $\phi(h_t)$ units of human capital. When they work in period t+1, their productivity is A_{t+1} and they receive $A_{t+1}w_L$ for their unskilled labor and $A_{t+1}w_H\phi(h_t)$ for their human capital. Therefore, the income of individuals who are born at period t and work at period t+1 is given by

$$A_{t+1}y_{t+1} \underset{d}{=} A_{t+1}(w_L + w_H\phi(h_t)). \tag{3}$$

Note that all individuals have the same potential ability and differ only in their levels of education.

Given the above income, agents choose the levels of their consumption of each good and children's education. First, consider the optimization of the share of c_{Mt+1} and c_{Zt+1} for a given amount spent on consumption. The utility maximization problem is given by

$$\max_{c_{Mt+1},\, c_{Zt+1}} \quad u(c_{Mt+1}, c_{Zt+1}) \tag{4}$$

$$\text{s.t.} \quad c_{t+1} = P_M c_{Mt+1} + P_Z c_{Zt+1}. \tag{5}$$

Denote the Marshallian demand functions of this problem as $c^*_{Mt+1}(P_M, P_Z, c_{t+1})$ and $c^*_{Zt+1}(P_M, P_Z, c_{t+1})$. As P_M and P_Z are constant, c^*_{Mt+1} and c^*_{Zt+1} depend only on c_{t+1}. Therefore, a Hicks' composite good can be defined as

$$P_M c^*_{Mt+1}(c_{t+1}) + P_Z c^*_{Zt+1}(c_{t+1}) \underset{d}{=} c_{t+1}, \tag{6}$$

which is called consumption thereafter and its price is one.

Secondly, agents choose c_{t+1} and h_{t+1}. They solve

$$\max_{c_{t+1},\, h_{t+1}} \quad u_{t+1} = u(c_{t+1}) + v(A_{t+2}(w_L + w_H\phi(h_{t+1}))) \tag{7}$$

$$s.t. \quad A_{t+1}(w_L + w_H\phi(h_t)) = c_{t+1} + \alpha h_{t+1} \tag{8}$$

$$h_{t+1} \geq 0,\ c_{t+1} \geq 0, \tag{9}$$

where u is the utility from the adults' consumption, v is the utility the altruistic parents gain from their children's income, and α denotes the unit cost of education. Perfect foresight is assumed concerning the level of A_{t+2} and individuals treat A_{t+2} as given.

The first constraint is an ordinary budget constraint, and the second and third are the non-negativity constraints on h_{t+1} and c_{t+1}. It is assumed that $u'>0$, $u''<0$, $u'''<0$, $v'>0$, $v'<0$, $\phi'>0$, $\phi''<0$.

Using Lagrange multiplier λ and Kuhn-Tucker multipliers μ and η, the first-order conditions of the above problem are given by the following equations and (8):

$$u'(c_{t+1})=\lambda_{t+1}-\eta_{t+1} \tag{10}$$

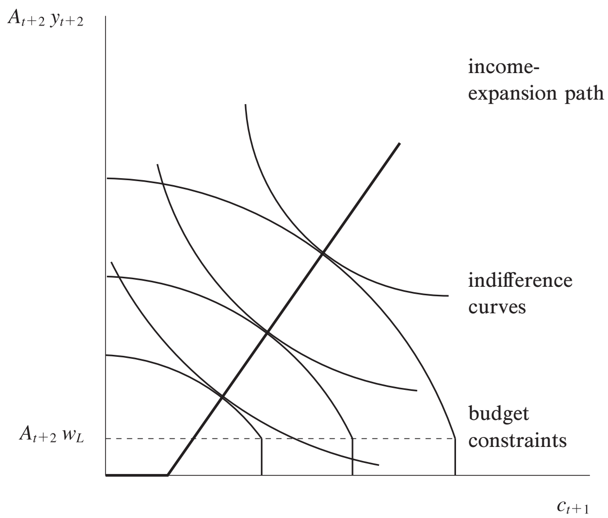
$$v'(\cdot)A_{t+2}w_H\phi'(h_{t+1})=\lambda_{t+1}\alpha+\mu_{t+1} \tag{11}$$

$$\mu_{t+1}\geq 0,\ h_{t+1}\geq 0,\ \mu_{t+1}h_{t+1}=0 \tag{12}$$

$$\eta_{t+1}\geq 0,\ c_{t+1}\geq 0,\ \eta_{t+1}c_{t+1}=0. \tag{13}$$

As there are Kuhn-Tucker conditions, the solutions can be divided into a number of cases. Assume, however, that the non-negativity constraint on consumption does not become binding as long as the agents have positive income, because the agents need to consume something to survive. Therefore it is not necessary to examine the case with $c_{t+1}=0$ and $\mu_{t+1}>0$, and $c_{t+1}>0$ and $\mu_{t+1}=0$ is assumed in the rest of the paper. On the other hand, the non-negativity constraint on educational level sometimes becomes binding and some very poor agents are unable to provide an education to their children. Thus, solutions are divided into the two cases with $h_{t+1}>0$ and $h_{t+1}=0$. Figure 2 gives the income-expansion path with such utility function. When income is lower than a given level, the optimum choice becomes a corner solution with $h_{t+1}=0$.

FIG. 2



When $\mu_{t+1}=0$ and $h_{t+1}=0$, the first-order conditions can be rewritten as

$$\frac{u'(A_{t+1}\tilde{y}_{t+1})}{v'(A_{t+2}w_L)A_{t+2}w_H\phi'(0)}=\frac{1}{\alpha}. \tag{14}$$

The level of income, $A_{t+1}\tilde{y}_{t+1}$, which divides the two cases is given by the above equation for a given A_{t+1}. Then, when $y_{t+1}>\tilde{y}_{t+1}$, the non-negativity constraint on education is not binding and $h_{t+1}>0$, and when $y_{t+1}\leq\tilde{y}_{t+1}$, it is binding and $h_{t+1}=0$. Note that $\tilde{y}_{t+1}$ rises if A_{t+1} increases.

In the first case with $h_{t+1}>0$ and $\mu_{t+1}=0$ $(y_{t+1}>\tilde{y}_{t+1})$, the first-order conditions become

$$\frac{u'(c_{t+1})}{v'(\cdot)A_{t+2}w_H\phi'(h_{t+1})}=\frac{1}{\alpha}, \quad \left(\frac{\text{MU of } c_{t+1}}{\text{MU of } h_{t+1}}=\frac{\text{MC of } c_{t+1}}{\text{MC of } h_{t+1}}\right). \tag{15}$$

By differentiating the above equation, the comparative statics give the following results. When the parents' income increases, their consumption and their children's education and income change such that

$$0<\frac{dh_{t+1}}{dy_{t+1}}=\frac{\alpha u''A_{t+1}}{\alpha u''+v'A_{t+2}w_H\phi''+v''A_{t+2}^2w_H^2\{\phi''\}^2}<1 \tag{16}$$

As income increases, some fraction of it rises c_t, and the rest rises h_t. h_t can converge to ∞.

In the second case with $h_{t+1}=0$ and $\mu_{t+1}\geq 0\,(y_{t+1}\leq\tilde{y}_{t+1})$, the first-order conditions become

$$\frac{u'(c_{t+1})}{v'(\cdot)(A_{t+2}w_H\phi'(h_{t+1}))}=\frac{\lambda_{t+1}}{\alpha\lambda_{t+1}-\mu_{t+1}}. \tag{17}$$

The levels of consumption and education are given by

$$c_{t+1}=A_{t+1}y_{t+1}, \tag{18}$$

$$h_{t+1}=0. \tag{19}$$

FIG. 3

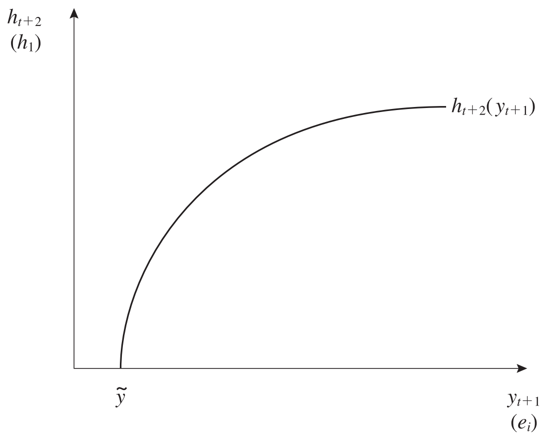
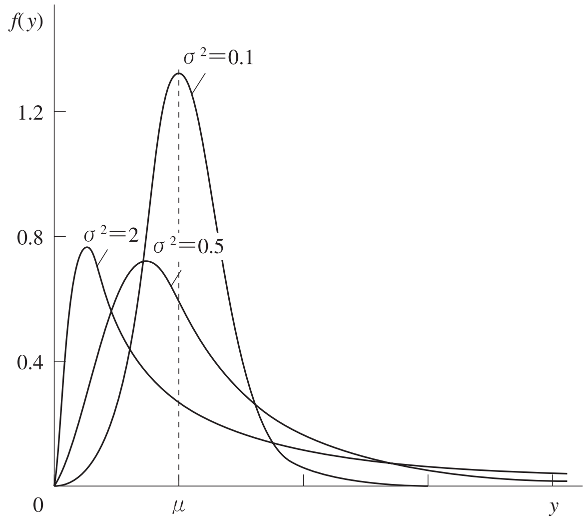


FIG. 4



In this case, the parents are too poor to educate their children, and spend all their income on their consumption. In developing countries where the average income level is low, such households constitute a considerable part of the economy.

The optimum choices for children's education which satisfy the above first-order conditions are shown in figure 3 for a given A_{t+1}. Notice that education reaches zero level at positive y_{t+1}.

As shown above, the level of education of children is a function of the level of parental income. Thus, in the whole economy, the pattern of income distribution determines the aggregate level of education and human capital. As income is approximately distributed lognormally, three density functions of lognormal distribution with different variance and the same mean are shown in figure 4. Figure 3 placed over figure 4 in different positions resulted in figure 5a and 5b. Figure 5a shows that the larger the inequality (variance σ^2) is, the lower the number of people who can receive education and the lower the economy's level of human capital, if average income is moderately low. In other words, in an equal developing country, a large share of the population can receive education and the country becomes human-capital abundant. On the other hand, in an unequal developing country, only a small number of people can receive education and therefore it becomes low-skilled labor abundant.

In a country where average income is extremely low, however, the opposite is true (Figure 5b). If income is equally distributed, everyone is equally poor and unable to afford education. If distribution is unequal, at least some of the agents can educate their children and therefore the country gains some aggregate human capital.

Using the above relationship between income distribution and factor endowment, the relationship between distribution of income and the pattern of production can be described. As the considered economy is a developing country, assume that it either specializes in the production of agricultural goods (Z) or produces both agricultural goods (Z) and manufacturing goods (M).

FIG. 5a

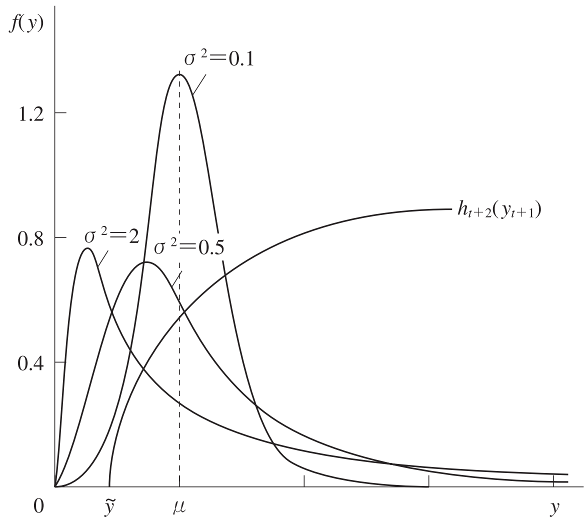
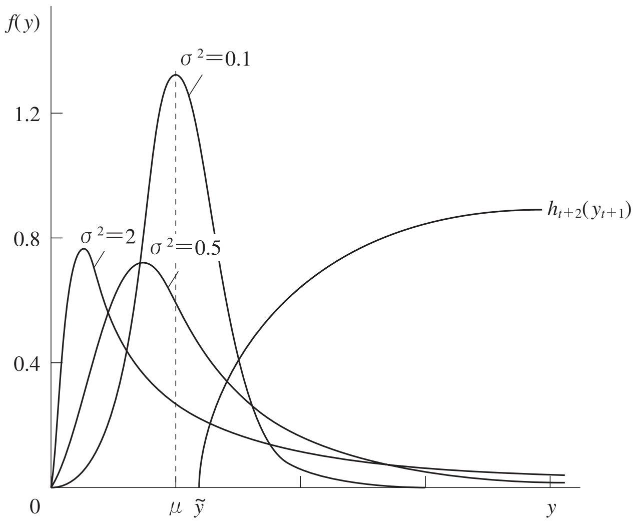


FIG. 5b



Consider, first, the case of a moderately poor country. If distribution is unequal with $\sigma^2 > \bar{\sigma}^2$, H_t is scarce and $\left(\frac{A_tH_t}{A_tL}\right) < \left(\frac{A_tH_t}{\underline{A_tL}}\right)$. This economy completely specializes in agriculture (z). In a relatively equal country with $\sigma^2 > \bar{\sigma}^2$, $\left(\frac{A_tH_t}{A_tL}\right) \in \left[\left(\frac{A_tH_t}{\underline{A_tL}}\right), \left(\frac{\overline{A_tH_t}}{A_tL}\right)\right]$ and the economy incompletely specializes in production. Namely, industrialization occurs in addition to agriculture. Therefore, the case we are currently considering is that of a moderately equal country.

In an extremely poor country, the opposite relationship between inequality and factor ratio exists. Therefore, an unequal country has a better chance to succeed in industrialization.

1.3 The factor market equilibrium

In the third stage, given the factor supplies examined in the second stage, the amounts of production of goods are determined in the equilibrium of the factor markets. Market clearing implies that

$$a_{HM}M_t + a_{HZ}Z_t = A_t H_t \tag{20}$$

$$a_{LM}M_t + a_{LZ}Z_t = A_t L. \tag{21}$$

Solving these two equations gives the equilibrium amount of production of each good as

$$Z_t = \frac{1}{|a|}(a_{HM}A_t L - a_{LM}A_t H_t), \tag{22}$$

$$M_t = \frac{1}{|a|}(a_{HZ}A_t L - a_{LZ}A_t H_t), \qquad \text{where } |a| = \begin{vmatrix} a_{HM} & a_{HZ} \\ a_{LM} & a_{LZ} \end{vmatrix} > 0 \tag{23}$$

Therefore, the GNP at period t, Q_t, is given by

$$\begin{aligned} Q_t &\underset{d}{=} P_Z Z_t + P_M M_t \\ &= P_Z\left\{\frac{1}{|a|}(a_{HM}A_t L - a_{LM}A_t H_t)\right\} + P_M\left\{\frac{1}{|a|}(-a_{HZ}A_t L + a_{LZ}A_t H_t)\right\}. \end{aligned} \tag{24}$$

Notice that the GNP level indicates the welfare level, because the considered economy is a small country.

2. The case of complete specialization

If only a small number of people can receive education, the economy becomes unskilled labor abundant. Such country completely specializes in the production of agricultural goods. The equilibria w_{H}, w_L, H_t, L_t, Z_t are simultaneously determined by the following equations:

$$w_H a_{HZ} + w_L a_{LZ} = P_Z \tag{25}$$

$$\begin{aligned} &\max_{c_{t+1}, h_{t+1}} \quad u_{t+1} = u(c_{t+1}) + v(A_{t+2}(w_L + w_H\phi(h_{t+1}))) \\ &\quad s.t. \quad A_{t+1}(w_L + w_H\phi(h_t)) = c_{t+1} + \alpha h_{t+1} \\ &\qquad\qquad h_{t+1} \geq 0,\ c_{t+1} \geq 0 \end{aligned} \tag{26}$$

$$a_{HZ}Z = A_t H_t \tag{27}$$

$$a_{LZ}Z = A_t L. \tag{28}$$

The GNP is given by

$$Q_t = P_Z Z_t. \tag{29}$$

III. *Dynamic Equilibrium*

Now consider how the economy evolves dynamically. In a dynamic equilibrium, the increase of H_t and the learning-by-doing of manufacturing goods production cause economic growth. w_H, w_L, H_t, M_t, Z_t and A_t are endogenously determined, while P_M and P_Z are exogenously given.

1. The increase of H_t

First, examine the effects of the increase of aggregate human capital, H_t. As shown in the previous section, adults determine their children's educational level and income for given A_{t+1} and A_{t+2}. As a result, the educational level in each dynasty changes and as does the aggregate human capital. In order to illustrate the dynamic evolution of education and income through time, the dynamics of y_t based on figure 3 are presented in figure 6 for a given A_{t+1}. As the educational level corresponds to income level by one-to-one in this model, this figure represents the evolution of educational level h_t as well as y_t.

FIG. 6

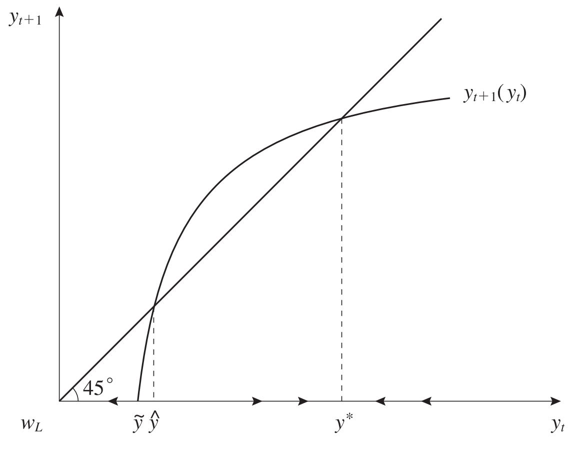


Figure 6 depicts a case where the dynamics of y_t intersect with the 45° line at two points. In this case, the descendants of wealthy individuals with incomes above $\hat{y}$ receive more and more education and converge to the high-level equilibrium with income y^*. On the other hand, the descendants of poor agents with incomes below $\hat{y}$ may receive some education but converge to the low level equilibrium with zero education and low income. In other words, all the dynasties are concentrated in two groups, depending on the level of initial income.

2. The increase of productivity through learning-by-doing

Secondly, consider the effect of learning-by-doing. In a country where industrialization occurs, learning-by-doing raises the factor productivity A_t and accelerates economic growth.

Namely, the cumulative amount of produced manufacturing goods raises the factor productivity A_t as described by the following functions:

$$A_t = f(\kappa_t), \qquad \text{where} \qquad \kappa_t = \sum_{s=1}^{t-1} M_s, \tag{30}$$

$$f' > 0, f'' < 0, \quad \lim_{\kappa_t \to \infty} f' = 0, \quad \lim_{\kappa_t \to \infty} f = \overline{A}, \; w_L \geq \frac{c}{\overline{A}}. \tag{31}$$

For the sake of discussion, assume that the knowledge accumulation of the manufacturing sector completely spillovers to the agricultural sector and raises the factor productivity of that sector at the same rate as that of the manufacturing sector. This case is analytically interesting and is considered at length in this paper. A case of incomplete knowledge spillover is briefly examined in the last section.

In a relatively equal country, industrialization occurs and raises A_t. The effects of an increase of A_t can be examined by differentiating the first-order-conditions. The following assumption is imposed to analyze this effect.

Assumption 1

$$-v''(\cdot) A_{t+2}\{w_L + w_H \phi(h_{t+1})\} / v'(\cdot) < 1$$

This means that the measure of comparative risk aversion is small enough and intertemporal substitution is large. Therefore, when A_{t+2} rises and the return to education increases, the optimal educational level of children h_t increases under this assumption.

In case 1, for a given y_t,

$$\frac{dh_{t+1}}{dA_{t+1}} = \frac{\alpha u''(\cdot)(w_L + w_H \phi(h_t))}{\alpha^2 u''(\cdot) + v''(\cdot)\{A_{t+2} w_H \phi'(\cdot)\}^2 + v'(\cdot) A_{t+2} w_H \phi''(\cdot)} > 0, \tag{32}$$

$$\frac{dh_{t+1}}{dA_{t+2}} = \frac{-[v''(\cdot)\{w_L + w_H \phi(\cdot)\} A_{t+2} w_H \phi'(\cdot) + v'(\cdot) w_H \phi'(h_t)]}{\alpha^2 u''(\cdot) + v''(\cdot)\{A_{t+2} w_H \phi'(\cdot)\}^2 + v'(\cdot) A_{t+2} w_H \phi''(\cdot)} > 0, \tag{33}$$

under assumption 1. Therefore,

$$\frac{dh_{t+1}}{dA_{t+1}} + \frac{dh_{t+1}}{dA_{t+2}} > 0 \tag{34}$$

and the educational level rises.

In case 2, the educational level remains at zero. As for the income level which divides the two cases,

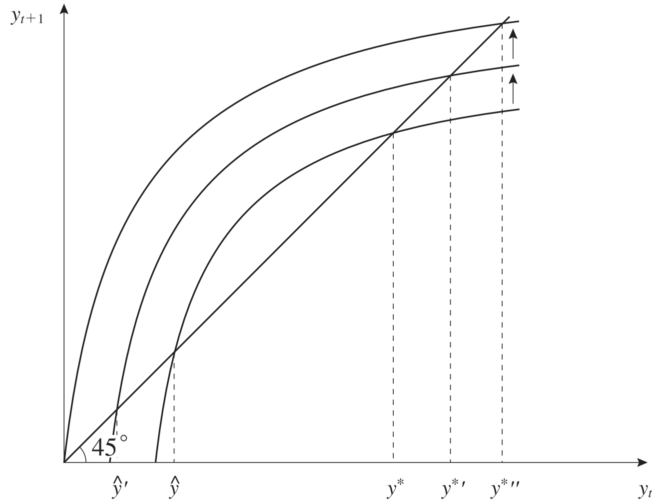
$$\frac{d\tilde{y}_{t+1}}{dA_{t+1}} = \frac{\tilde{y}_{t+2}}{A_{t+1}} < 0, \tag{35}$$

$$\frac{d\tilde{y}_{t+1}}{dA_{t+2}} = \frac{v''(\cdot) w_L A_{t+2} w_H \phi'(0) + v'(\cdot) w_H \phi'(0)}{\alpha^2 u''(\cdot) A_{t+1}} < 0, \tag{36}$$

under assumption 1. Therefore,

$$\frac{d\tilde{y}_{t+1}}{dA_{t+1}} + \frac{d\tilde{y}_{t+1}}{dA_{t+2}} < 0 \tag{37}$$

FIG. 7



and an increase in productivity enables more individuals to receive education.

These effects can be observed in figure 7 as an upward shift of the dynamics of y_t as A_t approaches the upper bound $\overline{A}$ (Figure 7). The non-negativity constraint on consumption becomes unbinding for more individuals, and more and more dynasties approach the high-level equilibrium. As $\overline{A}$ is assumed to satisfy $w_L \geq \frac{c}{\overline{A}}$, all the dynasties start to converge to the high-level equilibrium as infinite time passes.

In an unequal country where no manufacturing goods are produced, no learning-by-doing occurs and the dynamics are completely described by figure 6. In this case, the growth occurs only by the increase of H_t. Therefore, the growth rate is lower than that in an equal country where industrialization takes place.

Next, examine how the income distribution changes as the economy grows. In an unequal economy which completely specializes in agriculture, individuals become polarized into the rich and the poor as shown in figure 6. Therefore, an originally unequal country becomes unequal and poor.

In an equal economy, at first polarization takes place. Some of the agents approach the high-level equilibrium, while the rest move toward the low-level equilibrium. Next, as $\frac{c}{A_t}$ declines, more and more people become richer and educate their children. This further increases their income and accelerates industrialization, until all people reach a high-education and high-income equilibrium. In this process, inequality first rises and then declines. Therefore, there is a possibility that income distribution changes as the inverted-U hypothesis by Kuznets (Kuznets 1955).

IV. *The Effects of Government Policies*

In this section, the implications of three government policies on economic growth and welfare are considered. The policies are income redistribution, subsidy on education and import tariffs.

1. The Optimal Income Redistribution Policy

It is interesting to analyze what kind of income redistribution favors economic growth. For analytical purposes, assume that income follows a uniform distribution $U[\mu-\sigma, \mu+\sigma]$. Then, the variance of income is $\sigma^2/3$ and the ratio of agents who can receive education is $\mu+\sigma-\hat{y}/2\sigma$. Consider the welfare implications of a redistribution policy where the government alters the variance.

$$\frac{\partial}{\partial\sigma}\left(\frac{\mu+\sigma-\hat{y}}{2\sigma}\right)=\frac{\hat{y}-\mu}{2\sigma^2} \tag{38}$$

indicates the following results.

When $\mu>\hat{y}$ is satified (thus, in countries that are not extremely poor), the more equally income is redistributed, the greater the number of agents who are able to receive an education. This raises the level of human capital and the growth rate. This observation is consistent with the findings that equal East Asian countries grew faster than unequal Latin American countries after World War II.

In very poor countries with $\mu<\hat{y}$, on the other hand, the more unequally income is redistributed, the larger the number of agents who can receive education. This is because everyone is too poor to educate his/her child if distribution is equal, but some rich can afford education if distribution is unequal. Therefore, unequal redistribution raises the aggregate human capital, growth rate and steady-state income level. This effect is particularly clear when the country moves from complete specialization to incomplete specialization.

2. Subsidy to education

When the government gives subsidies to education and lowers the cost of education from α to $(1-\Psi)\alpha$, the following effects on the optimal choice of agents can be observed. Assuming incomplete specialization, the effects can be shown by comparative statics with differentiating equations (14), (15) and (19) and evaluation of the derivative at $\Psi=0$.
In Case 1, from equation (15),

$$\left.\frac{dh_{t+1}}{d\Psi}\right|_{\Psi=0}=\frac{-\alpha u'(c_{t+1})+\alpha^2 u''(c_{t+1})h_{t+1}}{\alpha^2 u''(c_{t+1})+v''(A_{t+2}y_{t+2})A^2_{t+2}w^2_H\phi(h_{t+1})^2+u'(A_{t+2}y_{t+2})A_{t+2}w_H\phi''(h_{t+1})}>0 \tag{39}$$

indicates that agents give more education to their children with the subsidy to education.

In case 2, from equation (19),

$$h_{t+1}=0$$

indicates that very poor agents are still unable to provide any education to their children, even if education is subsidized.

As for $\tilde{y}_{t+1}$, from equation (14),

$$\left.\frac{d\tilde{y}_{t+1}}{d\Psi}\right|_{\Psi=0}=\frac{u'(\cdot)}{u''(\cdot)A_{t+1}}<0 \tag{40}$$

shows that the ratio of individuals who can receive education increases.

This effect can be observed as the upward shift of $h_{t+1}(y_t)$. Subsidy enables agents who are originally unable to receive any education to gain more education, and increases the number of agents who can receive education. As a whole economy, the level of education always rises, thereby accelerating industrialization and raising the steady-state level of income.

3. Import Tariff on Manufactured goods

What are the welfare implications of trade policy? To clarify the results, examine this policy with specific Cobb-Douglas utility and production functions.

$$u_{t+1}=C_{t+1}^{\beta}(A_{t+2}y_{t+2}-\bar{y})^{1-\beta},\ \phi(h_{t+1})=h_{t+1}^{\theta},$$

$$M_t=B_M H_t^{\delta}L_t^{1-\delta},\ Z_t=B_Z H_t^{\gamma}L_t^{1-\gamma}$$

Assuming incomplete specialization, factor prices vary as domestic prices of manufactured goods change with the import tariff.

$$\frac{dw_L}{w_L}=\frac{-\gamma}{\delta-\gamma}\frac{dP_M}{P_M},\ \frac{dw_H}{w_H}=\frac{1-\gamma}{\delta-\gamma}\frac{dP_M}{P_M}, \tag{41}$$

When the tariff rate is denoted by T_M, the assumption of a small country ensures $dP_M=dT_M$. These conditions make it possible to examine the effects of import tariff on the optimal choice of education.[1]

In case 1, the first-order-condition of utility maximization is given by

$$\frac{\beta}{y_{t+1}-\alpha h_{t+1}}=\frac{(1-\beta)w_H\theta h_{t+1}^{\theta-1}}{\alpha(w_L+w_H h_{t+1}^{\theta})}. \tag{42}$$

Total differentiation of this condition implies

$$\frac{dh_{t+1}}{dw_L}=\frac{\alpha\beta}{\alpha w_H\theta h_{t+1}^{\theta-1}}>0,\ \frac{dh_{t+1}}{dw_H}=\frac{\beta w_L}{w_H^2\theta h_{t+1}^{\theta-1}}>0. \tag{43}$$

Therefore, combining equations (39) and (40), the effects of import tariff on education is given by

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[1] When domestic P_M changes due to import tariffs, the price of composite good $C_t=P_M C_{Mt}+P_Z C_{Zt}$ changes. In this case, however, the Cobb-Douglas utility function ensures a constant expenditure share for C_t and $A_{t+2}y_{t+2}-\bar{y}$, and it is thus unnecessary to examine the effect of the change of P_{Mt} on education.

$$\frac{dh_{t+1}}{dT_M}=\frac{\beta w_L(1-2\gamma)}{w_H\theta h_{t+1}^{\theta-1}(\delta-\gamma)P_M}, \tag{44}$$

which is positive if $\gamma<1/2$ ($\because \delta-\gamma>0$). This condition has the following implications.

When domestic P_M rises due to import tariff, w_H increases and w_L decreases as the unit cost curve of good M shifts to the right in figure 1 (Stolper-Samuelson Theorem). If γ is small enough and good Z is very unskilled labor intensive, w_H increases largely and w_L decreases only slightly. In this case, parental income increases and this in turn raises the children's educational level and income, because children's income is assumed to be a normal good. Therefore, if $\gamma<1/2$, the import tariff raises the educational level and human capital. This argument shows that protecting an industry with externality such as manufacturing can accelerate economic growth, even if at the time the country does not have a comparative advantage in that particular industry (Infant industry).

The case with incomplete knowledge spillover from learning-by-doing can be analyzed in the present context. If productivity in the manufacturing sector rises more than in the agricultural sector, the unit cost curve of good M in figure 1 shifts to the right more than that of good Z. Therefore, w_H increases and w_L decreases, which changes the educational level of children. This effect on human capital and growth are the same as those triggered by an import tariff on good M. Thus, in the case of incomplete knowledge spillover, learning-by-doing in the manufacturing sector raises growth rates only when good Z is very unskilled labor intensive.

Conclusion

The post-war growth experiences of developing countries lead to the idea that income equality may accelerate economic growth. In this paper, a theoretical model is used to show the possibility that equality makes a country human-capital abundant, which in turn enables industrialization and higher economic growth. In addition, the two-good framework is used to illustrate the possibility that protecting infant industries with dynamic externality enhances economic growth.

Two additional extensions will be addressed in future work. First, unequal distribution may lower the economic growth rate through higher population growth. As shown in Barro and Becker (1989) and Becker, Murphy and Tamura (1990), if quantity and "quality" of children are substitutes, poor households tend to have many children with low education. Therefore, in an unequal economy with a large number of poor, the population growth rate rises and the economy becomes more unskilled labor abundant, which further deters industrialization. The second issue to be tackled is whether the comparative advantage explanations will pass a proper econometric investigation.

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