【研究ノート】

In School, at Work, or a Predator ? *)

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Introduction

Do people in developing countries choose to be more productive in the long run if the countries import the technologies from developed countries ? To answer this question, the paper analyzes within a general equilibrium framework the effect of a technology transfer on the determination of two ratios : the ratio of predators to workers and the ratio of more educated workers to less educated workers.

Acemoglu (1999) and Acemoglu and Zilibotti (2000) argue that many technologies used by developing countries are imported from developed countries but they are not appropriate for development because they are designed for the developed countries which have abundant supplies of more educated workers. Namely the imported technologies use larger numbers of more educated workers in production.

In the recent U.S. economy, technological innovations have increased both educational inequality and ability premium.[1] Hence technology transfers from

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1) Educational inequality is defined as the ratio of the average earnings per period of a more educated worker to the average earnings per period of a less educated worker. Ability premium↗

developed countries might also have the same effects in developing countries. From this point of view, the paper distinguishes between an education-bias in which a technology transfer increases the demand for the workers who choose to be more educated, and an ability-bias in which a technology transfer increases the demand for the more educated workers with relatively high ability.

Moreover in the developing countries in which workers' property rights are not well protected, technology transfers may affect in the long run the choice of people to be workers or predators. Grossman (1998) develops a general equilibrium model in which people choose to be either producers or predators. The present paper extends this model to analyze the determination of two ratios : the ratio of predators to workers and the ratio of more educated workers to less educated workers. The analyses show the following results.

If a technology transfer is education-biased, then it increases educational inequality in the short run, which reverses in the long run in which the relative supply of more educated workers to less educated workers increases. However in the benchmark case in which the technologies of production and predation exhibit constant returns to scale, this technology transfer does not affect the ratio of predators to workers. Accordingly, in the long run this technology transfer increases the number of more educated workers, decreases the number of less educated workers, and does not affect the number of predators. This result implies that the technology transfer that increases the demand for more educated workers induces more workers to choose to be more educated in the long run.

↘is defined as the ratio of the earnings per period of a more educated worker with high ability to the earnings per period of a more educated worker with ordinary ability. In 1970s, the movements of educational inequdity and ability premium were different. Azuma and Grossman (2001) study the effect of education-biased and ability-biased innovations on educational inequality in the U. S. economy over the last century.

If a technology transfer is ability-biased, then it increases ability premium in both the short run and the long run. Some ordinary workers choose not to be more educated. Some less educated people choose to be predators even if the technologies of production and predation exhibit constant returns to scale. Accordingly, in the long run this technology transfer decreases the number of more educated workers and increases both less educated workers and predators. This result implies that the technology transfer that increases the demand for high ability people discourages some ordinary people to choose to be more productive in the long run.

The paper is organized as follows. Section I derives educational inequality within a general equilibrium framework. Assuming that people are homogeneous in ability, section II analyzes the determination of two ratios : the ratio of predators to workers and the ratio of more educated workers to less educated workers. Section III extends the model to allow high ability and ordinary people among workers. Last section concludes.

I Educational Inequality

Assume, for simplicity, that the output per period of a representative firm in a representative industry is a Cobb-Douglas function of inputs of more educated labor and less educated labor, as in

$$Y=L_m^{\sigma}L_s^{1-\sigma}, \qquad \sigma\in(0,1), \tag{1}$$

where Y denotes output per period, and where L_m and L_s denote the numbers of efficiency units of more educated labor and less educated labor that the firm employs per period. The parameter σ measures the relative importance of more educated labor in production.[2)]

2) The Cobb-Douglas function in equation (1) is a special case of an aggregate production function that exhibits constant elasticity of substitution between more educated labor and less↗

Let $\widetilde{L}_m$ and $\widetilde{L}_s$ denote the quantities supplied per firm per period of efficiency units of more educated labor and less educated labor, and let w_m and w_s represent the earnings per period of an efficiency unit of more educated labor and less educated labor. Assume that the firm takes earnings per efficiency unit of labor as given and demands quantities of each type of labor such that the marginal product of an efficiency unit of labor equals earnings per efficiency unit. Calculating marginal products from equation (1), and using the market-clearing conditions that $\widetilde{L}_m$ equals L_m and $\widetilde{L}_s$ equals L_s, we find that

$$\frac{w_m}{w_s}=\frac{\sigma}{1-\sigma}\frac{\widetilde{L}_s}{\widetilde{L}_m}. \qquad (2)$$

Equation (2) shows that relative earnings per efficiency unit of more educated labor depend negatively on the relative supply of efficiency units of more educated labor and positively on the parameter of the production technology σ.

Assume for now that a more educated worker supplies one unit of more educated labor and a less educated worker supplies one unit of less educated labor. Thus, we have $W_m=w_m$ and $W_s=w_s$, where W_m and W_s represent earnings per period of a more educated worker and a less educated worker. Then equation (2) represents educationl inequality, defined as the ratio of the average earnings per period of a more educated worker to the average earnings per period of a less educated worker. Define the short run to be the period in which the supplies of more educated workers and less educated workers are given. Then in the short run an increase in σ increases educational inequality and thus has a bias toward education.

↘educated labor, as in $Y=[\sigma L_m^\rho+(1-\sigma)L_s^\rho]^{1/\rho}$, $\rho<1$, $\rho\neq 0$. Equation (1) obtains in the limit as the parameter ρ goes to zero. Most of the results derived below generalize to any aggregate production function that exhibits constant elasticity of substitution as long as ρ is not negative.

II Occupational Choice

The population is constant and normalized to one. Each worker is active for T periods. In each period $1/T$ old workers exit and $1/T$ new young workers enter. All young workers start with a basic education. Let n denote the endogenously determined fraction of the population that chooses to remain less educated. The fraction $1-n$ of the population chooses to become more educated. To become more educated a person must spend the first τ periods of his life acquiring more education, where $\tau \leq T$. While in school a person cannot be either a worker or a predator and, hence, has no income, although he can consume by borrowing costlessly against future income.

Let r denote the fraction of the population that chooses to be predators. Predators are those who do not produce and live by appropriating the income of workers. The fraction $1-r$ of the population chooses to be workers. Let $R \equiv r/(1-r)$. Assuming that more educated workers and less educated workers are equally good at being predators, nobody would choose both to become more educated and to be a predator. Hence, all of the predators are less educated, with the implication that $r \leq n$. The supplies of each type of labor are given by

$$\tilde{L}_m = \left(\frac{T-\tau}{T}\right)(1-\mathrm{n}) \quad \text{and} \quad \tilde{L}_s = n - r. \tag{3}$$

Assume that guarding uses output. Each worker spends the faction g of his gross income on guarding the remaining fraction, $1-g$, of his gross income. Let $G \equiv g/(1-g)$. Net of spending on guarding the income of a less educated worker is $W_s/(1+G)$ per period, whereas the income of a more educated worker is $W_m/(1+G)$ per period.

Let θ denote the technology of predation. Assume that each worker consumes the fraction q of this net income, and that predators take the fraction $1-q$, where[3)]

$$q=\frac{1}{1+\theta R/G}. \tag{4}$$

Let C_s denote the lifetime consumption of a less educated worker, where

$$C_s=\frac{q\,T\,W_s}{1+G}. \tag{5}$$

Let C_m denote the lifetime consumption of a more educated worker, where

$$C_m=\frac{q(T-\tau)\,W_m}{1+G}. \tag{6}$$

Let C_p denote the lifetime consumption of a predator, where

$$C_p=\frac{T(1-q)\,Y}{r(1+G)}. \tag{7}$$

To maximize consumption each worker chooses

$$G=\sqrt{\theta R}. \tag{8}$$

With people choosing to be more educated workers, less educated workers, or predators according to which activity yields the higher lifetime consumption, in equilibrium, if there are positive numbers of each type, the fractions of people choosing to be more educated workers, less educated workers, and predators have to be such as to equate C_m, C_s, and C_p. The equalities $C_m=C_s=C_p$ imply

$$1-n=\frac{\sigma}{1+\theta},\quad n-r=\frac{1-\sigma}{1+\theta},\quad \text{and}\quad r=\frac{\theta}{1+\theta}. \tag{9}$$

Equivalently, $C_m=C_s=C_p$ implies[4)]

3) This function is called a "contest success function," which is a generic black box that conceals the process of predation, just as the standard generic production function conceals the process of production. See, for example, Dixit (1987) for the analyses of contests in general.

4) $C_m=C_s$ also implies that in the long run educational inequality becomes

$$\frac{W_m}{W_s}=\frac{T}{T-\tau}.$$

This equation implies that the short run increase in educational inequality caused by an increase in σ reverses in the long run. This result obtains because in the long run individual decisions to become more educated eliminate differences between the lifetime earnings of more educated and less educated workers.

$$\frac{1-n}{n-r}=\frac{\sigma}{1-\sigma} \quad \text{and} \quad R=\theta. \tag{10}$$

These results show that the number of predators, as well as the ratio of predators to workers, depends only on the technology of predation θ, and not on the technology of production σ. Generally speaking, as Hirshleifer (1991) pointed out, the parameter σ has similar effects on the incomes of workers and predators. In this model, however, those effects are exactly offsetting. The ratio of more educated workers to less educated workers depends only on the technology of production σ, and not on the technology of predation θ. The numbers of more educated workers and less educated workers depend on both σ and θ. Specifically, both r and R are increasing in θ, $1-n$ is increasing in σ and decreasing in θ, $n-r$ is decreasing both in σ and in θ, and the ratio of $1-n$ to $n-r$ is decreasing in σ. These results imply that a technology transfer which increases the demand for more educated workers increases the number of more educated workers, decreases the number of less educated workers, and does not affect the number of predators.

III High Ability and Ordinary People

In Section II every person has the same lifetime consumption. To avoid this implication assume that the fraction z of the population has ordinary ability. The fraction $1-z$ of the population has relatively high ability. Assume that a more educated worker with ordinary ability supplies one unit of more educated labor, whereas a more educated worker with high ability supplies α units of more educated labor, where α is larger than one. In the limit as $\alpha\rightarrow 1$, we have the homogeneous case.

Consider an economy in which only a fraction of more educated workers has high ability. Let $W_{mo}=w_m$ represent the earnings per period of more educated workers with ordinary ability and let $W_{mh}=\alpha w_m$ represent the earnings per period of more educated workers with high ability. Ability premium is defined as the ratio of the earnings per period of a more educated worker with high ability to the earnings per period of a more educated worker with ordinary ability:

$$\frac{W_{mh}}{W_{mo}}=\alpha. \tag{11}$$

Equation (11) shows that an increase in α increases ability premium in both the short run and the long run and thus has a bias toward ability.

Let C_{mo} denote the lifetime consumption of a more educated worker with ordinary ability and let C_{mh} denote the lifetime consumption of a more educated worker with relatively high ability. Assuming the Cobb-Douglas technology, the number of more educated workers and the number of less educated workers must be positive in equilibrium because $\lim_{Ls\to 0} w_s=\lim_{Lm\to 0} w_m\to\infty$. In the equilibrium in which only the fraction of more educated workers has relatively high ability, $C_{mh}>C_s=C_p=C_{mo}$ must be satisfied.[5)]

In this economy, lifetime consumption is larger for a more educated worker with high ability than for a more educated worker with ordinary ability, whereas it is the same for a less educated worker and a more educated worker with ordinary ability. All of the workers who choose to remain less educated have ordinary ability, and both high ability workers and ordinary workers can choose to be more educated, with the implication that $n<z$. The supplies of each type of labor are

$$\tilde{L}_m=\left(\frac{T-\tau}{T}\right)(B-n) \quad \text{and} \quad \tilde{L}_s=n-r, \tag{12}$$

where $B\equiv\alpha(1-z)+z$ is a composite of the parameters α and z. The parameter

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5) There are two other possible cases: $C_{mh}=C_s=C_p>C_{mo}$ and $C_{mh}>C_s=C_p>C_{mo}$. In both economies, all of the workers who choose to become more educated have high ability. See Appendix for the equilibrium conditions of each case.

B increases either if α increases or if z decreases.

The lifetime consumption of a more educated worker with ordinary ability is

$$C_{mo}=\frac{q(T-\tau)W_{mo}}{1+G}, \tag{13}$$

and the lifetime consumption of a more educated worker with relatively high ability is

$$C_{mh}=\frac{q(T-\tau)W_{mh}}{1+G}. \tag{14}$$

Equations (5) and (7) show the lifetime consumption of a less educated worker and a predator.

In the long run people choose to be a more educated worker, a less educated worker, and a predator according to which activity yields the higher lifetime consumption. The equality $C_s=C_p$ implies

$$\frac{R}{\sqrt{\theta R}}=\frac{B-r}{1-r}>1. \tag{15}$$

Equation (15) shows that an increase in α increases the ratio of predators to workers whereas an increase in σ does not affect the ratio of predators to workers. Let $r[\theta,B]$ be the solution to equation (15). Since an increase in α increases R, it also increases the number of predators.

The equality $C_{mo}=C_s$ implies

$$\frac{B-n}{n-r}=\frac{\sigma}{1-\sigma}. \tag{16}$$

Equation (16) shows that the parameter σ determines the ratio of efficiency units of more educated labor to efficiency units of less educated labor. Solving equation (16) for n and using $r[\theta,B]$, we obtain the number of less educated workers to be

$$n=(1-\sigma)B+\sigma r[\theta,B]. \tag{17}$$

Equation (17) shows that an increase in α decreases the number of more educated workers but an increase in σ increases the number of more educated workers. The former result obtains because from equation (16), given the number of less educated people, both an increase in α and the associated increase in r increase the ratio of efficiency units of more educated labor to efficiency units of less educated labor. Assuming the complementarity between two types of labor, a relative increase in more educated labor decreases the relative earnings per efficiency units of more educated labor. Hence, in order to recover the equality in equation (16), the numbers of more educated workers must decrease.

Summarizing these results, in the long run an increase in σ increases the number of more educated workers, decreases the number of less educated workers, and does not affect the number of predators. In contrast, an increase in α decreases the number of more educated workers and increases the number of less educated workers and predators.[6] Hence if a technology transfer is education-biased, then it increases the number of workers who choose to be more educated. However if a technology transfer is ability-biased, then it induces some ordinary people to choose to be less productive.

For $C_{mh} > C_s = C_p = C_{mo}$ to be the case, solving $n > z$ and equation (17), the parameters must satisfy

$$(1-\sigma)B + \sigma r[\theta, B] < z. \qquad (18)$$

Note that if z increases, then the left hand side of equation (18) decreases. This analysis then applies to an economy in which a small enough fraction of people has a relatively high ability.

6) If $\theta=0$, then nobody chooses to be a predator. In that economy, Azuma and Grossman (2001) show the following long-run results of educational inequality: An increase in α increases educational inequality whereas, given that $\alpha > 1$, an increase in σ decreases educational inequality.

Summary

Do people in developing countries choose to be more productive in the long run if the countries import the technologies from developed countries ? To answer this question, the paper analyzed within a general equilibrium framework the effect of a technology transfer on the determination of two ratios : the ratio of predators to workers and the ratio of more educated workers to less educated workers. The analyses show that the answer depends on whether a technological transfer is education-biased or ability-biased.

If a technology transfer is education-biased, then it increases the number of more educated workers, decreases the number of less educated workers, and does not affect the number of predators. This result implies that the technology transfer that increases the demand for more educated workers induces more workers to choose to be more educated in the long run. If a technology transfer is ability-biased, then it decreases the number of more educated workers and increases both less educated workers and predators. This result implies that the technology transfer that increases the demand for high ability people discourages some ordinary people to choose to be more productive in the long run.

Appendix

i. $C_{mh}=C_s=C_p>C_{mo}$

Under these conditions all ordinary people and some high ability people are less educated. All more educated workers have high ability. Hence $n>z$. $C_{mh}=C_s$ implies

$$\frac{1-n}{n-r}=\frac{\sigma}{1-\sigma}. \tag{19}$$

$C_s=C_p$ with equations (4) and (19) implies

$$R=\theta. \tag{20}$$

Combining $n>z$ with equations (19) and (20) the parameters must satisfy

$$(1-\sigma)+\sigma\frac{\theta}{1+\theta}>z. \tag{21}$$

ii. $C_{mh}>C_s=C_p>C_{mo}$

Under these conditions all more educated workers have high ability. All high ability people are more educated. Hence $n=z$. Using $C_{mh}>C_s$, $n=z$, and $C_s>C_{mo}$ the parameters must satisfy

$$B(1-\sigma)+\sigma r[\theta,B]>z>(1-\sigma)+\sigma\frac{\theta}{1+\theta}. \tag{22}$$

$C_s=C_p$ implies

$$\frac{R}{\sqrt{\theta R}}=\frac{z-r}{(1-r)(1-\sigma)}. \tag{23}$$

The left-hand-side of equation (23) is larger than one because it is equivalent to

$$z>(1-\sigma)+\sigma r, \tag{24}$$

which holds from equation (22). Hence $R>\theta$.

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