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Abstract

This study focuses on three factors that can boost the level of individual human capital through education: class size, students' earnestness toward studying, and individual learning environment. We then compare the benefits of three school policies that control these three factors, and suggest an optimal policy by examining the budgets for education, the duration for which the policies have to be implemented, and the initial level of the three factors. First, we find that class-size reduction is not always effective in increasing the level of human capital. Second, a school policy to enhance the level of individual learning environment is effective with a small budget, in the short term, or when students' initial learning environment and earnestness toward studying are low. By contrast, a school policy that boosts individuals' earnestness is effective with a large budget, in the long term, or when students already have access to a learning environment and are motivated to study.

Keywords: human capital, class-size reduction, individual learning environment, students' earnestness toward studying

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1 Introduction

Ever since Becker (1964) proposed that the accumulation of human capital through education positively affects individual incomes, many studies have focused on the factors that raise the level of individual human capital through education, and the effects of school policies that boost the level of these factors. First, Knueger (1999), Molnar et al. (1999), and Ecalle et al. (2006) show that human capital increases with a class-size reduction. Bonesrønning (2003) notes that the class-size effects are relevant only when students have high motivation for studying. Moreover, Browning and Heinesen (2007) indicate that class-size effects are larger for students from less advantaged backgrounds. Second, Arnott and Rowse (1987) and Lazear (2001) focus on the peer group effect. They show that students' average level of earnestness when studying in a classroom, affects the level of individual human capital. Third, Coleman et al. (1966) demonstrate that human capital formed by education is related to individuals' own background. Corcoran et al. (1991), Seshadri and Yuki (2004), and Nakamura (2020) show the effects of individual learning environments on the level of human capital. Although these studies analyze the effects of school policies that boost some factors that can boost the level of individual human capital through education, few studies compare the school policies.

In this study, we, therefore, focus on three factors that can boost the level of individual human capital through education: class size, students' earnestness toward studying, and their individual learning environments. We then compare the relative benefits of three school policies that control these three factors, and suggest an optimal policy by examining the budgets for education, the duration for which the policies have to be implemented, and the initial level of the three factors. First, we find that there is an optimal class size. That is, class-size reduction is not always effective in increasing human capital. Second, a school policy to enhance the level of an individual's learning environment is effective with a small budget, in the short term, or when students' initial learning environment and earnestness toward studying are low. By contrast, a school policy that boosts individuals' earnestness toward studying is effective with a large budget, in the long term, or when students already have access to a learning environment and are motivated to study.

In the following section, we analyze a model that explains the benefits of education. In section 3, we compare the benefits of school policies that raise the level of individual human capital. Section 4 provides concluding remarks.

2 The model

We compare the benefits of certain policies that aim to raise the value of human capital through education, using a simple model based on Lazear (2001) and Oshio (2002).¹ The value of human capital acquired by education is V ; the value of V

¹Lazear (2001) proposed a model of the relationship between class size and students' earnestness toward studying. Oshio (2002) simplified this model. In our study, we add the factors of individual

depends on individuals' ability to understand, θ and the level of individual learning environment, e . Therefore, V is shown as

$$V = A\theta^\alpha e^\beta, \quad (1)$$

by using the Cobb–Douglas production function, and $0 < \alpha, \beta < 1$ are satisfied. p is the level of an individual's earnestness toward studying. We assume that each student is identical, and $0 \leq p \leq 1$ is satisfied. n is the number of students in a classroom. The operating costs of a classroom (such as the salary of a teacher and installing equipment for learning, such as a blackboard or air conditioners) are W and individuals incur these costs. Therefore, the benefits per student from education, π , can be written as

$$\pi = A\theta^\alpha e^\beta p^n - \frac{W}{n}. \quad (2)$$

$\pi > 0$ is satisfied because we assume that education systems aid the formation of human capital, and its benefit exceeds its costs. The first-order condition of (2) for n is

$$\frac{\partial \pi}{\partial n} = A\theta^\alpha e^\beta p^n \ln p + \frac{W}{n^2} = 0. \quad (3)$$

Let us consider the relationship between p and n . As Lazear (2001) shows, the number of n increases when the value of p increases from (2) and (3), and vice versa (see Appendix A). That is, a large class size can maximize the benefits when students are earnest. On the contrary, a small class size is optimal when students are not earnest.

Now, we assume that each school considers raising the benefits through education using the budgets from the government, and that these budgets are exogenous.² We focus on three school policies to boost the benefits of education. First, a school hires more teachers and creates classes of a small size. In this case, the benefit through education can be written as:

$$\pi_1 = A\theta^\alpha e^\beta p^m - \frac{W}{m}, \quad (4)$$

where m is the number of students after hiring new teachers. $2 < m < n$ is satisfied because the number of students in a classroom is usually plural.

Second, a school provides facilities that boost students' earnestness toward studying, such as increased student grants, sufficient equipment for cooling and heating, and a school lunch. In addition, the opportunity to participate in a short overseas

learning environments that relate to the formation of individual human capital, and examine the effects of certain school policies, to reflect the actual condition in society.

In addition, we adopt the Cobb–Douglas production function to examine the effects of each factor.

²For simplification, we do not analyze the budgets endogenously in this study. We assume that the budget is similar to an official development assistance or subsidies from the central government that levies lump-sum tax on all citizens.

study program can increase students' interest in learning foreign languages. In this case, the value of p increases. Then, the benefit through education is:

$$\pi_2 = A\theta^\alpha e^\beta p^m - \frac{W}{n}, \quad (5)$$

and $0 < p < p' < 1$ is satisfied.

Third, a school improves an individual's learning environment. For example, the school provides school supplies to each family, or study areas where students can do their homework after school. In this case, the value of e increases. The benefit through education is

$$\pi_3 = A\theta^\alpha e'^\beta p^n - \frac{W}{n}, \quad (6)$$

and $0 < e < e'$ is satisfied.

π_2 and π_3 are the increasing functions of the values of p and e , respectively, whereas π_1 is not a decreasing function of the class size. Moreover, the marginal rate of the benefit from the policy that boosts the individual learning environment is negative because

$$\frac{\partial^2 \pi_1}{\partial e^2} = A\theta^\alpha \beta(\beta - 1)e^{\beta-2} p^m < 0, \quad (7)$$

$$\frac{\partial^2 \pi_2}{\partial e^2} = A\theta^\alpha \beta(\beta - 1)e^{\beta-2} p^m < 0, \quad (8)$$

$$\frac{\partial^2 \pi_3}{\partial e^2} = A\theta^\alpha \beta(\beta - 1)e'^{\beta-2} p^n. \quad (9)$$

On the other hand, from the following three equations, it is found that the marginal rate of the benefit from the policy that raises individuals' earnestness is positive as long as $2 < m < n$ is satisfied.

$$\frac{\partial^2 \pi_1}{\partial p^2} = A\theta^\alpha e^\beta m(m - 1)p^{m-2} > 0, \quad (10)$$

$$\frac{\partial^2 \pi_2}{\partial p^2} = A\theta^\alpha e^\beta n(n - 1)p^{m-2} > 0, \quad (11)$$

$$\frac{\partial^2 \pi_3}{\partial p^2} = A\theta^\alpha e'^\beta n(n - 1)p^{n-2} > 0. \quad (12)$$

3 An optimal school policy to increase benefits through education

We introduce two propositions by analyzing the benefits from three school policies for education explained in the previous section.

Proposition 1 *The decision regarding an optimal school policy depends on the budget. When budgets for education are large, a policy that boosts students' earnestness can be more effective compared to policies that increase the level of individual learning environments or the number of hired teachers.*

Proof. The benefits through the two policies that increase individuals' earnestness toward studying and the level of learning environment, are increasing functions of the students' earnestness and their learning environment, respectively, whereas the benefit from the policy of class-size reduction is not an increasing function of the number of teachers. That is, having too many teachers decreases the benefits from education because individuals' costs become large, as shown in (4). Moreover, (10), (11), and (12) show that the marginal benefit of p is increasing. Therefore, the more budgets, the more effective the policy to increase students' earnestness is. ■

Proposition 2 *When initial levels of students' earnestness and individual learning environments are low, improving individual learning environments can be effective in the short term, whereas boosting students' earnestness can be effective in the long term.*

Proof. The marginal rate of benefit by a policy that raises the individual learning environment is negative, whereas one by a policy that boosts students' earnestness is positive. Therefore, when the initial levels of the individual learning environment and earnestness are low, the impact of the former policy can be larger than the latter in the short term. However, when they reach a certain level, the latter policy can be effective at an accelerating rate. ■

From these two propositions, we should consider the optimal policy to increase benefits through education by focusing on the budgets, the duration for which the policies have to be implemented, and the initial level of students' earnestness and learning environments. Moreover, in many cases, the initial levels of individual learning environments and earnestness are low in developing countries as compared to those in developed countries.³ Therefore, developing countries must be careful while implementing policies, so that human capital through education can be increased effectively.

4 Conclusion

In this study, we compared the effects of three school policies that can increase benefits through education: class-size reduction by increasing the number of teachers, increasing students' earnestness toward studying, and improving their individual learning environment. Only the first policy is optimally capable of maximizing the

³Even if individual students have a high incentive to learn, they cannot concentrate on studying because of poverty. For example, some of them have to help their family business and may suffer from lack of sleep. As a result, their earnestness suffers.

benefits through education. When it comes to the remaining two school policies, the more the investments in education, the larger the benefits from education are.

We consider the optimal investments for two factors by considering the budgets, the duration for which the policies have to be implemented, and the initial amount of the two factors that each student has. We found that the policy to boost students' earnestness, such as increasing student grants, installing sufficient equipment for cooling and heating, providing lunch, and giving students the opportunity to participate in short overseas study programs can be more effective than increasing the level of individual learning environments, when schools have large budgets for education or when the policy is aimed at long-term implementation. By contrast, the policy to boost individual learning environments can be more effective than increasing students' earnestness when the budget is small and the policy is implemented for the short term, or individual initial conditions regarding earnestness and the environment for education are poor.

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Appendix A

From (2), we can introduce

$$W = -A\theta^\alpha e^\beta p^n n^2 \ln p. \quad (13)$$

By substituting (13) into (2), we obtain

$$1 + n \ln p > 0. \quad (14)$$

Using the implicit function theorem in (3), we introduce the following equation:

$$\frac{\partial n}{\partial p} = -\frac{\frac{\partial^2 \pi}{\partial n \partial p}}{\frac{\partial^2 \pi}{\partial n^2}} = -\frac{n(1 + n \ln p)}{p \ln p(2 + n \ln p)} > 0, \quad (15)$$

because $\ln p < 0$.