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# Elementary Education, Higher Education, and Inequality

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January 23, 2008
Discussion Paper No. 7

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# Elementary Education, Higher Education, and Inequality*

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**Abstract** : By considering elementary education and higher education separately, this paper investigates the effect of education on income inequality within a country and macroeconomic development. Under the assumption of borrowing constraints, we define elementary education to be compulsory, higher education to be elective and with a fee. If the productivity of elementary education is low, even if the educational level of poor individuals is higher than a poverty trap, income inequality will widen because of an increase in the educational price. However, if the productivity of elementary education is high, income inequality will disappear.

**Keywords:** Elementary education, Higher education, Educational price, Poverty trap, Income inequality;

**JEL Classification:** I20, O11, O15.

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## 1. Introduction

Quah (1996a,1996b), among others, has pointed out that the income distribution throughout the world since World War II has become polarized. The distribution shows two peaks, and the distance between these peaks is widening. While rich countries have become richer, poor countries have remained poor, and middle-income countries have tended to move into either the rich category or the poor category.

We prepared the histogram of the GDP-per-labor unit and of human capital stock-per-labor unit for the years 1960 and 1990 shown in Figure 1. The histogram uses data on the GDP-per-labor unit, $gdp_t$, taken from the Penn World Table (Mark 5.6a) constructed by Summers and Heston (1991) and average schooling years in the population aged 15 over, $h_t$, taken from the data set on educational attainment constructed by Barro and Lee (1996). The data on average schooling years were used as a proxy for the human capital stock-per-labor unit. Cross-country data in which eighty-two countries are selected according to the availability of data reveal highly positive correlations between the GDP-per-labor unit and the human capital-per-labor unit. Polarization of the GDP-per-labor unit and the human capital-per-labor unit is also clearly revealed. Human capital accumulation has increased in the developed economies including catch-up countries such as Japan and the Asian Newly Industrialized Economies (NIEs). Meanwhile, the developing economies continue to stagnate because of low human capital accumulation.

In addition, by using both historical panel data and postwar cross sections,

Persson and Tabellini (1994) reported a significant and large negative relationship between inequality and growth. Bénabou's survey (1996a) found that inequality and growth are inversely related.[1]

Galor and Zeira (1993) authored a pioneering work explaining the linkage between income inequality within a country and club convergence across countries by assuming the imperfection of the credit market and indivisibilities in human capital investment. They investigated how the initial distribution of wealth influences income inequality in the long run and macroeconomic development through individuals' decisions about education. Countries with different initial distributions of wealth clustered around different steady states.[2] Moav (2002) reached the same conclusions as Galor and Zeira (1993) by replacing non-convexities in technology with the convexity of bequest.

Given the assumptions of credit constraints and a convex bequest function, Galor and Moav (2004) presented a dynamic model to explain both income inequality within a country and the process of macroeconomic development. By considering

[1] Voitchovsky (2005) examined the relationship between the shape of the income distribution and growth in detail.

[2] In the presence of the imperfection of the credit market and non-convex technology, Banerjee and Newman (1993) also explored persistent inequality within a country. The relationship between intergenerational mobility and persistent inequality has been investigated with the assumption of credit market imperfections in theoretical studies such as those of Freeman (1996), Aghion and Bolton (1997), Piketty (1997), Owen and Weil (1998), Maoz and Moav (1999), Matsuyama (2000), Ghatak and Jiang (2002), Mookherjee and Ray (2002, 2003) and Das (2007).

the essential differences between physical capital and human capital, they showed the replacement of physical capital accumulation by human capital accumulation as a prime engine of growth. Galor and Moav (2006) emphasized capital-skill complementarity in the timing the public education of the masses. They showed that the implications of their model are consistent with the empirical facts on education in western countries.

Given the assumption of borrowing constraints, this paper further investigates the effect of education on income inequality within a country and macroeconomic development. We consider elementary education and higher education as separate from one another. Elementary education that is assumed to be run by the government is compulsory for individuals. If a parent spends on education, his or her child will further receive a higher education. We explicitly consider the price of higher education by assuming that higher education is run by a non-profit organization. The utility function depends on consumption and the educational expenditure. Because an individual can work as an unskilled worker even in the case of zero expenditure on higher education, we assume that the educational expenditure on higher education is a convex function of income. While we follow Moav (2002) and Galor and Maov (2004,2006) that assumed a convex bequest function, as explained in Section 2.3, our assumption could be interpreted as that parental preferences depend on the total amount of educational expenditure for elementary education and higher education. The assumption of a convex educational expenditure on higher education implies that when the productivity of elementary education is low, there is a possibility of

zero expenditure on higher education. However, individuals always invest in higher education in the case that the productivity of elementary education is high.

We must first stress a number of important points. This paper shows that the productivity of elementary education plays a crucial role on income inequality and macroeconomic development through individuals' decisions about higher education. When the productivity of elementary education is low, multiple steady states including a poverty trap can exist in the level of higher education. If the initial educational level of the rich exceeds the educational level of poverty trap, the educational level of the rich will advance while the poor will not be able to attain education regardless of their initial educational level. As long as the initial educational level of the poor is lower than that of the rich, even if the educational level of the poor exceeds the educational level of poverty trap, the educational level of the poor would converge to zero because the educational price on higher education would increase more than the income of poor. Therefore, income inequality will widen and the average levels of education and income in an economy where the productivity of elementary education is low will remain low. In addition, it would be difficult for such an economy to provide educational assistance for the poor that would reduce inequality.

On the other hand, when the productivity of elementary education is high, both rich and poor can attain the same educational level regardless of their initial levels. Income inequality will disappear, and therefore, the average levels of education and income in this economy will become high.

Galor's survey (1996) found that, along with capital market imperfections, ex-

ternalities and non-convexities, initial conditions such as the level of human capital stocks or their distribution were crucial for the bipolarization of economic growth throughout the world.[3]

Assuming borrowing constraints and a convex function of educational expenditure, we show that the initial condition that the educational level of the poor is lower than that of the rich is crucial for dynamics just in the case of low productivity of elementary education. Even if the average educational level at the beginning is high in an economy where the productivity of elementary education is low, there would be a possibility that income inequality widens and the economy stagnates. This would enable us to explain the phenomenon whereby middle-income countries move into the poor category. Furthermore, even if initial educational levels not only of the poor, but also of the rich are low in an economy with high productivity of elementary education, rich and poor will attain the same high educational level. This implies an explanation for the economic growth of catch-up countries such as Japan and the Asian NIEs.

Barro (1997) reported that higher education, but not elementary education, is significant in his growth regression. Our model implies that the productivity of elementary education crucially affects the attainment of higher education. Even if elementary educational levels do not differ largely among economies, the productivity of elementary education would positively and significantly influence the GDP

[3] Azariadis and Stachurski (2005) also investigated traps that prevent an economy from adopting more advanced production technology.

level and its rate of growth through increasing the average level of higher education.

The rest of the paper is organized as follows. Section 2 explains our model, and Section 3 discusses its dynamics. Section 4 presents our conclusions.

## 2. Model

Our model is a closed overlapping-generations economy. Individuals receive a compulsory elementary education in the first period. If a parent decides to make an educational expenditure, his or her child will further receive a higher education in the first period. Individuals work in the second period. They must pay taxes that are used for elementary education. The disposable income is divided into consumption and higher education expenses. For simplicity, the population in each generation is normalized to unity. We assume that the numbers of rich and poor persons are respectively $\lambda$ and $1-\lambda$. While the educational level of the rich is assumed to be higher than that of the poor at the initial time, we also investigate the case that there exist only homogeneous individuals in an economy as the benchmark. The model has a consumption goods sector and two educational sectors. Firms in the consumption goods sector are perfectly competitive. The educational sectors are the elementary and higher education sectors. The higher education is assumed to be run by a non-profit organization.

### 2.1 Educational sectors

This section explains an elementary education sector and a higher educational sector. First, we shall describe the relationship between education and human capital

formation. Human capital of an individual is assumed to be of the following linear type in which we allow different productivities between elementary education and higher education:

$$h(\bar{e}, e_{it-1}) = \eta\bar{e} + \gamma e_{it-1}, \quad \eta, \gamma > 0, \tag{1}$$

where $i = r, p$, $h(\bar{e}, e_{rt-1})$ and $h(\bar{e}, e_{pt-1})$ are the levels of human capital stock of the rich and poor respectively. $\bar{e}$ is the level of elementary education. $e_{rt-1}$ and $e_{pt-1}$ are respectively, the levels of higher education of the rich and poor that are received in period $t-1$.

While the government determines the level of elementary education, individuals can choose the levels of higher education.

Next, we shall describe the sector of elementary education. Both rich and poor receive the same level of elementary education. The government runs the institution of elementary education by collecting taxes. For simplicity, we consider the productivity and cost of elementary education by the consumption goods. We represent the difference between productivity and cost per schoolchild as follows:

$$\eta\bar{e} - v(\bar{e}), \tag{2}$$

where $v(\bar{e})$ is the cost of elementary education per schoolchild. We assume that $v'(0) = 0$, $v'(\bar{e}) > 0$ and $v''(\bar{e}) > 0$.

The level of elementary education is determined at the following efficient level:

$$\eta = v'(\bar{e}). \tag{3}$$

When the productivity is high and the cost is low, the educational level, $\bar{e}$, becomes high. We assume that the government maintains a balanced budget. This implies that $T = v(\bar{e})$, where $T$ represents the tax paid per individual.

Finally, we shall explain the sector of higher education. We explicitly consider the educational price to investigate the effect of educational price on income inequality and macroeconomic development. The workers of the highest educational level can become teachers. This implies that teachers are among the rich, not the poor. When the human capital of a teacher is high and the number of teachers is large, education will progress well. Furthermore, we can see complementary relationships between teachers and students. Therefore, we presume the following Cobb-Douglas production function:

$$e_t L_t^S = (h(\bar{e}, e_{rt-1}) L_t^T)^{\alpha} (L_t^S)^{1-\alpha}, \quad 0 < \alpha < 1. \tag{4}$$

where $e_t$ is the educational level that is received in period $t$, $L_t^T$ is the number of teachers in period $t$, and $L_t^S$ is the number of students in period $t$.[4]

There exist diminishing returns in the level of teachers and the numbers of teachers and students in equation (4). Although diminishing returns in teachers would yield the same results even if we did not consider students as an input, for simplicity, we assume homogeneity of degree one for this production function.[5]

[4]Our model implies two cases, one in which all the students are the children of rich and the other in which the students are the children of rich and poor. Therefore, in this explanation, we represent the educational level of students simply as $e_t$.

[5]Given the assumption of a convex bequest function, Nakajima (2007) investigated how perfect

The institution of higher education is assumed to be a non-profit organization. Tuitions are used for the wages of the teachers. As shown in the next section, the normalization of the consumption goods price implies that the wage of a teacher is represented by the level of his or her human capital. The balanced budget of this organization can be written as follows:

$$p_t e_t = h(\bar{e}, e_{rt-1})\tau_t, \tag{5}$$

where $p_t$ is the educational price and $\tau_t \equiv L_t^T/L_t^S$ is the number of teachers per student.

While the left-hand side in equation (5) means tuition per student, the right-hand side implies the wage cost of teachers per student. The educational price is determined by a zero profit condition. Using equations (4) and (5), the educational price is represented as

$$p_t = (h(\bar{e}, e_{rt-1})\tau_t)^{1-\alpha}. \tag{6}$$

The educational price becomes a concave function with respect to the human capital of a teacher and the number of teachers per student. When diminishing returns in teachers are stronger, the educational price increases more.

Glomm and Ravikumar (1992), Zhang (1996), Bräuninger and Vidal (2000) and Das (2007) argue the merits of public and private education in terms of their effect

credit markets influence inequality. He used the same type of production function written in equation (4) to consider the educational price. Rothschild and White (1995) investigated competitive prices and efficient allocations in the case that outputs partially depend on customers as inputs.

on long-run growth.[6] We consider that the productivity of an unskilled worker is formed through their elementary education because we assume that elementary education is compulsory. In addition, we explicitly consider the educational price of higher education to investigate how its price affects individuals' decisions about education with their budget constraints.

## 2.2 Consumption goods sector

There exist many competitive firms in the consumption goods sector. While the rich are employed in the higher educational sector and in the consumption goods sector, the poor are only employed in the consumption goods sector. The production function is assumed to be of the following linear type:

$$Y_t = h(\bar{e}, e_{pt-1})(1-\lambda) + h(\bar{e}, e_{rt-1})L_t^C, \tag{7}$$

where $L_t^C$ is the number of the rich that are employed in the consumption goods sector. The equality, $L_t^C + L_t^T = \lambda$, holds in the labor market.

Because the price of consumption goods is normalized to be unity, the income of a worker is represented by the level of human capital.

## 2.3 Individuals

[6] Assuming both local externalities and an economy-wide externality, Bénabou (1996b) investigated how socioeconomic stratification and alternative systems of education finance influence inequality and growth. Bénabou (1994) and Durlauf (1996) considered stratification or segregation caused by externalities of human capital in communities to explain persistent inequality.

Individuals live in two periods. They receive an elementary education in the first period. If their parents make an educational expenditure, they further receive a higher education in the first period. They work in the second period. They have to pay taxes that are equally levied.[7] The disposable income is used for consumption and higher education. Because they can work as unskilled workers even in the case of zero educational expenditure, we assume that the expenditure on higher education is a convex function of income.

The utility maximization problem of an individual born in period $t-1$ is as follows:

$$\max_{c_{it},e_{it}} \beta \ln c_{it} + (1-\beta)\ln(p_t e_{it} + \theta), \qquad \theta > 0, \tag{8}$$

$$s.t. \qquad h(\bar{e}, e_{it-1}) - T = c_{it} + p_t e_{it}, \tag{9}$$

where $i = r, p$. $c_{rt}$ and $c_{pt}$ are the consumption levels of the rich and poor, respectively.[8]

If we considered $\theta$ as the cost for elementary education per schoolchild, $v(\bar{e})$, the term, $p_t e_{it} + \theta$, could be interpreted as the total amount of educational expenditure.

The first-order conditions yield the following equations that represent the expen-

[7] If we considered taxes that are unequally levied, the dynamics would become complicated. See footnote 10.

[8] Nakajima and Nakamura (2008) investigated the effect of educational price on educational expenditure by assuming that the utility function of a parent depends on the income of his or her child. They also considered educational systems.

diture on higher education:

$$p_t e_{it} = a e_{it-1} + b(\bar{e}) \quad if \quad a e_{it-1} + b(\bar{e}) > 0,$$

$$p_t e_{it} = 0 \qquad otherwise, \tag{10}$$

where $a \equiv (1-\beta)\gamma$, $b(\bar{e}) \equiv (1-\beta)(\eta\bar{e} - v(\bar{e})) - \beta\theta$. Note that $v(\bar{e}) = T$.

The sign of the constant term, $b(\bar{e})$, in equation (10) crucially influences educational expenditure. It is determined by the productivity and cost of elementary education. Productivity positively influences $b(\bar{e})$:

$$\frac{\partial b(\bar{e})}{\partial \eta} = (1-\beta)\bar{e} + (1-\beta)(\eta - \frac{\partial v(\bar{e})}{\partial \bar{e}})\frac{\partial \bar{e}}{\partial \eta} = (1-\beta)\bar{e}. \tag{11}$$

We used the first-order condition of elementary education for equation (3) to derive equation (11). We can infer that the cost of elementary education negatively influences $b(\bar{e})$.

Therefore, when the productivity of elementary education is high and its cost is low, $b(\bar{e})$ is likely to take on a positive value. This implies that individuals necessarily make an educational expenditure. However, low productivity and high cost of elementary education yield a negative value of $b(\bar{e})$. In this case, there would be the possibility of zero expenditure on higher education.

## 3. Effects of education on income inequality

### 3.1 Dynamics in the case of homogeneous individuals

While this paper investigates the effect of education on income inequality, we first

consider the case that there is no difference in initial educational levels between the rich and the poor, i.e., the case that $e_{r,-1} = e_{p,-1}$.

We see the dynamics of educational level of individuals. Using equations (4) and (5), the educational price in equation (6) becomes

$$p_t = e_t^{(1-\alpha)/\alpha}. \tag{12}$$

Using equations (10) and (12), the dynamics of educational level can be represented as follows:

$$e_t^{1/\alpha} = ae_{t-1} + b(\bar{e}). \tag{13}$$

The dynamics is shown in Figure 2 for $b(\bar{e}) < 0$. $f(e_t)$ and $g(e_{t-1})$ represent the left-hand and right-hand sides in equation (13), respectively. There exist multiple steady states in the level of higher education. While $e^{**}$ that means a poverty trap is unstable, $e^*$ is stable. When the initial educational level is lower than $D$ where $D \equiv -b(\bar{e})/a$, the educational level remains zero because of a convex educational expenditure. When the initial level is lower than $e^{**}$ while it is higher than $D$, the educational level converges to zero. However, if the initial educational level is larger than the educational level of poverty trap, it converges to $e^*$. That is, the relationship between the initial value and the poverty trap is crucial to the dynamics in the case of low elementary education productivity. On the other hand, for $b(\bar{e}) > 0$ in Figure 3, only a stable steady state exists. Any initial value converges to $e^*$. An increase in $e_t$ causes an increase in the educational price because both the number of teachers and their educational level increase.

Let us perform a comparative statistic analysis:[9]

$$\frac{\partial e^*}{\partial \eta} > 0, \quad \frac{\partial e^*}{\partial \gamma} > 0, \quad \frac{\partial e^*}{\partial \alpha} > 0, \quad \frac{\partial e^*}{\partial \beta} < 0,$$

$$\frac{\partial e^{**}}{\partial \eta} < 0, \quad \frac{\partial e^{**}}{\partial \gamma} < 0, \quad \frac{\partial e^{**}}{\partial \alpha} < 0, \quad \frac{\partial e^{**}}{\partial \beta} > 0.$$

We first investigate the effect of the parameters on $e^*$ that is a stable steady state. Any rise productivity of elementary education, productivity of higher education, or efficiency of higher education increases the level of higher education of the stable steady state. However, a rise in the weight of consumption in the utility function decreases the educational level.

Next, while any rise in productivity of elementary education, productivity of higher education, or efficiency of higher education decreases the educational level of an unstable steady state, a decline in the weight of consumption decreases the educational level. Because this suggests a decrease in the educational level of poverty trap, it would be easier for a trapped economy to converge to the higher stable steady state.

## 3.2 Existence of the rich and poor

In this section, given then assumption that $e_{r,-1} > e_{p,-1}$, i.e., that the initial educational level of the rich is higher than that of the poor, we investigate how education influences income inequality and macroeconomic development.

[9]We assume that the educational level of a steady state is larger than unity to see the effect of $\alpha$.

The production function of higher education noted in equation (4) is written as

$$e_{at} = (h(\bar{e}, e_{rt-1})\tau_t)^{\alpha}, \tag{14}$$

where $e_{at} \equiv \lambda e_{rt} + (1-\lambda)e_{pt}$. That is, $e_{at}$ is the average educational level of the rich and poor.

The budget of an educational institution in equation (5) becomes

$$p_t e_{at} = h(\bar{e}, e_{rt-1})\tau_t. \tag{15}$$

Using equations (10), (14) and (15), the dynamics of average educational level is represented as follows:

$$e_{at}^{1/\alpha} = ae_{at-1} + b(\bar{e}). \tag{16}$$

This is essentially the same as equation (13) that shows the dynamics of homogeneous individuals.

Using the educational price, $p_t = e_{at}^{(1-\alpha)/\alpha}$, and equations (10) and (16), the dynamics of the rich and poor can be respectively written as

$$e_{rt} = \frac{ae_{rt-1} + b(\bar{e})}{\{\lambda ae_{rt-1} + (1-\lambda)ae_{pt-1} + b(\bar{e})\}^{1-\alpha}}, \tag{17}$$

$$e_{pt} = \frac{ae_{pt-1} + b(\bar{e})}{\{\lambda ae_{rt-1} + (1-\lambda)ae_{pt-1} + b(\bar{e})\}^{1-\alpha}}. \tag{18}$$

The dynamics crucially depend on the sign of $b(\bar{e})$. We first investigate the case that the productivity of elementary education is low and its cost is high, i.e., that $b(\bar{e}) < 0$. The phase diagram in Figure 4 shows that there are multiple steady states. While the steady state, $C$, is unstable, the steady state, $B$, is a saddle point.

The saddle path exists on the 45 degree line. The dynamics becomes asymmetric depending on the numbers of the rich and poor.

Let us assume that the initial point is located at $A_1$. This indicates that while the initial educational level of the rich is higher than the educational level of poverty trap, the initial educational level of the poor is zero. Because the initial educational level of the poor is lower than $D$ that indicates the threshold of educational expenditure and the educational price increases as the educational level of the rich increases, the educational level of the poor remains zero, i.e., the poor do not spend any more on education. All the students in the educational institution are the children of rich. The dynamics of the educational level of the rich are the same as those of homogeneous individuals:

$$e_{rt}^{1/\alpha} = ae_{rt-1} + b(\bar{e}). \tag{19}$$

Because the initial educational level of the rich is assumed to be higher than the educational level of poverty trap, it converges to $e^*$.

Now, we consider the case that the initial educational levels of both rich and poor are higher than the educational level of poverty trap. This can be represented by the initial point, $A_2$, in Figure 4. The educational levels of both increase temporarily. However, the educational level of the poor, but not of the rich, soon decreases because of an increase in the educational price, and it eventually becomes zero. Educational price becomes high when the number of rich is large and their educational level is high, i.e., when income inequality is large. Given that the educational level of the poor is zero, the dynamics of educational level of the rich follows equation

(19). That is, we can see the dynamics in Figure 2. Note that Figure 4 shows the dynamics in the case that both rich and poor make educational expenditures.

Now, let us consider the case of educational assistance for the poor. The saddle point, $B$, will be reached only if the initial values of both rich and poor are on the 45 degree line and are higher than the educational level of poverty trap. If the educational assistance did not equate the educational levels of the poor and rich, the educational level of the poor would converge to zero.[10] Therefore, educational assistance for the poor would not be effective in decreasing inequality in an economy where the productivity of elementary education is low.

Here, we have the following proposition for the case that the productivity of elementary education is low.

**Proposition 1:** *If* $b(\bar{e}) < 0$ *and given that the initial educational level of the rich is higher than that of the poor, income inequality between them necessarily increases in the long run.*

The lines, $\Delta e_{rt} = 0$ and $\Delta e_{pt} = 0$, become identical in the case that $b(\bar{e}) = 0$. A continuum of steady states exists on that line. While the rich and poor attain higher education as long as their initial educational levels are strictly greater than zero, income inequality in a steady state depends on their initial educational levels.

Next, we investigate the case that the productivity of elementary education is

[10] When we tried income transfers from the rich to the poor, $b(\bar{e})$ of the poor increased temporarily while that of the rich decreased. This implies that the saddle path would not exist on the 45 degree line any more and it would move counter-clockwise.

high and its cost is low, i.e., that $b(\bar{e}) > 0$. Figure 5 shows the phase diagram in which there is only a stable steady state. Compared with Figure 4, the slopes of $\Delta e_{rt} = 0$ and $\Delta e_{pt} = 0$ are opposite. Any initial value converges to $e^*$. Income inequality disappears in the long run because the educational levels of the rich and the poor are the same as in the steady state. Compared with the case that $b(\bar{e}) < 0$, the educational level of both the rich and the poor become higher. Therefore, the GDP level also becomes larger.

Here, we have a proposition for the case that the productivity of elementary education is high.

**Proposition 2:** *If $b(\bar{e}) > 0$, income inequality between the rich and the poor disappears regardless their initial educational levels. In addition, the GDP level is higher than the GDP level in the case that $b(\bar{e}) < 0$.*

If we assumed that the productivity of elementary education positively depends on the total amount of human capital in an economy, we could consider it endogenously.[11] When the educational level of the rich is high and its number is sufficient to assure a positive $b(\bar{e})$, not only the rich, but also the poor also can accumulate human capital and therefore, income inequality disappears. However, if the amount of human capital stock remains low, income inequality might widen because it would

[11]Given the assumption of perfect capital markets, Galor and Tsiddon (1997) investigated economies where a rise in the average level of human capital in an economy increases the productivity of all workers. In their model, polarization in the income distribution would be a necessary ingredient for future economic growth.

be impossible for the poor to attain a higher education.

## 4. Conclusion

Assuming borrowing constraints and a convex expenditure on higher education, this paper separately considered elementary education and higher education. We showed that the productivity and cost of elementary education have significant effects on income inequality and macroeconomics through individuals' decisions about higher education with the educational price.

However, an economy caught in a poverty trap can not endogenously escape from it because the productivity of elementary education was exogenously given. By considering household fertility behavior, Galor and Weil (2000) developed a unified growth model explaining the historical evolution of population, technology, and output. In their model, a poverty trap vanishes endogenously, because technological progress ensures that eventually economies will escape from stagnation to achieve sustained economic growth.[12] In the future, we intend to endogenously consider the productivity of elementary education. If a poverty trap disappears due to an increase in elementary education productivity, the economy will be able to achieve equalization and high economic growth.

[12]By considering heterogeneous households that have different perceptions on the quality of their children, Galor and Moav (2002) also explained sustained economic growth from stagnation.

# References


[1] Aghion, Philippe and Patrick Bolton (1997) A Theory of Trickle-Down Growth and Development. *Review of Economic Studies* 4, 151-172.

[2] Azariadis, Costas and John Stachurski ( 2005) Poverty Traps. In Philippe Aghion and Steven N. Durlauf (eds.), *Handbook of Economic Growth*, Volume 1A, Elsevier B.V.

[3] Banerjee, Abhijit V. and Andrew F. Newman (1993) Occupational Choice and the Process of Development. *Journal of Political Economy* 101, 274-298.

[4] Barro, Robert J. (1997) *Determinants of Economic Growth: A Cross-Country Empirical Study*. MIT press.

[5] Barro, Robert J. and Jong-Wha Lee (1996) International Measures of Schooling Years and Schooling Quality. *American Economic Review* 86, 218-223.

[6] Bénabou, Roland (1994) Human Capital, Inequality, and Growth: A Local Perspective. *European Economic Review* 38, 817-826.

[7] Bénabou, Roland (1996a) Inequality and Growth. *NBER Macroeconomics Annual*, 11-73.

[8] Bénabou, Roland (1996b) Heterogeneity, Stratification and Growth: Macroeconomic Implications of Community Structure and Education Finance. *American Economic Review* 86, 584-609.

[9] Bräuninger, Michael and Jean-Pierre Vidal (2000) Private versus Public Financing of Education and Endogenous Growth. *Journal of Population Economics* 13, 387-401.

[10] Das, Mausumi (2007) Persistent Inequality: An Explanation based on Limited Parental Altruism. *Journal of Development Economics* 84, 251-270.

[11] Durlauf, Steven N. (1996) A Theory of Persistent Inequality. *Journal of Economic Growth* 1, 75-95.

[12] Freeman, Scott (1996) Equilibrium Income Inequality among Identical Agents. *Journal of Political Economy* 104, 1047-1064.

[13] Galor, Oded (1996) Convergence? Inferences from Theoretical Models. *Economic Journal* 106, 1056-1069.

[14] Galor, Oded and Omer Moav (2002) Natural Selection and the Origin of Economic Growth. *Quarterly Journal of Economics* 117, 1133-1191.

[15] Galor, Oded and Omer Moav (2004) From Physical to Human Capital Accumulation: Inequality and the Process of Development. *Review of Economic Studies* 71, 1001-1026.

[16] Galor, Oded and Omer Moav (2006) Das Human-Kapital: a Theory of the Demise of the Class Structure. *Review of Economic Studies* 73, 85-117.

[17] Galor, Oded and Daniel Tsiddon (1997) The Distribution of Human Capital and Economic Growth. *Journal of Economic Growth* 2, 93-124.

[18] Galor, Oded and David N. Weil (2000) Population, Technology, and Growth: from Malthusian Stagnation to the Demographic Transition and Beyond. *American Economic Review* 90, 806-828.

[19] Galor, Oded and Joseph Zeira (1993) Income Distribution and Macroeconomics. *Review of Economic Studies* 60, 35-52.

[20] Ghatak, Maitreesh and Neville Nien-Huei Jiang (2002) A Simple Model of Inequality, Occupational Choice, and Development. *Journal of Development Economics* 69, 205-226.

[21] Glomm, Gerhard and B. Ravikumar (1992) Public vs Private Investment in Human Capital: Endogenous Growth and Income Inequality. *Journal of Political Economy* 100, 818-834.

[22] Maoz, Yishay D. and Omer Moav (1999) Intergenerational Mobility and the Process of Development. *Economic Journal* 109, 677-697.

[23] Matsuyama, Kiminori (2000) Endogenous Inequality. *Review of Economic Studies* 67, 743-759.

[24] Moav, Omer (2002) Income Distribution and Macroeconomics: the Persistence of Inequality in a Convex Technology Framework. *Economics Letters* 75, 187-192.

[25] Mookherjee, Dilip and Debraj Ray (2002) Contractual Structure and Wealth Accumulation. *American Economic Review* 92, 818-849.

[26] Mookherjee, Dilip and Debraj Ray (2003) Persistent Inequality. *Review of Economic Studies* 70, 369-393.

[27] Nakajima, Tetsuya (2007) Persistent Inequality in the Framework of a Perfect Credit Market. Mimeo, Osaka City University.

[28] Nakajima, Tetsuya and Hideki Nakamura (2008) Significant Effects of Higher Education on Inequality and Economic Development. Mimeo, Osaka City University.

[29] Owen, Ann L. and David N. Weil (1998) Intergenerational Earnings Mobility, Inequality, and Growth. *Journal of Monetary Economics* 41, 71-104.

[30] Persson, Torsten and Guido Tabellini (1994) Is Inequality Harmful for Growth? *American Economic Review* 84, 600-621.

[31] Piketty, Thomas (1997) The Dynamics of the Wealth Distribution and the Interest Rate with Credit Rationing. *Review of Economic Studies* 64, 173-189.

[32] Quah, Danny (1996a) Twin Peaks: Growth and Convergence in Models of Distribution Dynamics. *Economic Journal* 106, 1045-1055.

[33] Quah, Danny (1996b) Empirics for Economic Growth and Convergence. *European Economic Review* 40, 1353-1375.

[34] Rothschild, Michael and Lawrence J. White (1995) The Analytics of the Pricing of Higher Education and Other Services in Which the Customers Are Inputs. *Journal of Political Economy* 103, 573-586.

[35] Summers, Robert and Allan Heston (1991) The Penn World Table (Mark 5):An Expanded Set of International Comparisons, 1950-1988. *Quarterly Journal of Economics* 106, 327-368.

[36] Voitchovsky, Sarah (2005) Does Profile of Income Inequality Matter for Economic Growth? Distinguishing Between the Effects of Inequality in Different Parts of the Income Distribution. *Journal of Economic Growth* 10, 273-296.

[37] Zhang, Jie (1996) Optimal Public Investment in Education and Endogenous Growth. *Scandinavian Journal of Economics* 98, 387-404.

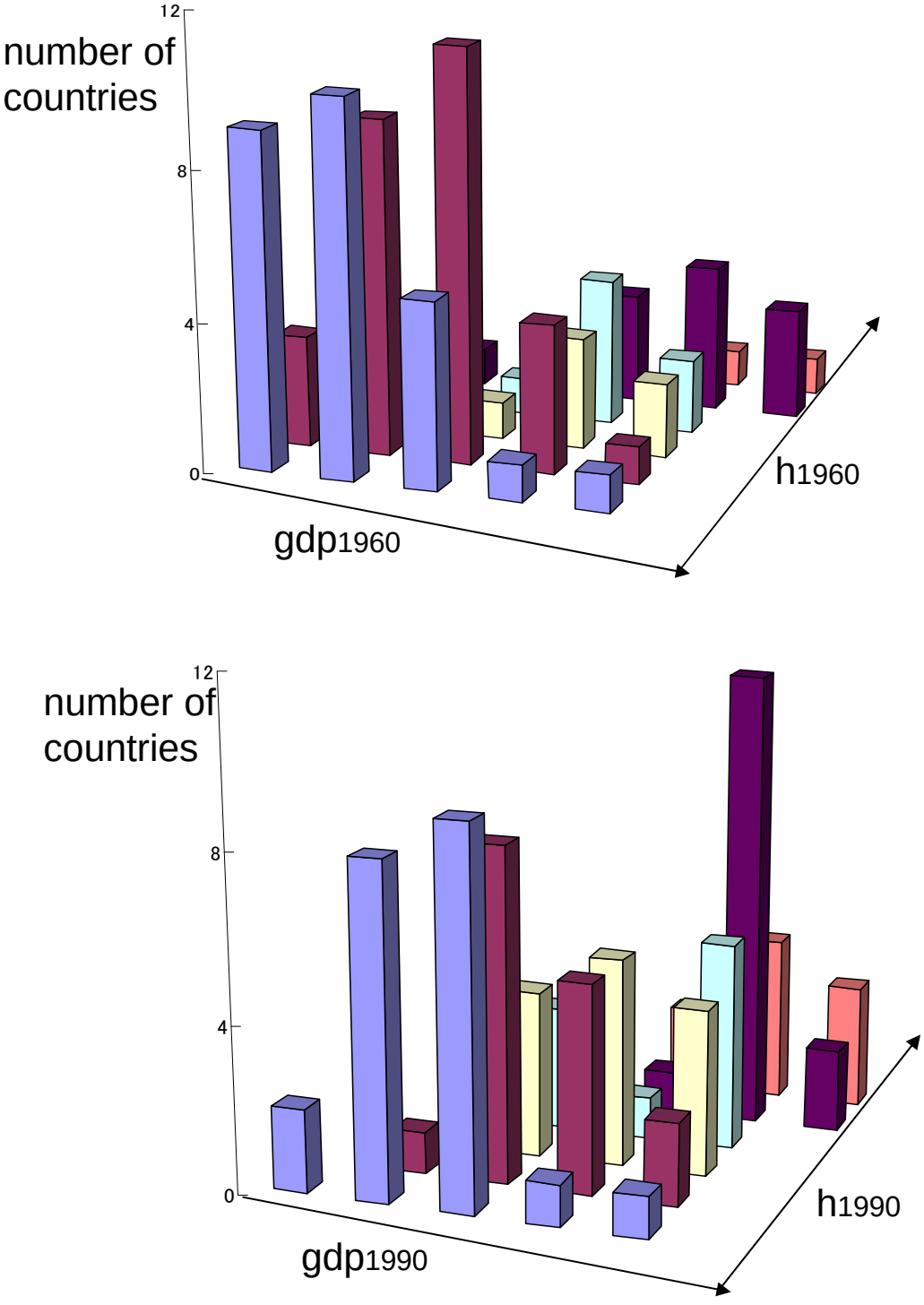


Figure 1. Histogram of average schooling years and GDP-per-labor unit in years 1960 and 1990

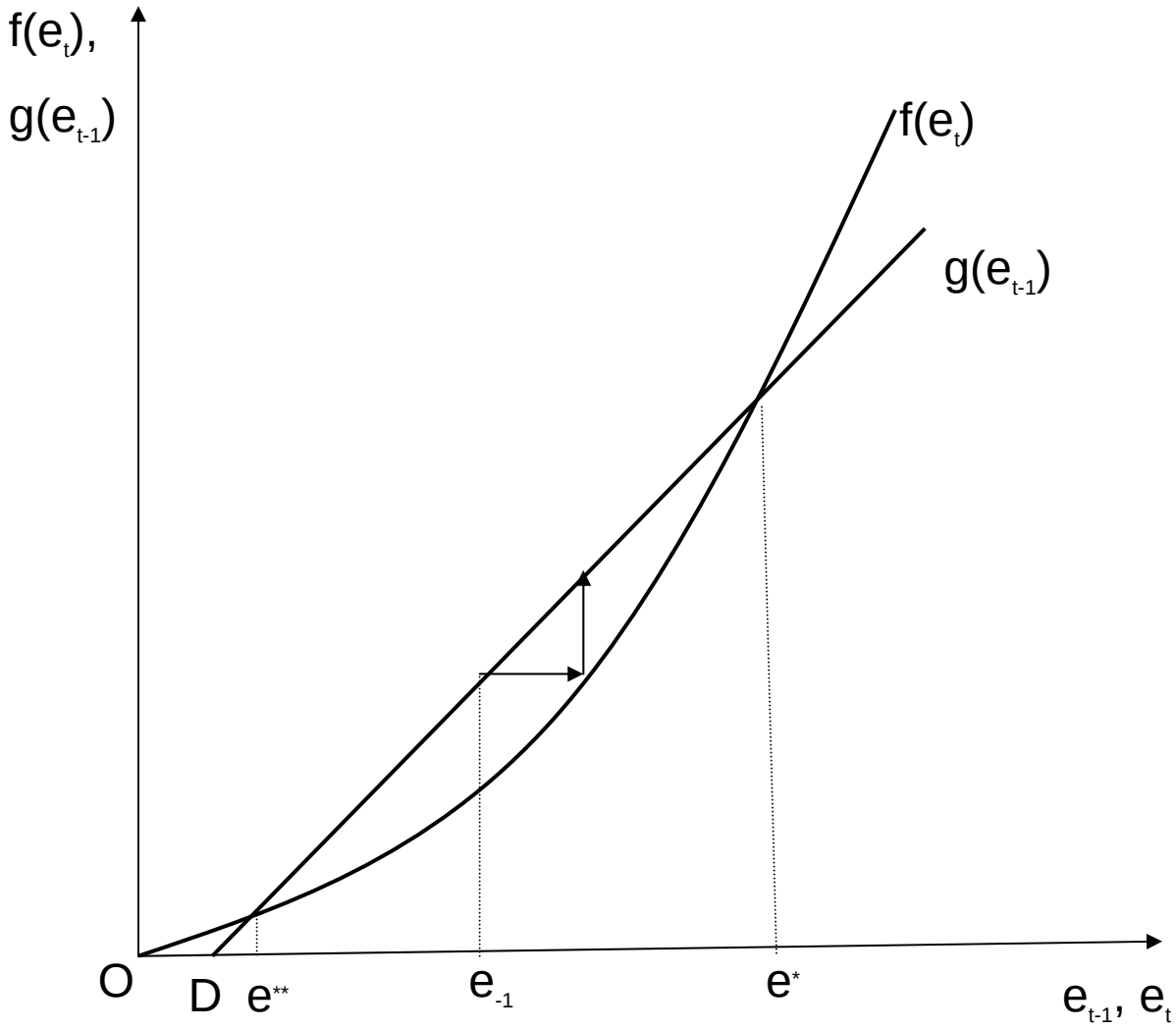


Figure 2. Dynamics of educational level in the case of low productivity of elementary education

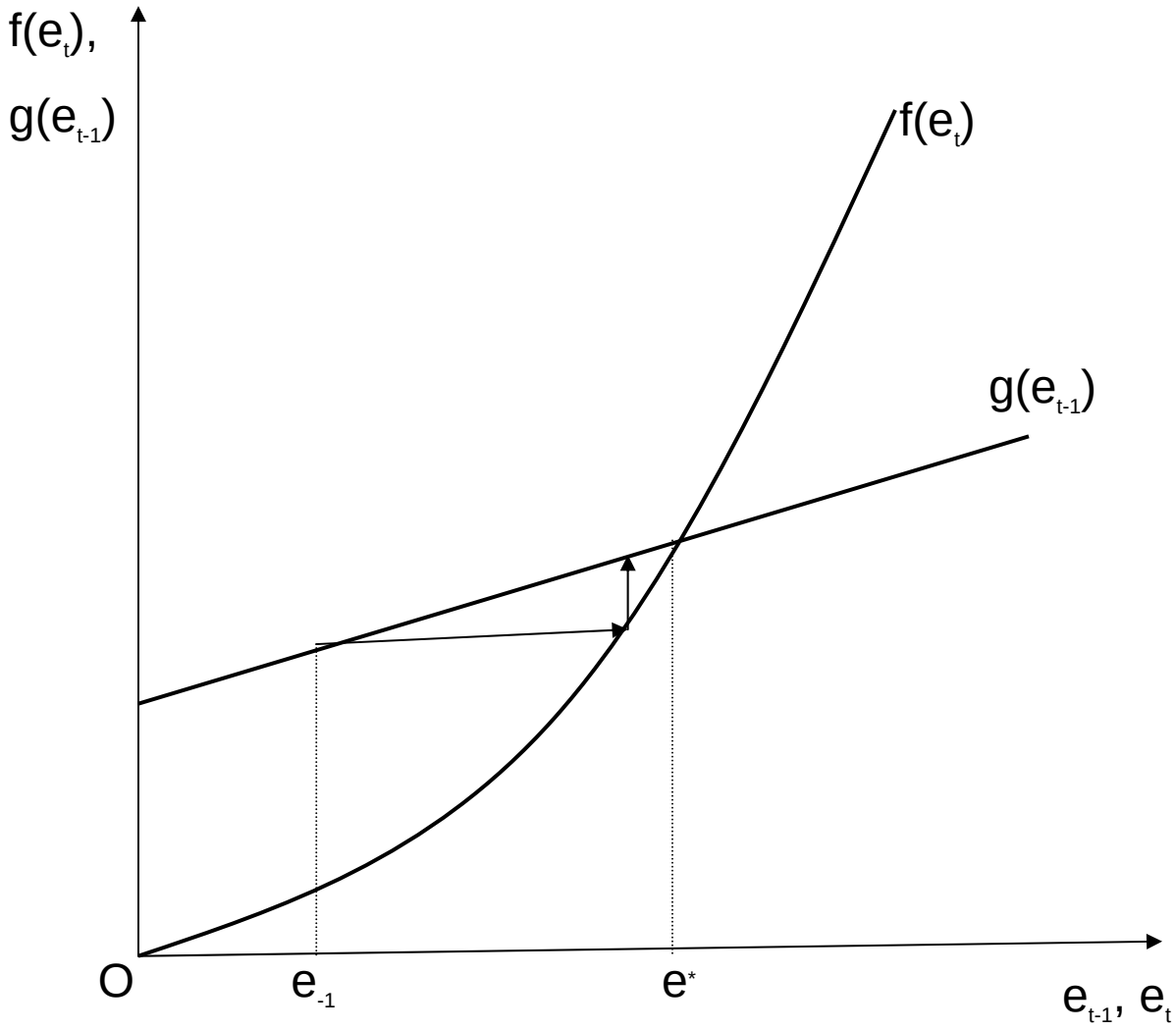


Figure 3. Dynamics of educational level in the case of high productivity of elementary education

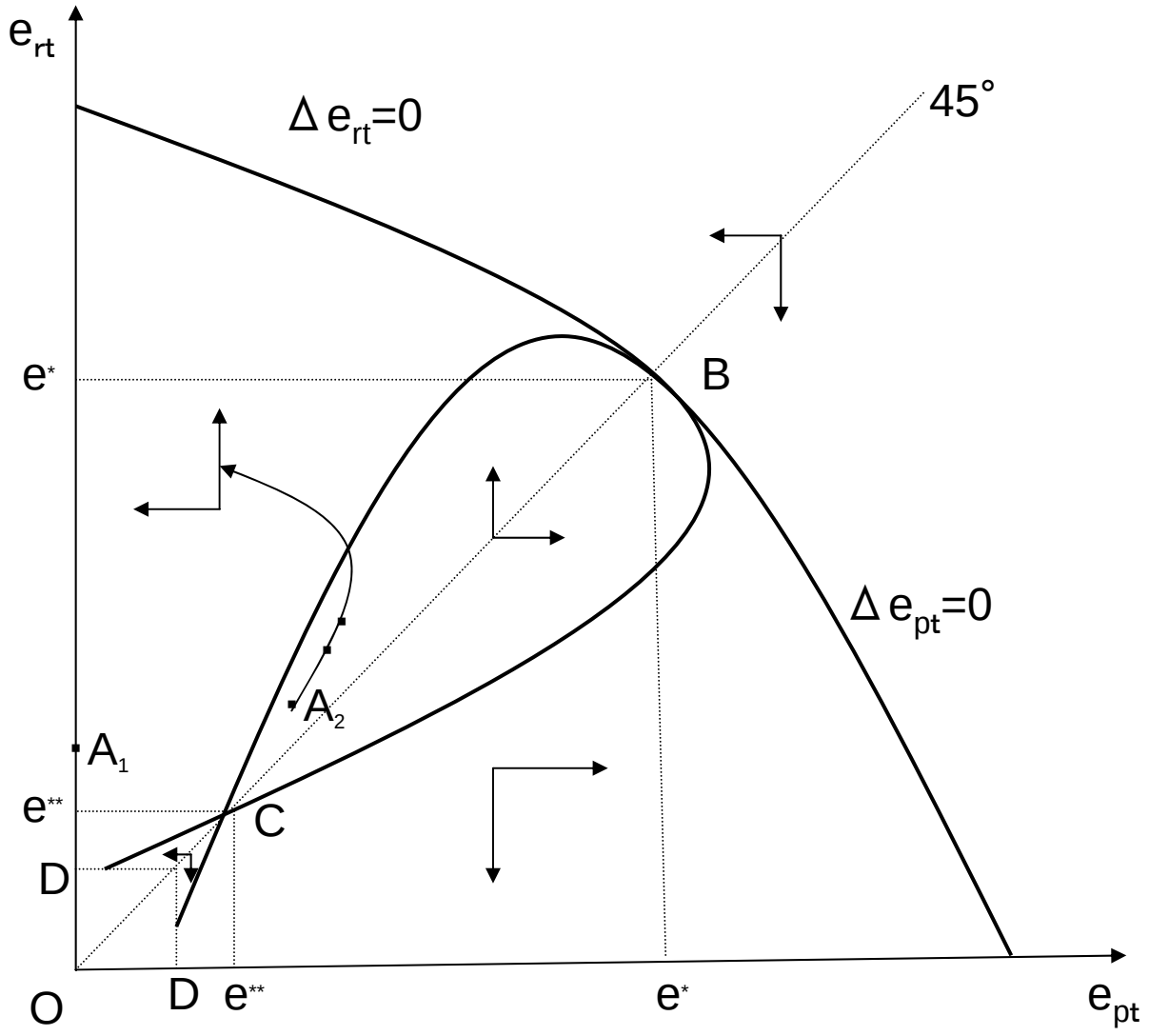


Figure 4. Phase diagram in the case of low productivity of elementary education

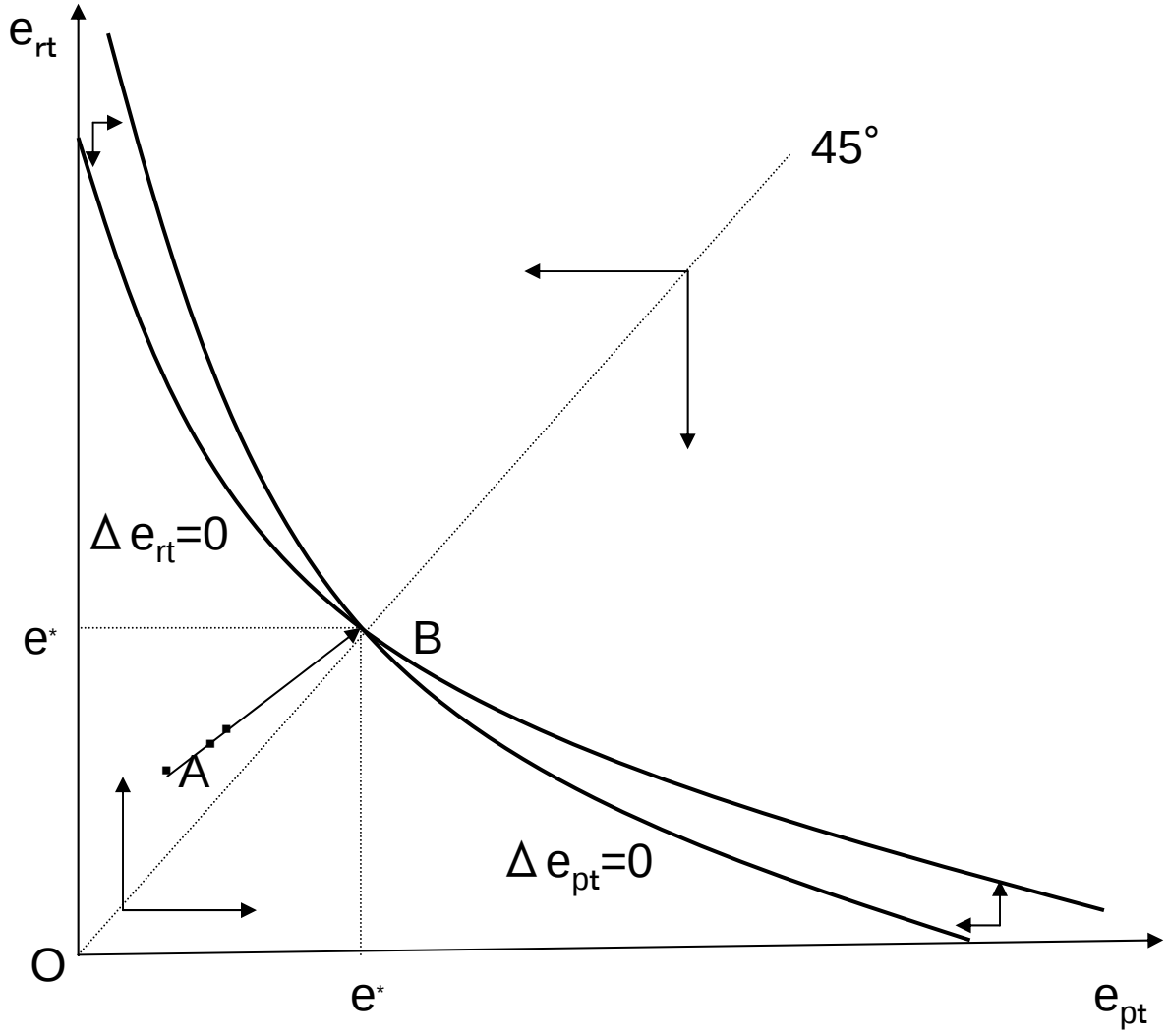


Figure 5. Phase diagram in the case of high productivity of elementary education