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Research on Effect of Public Education Policy on Economic Growth in China Based on Human Capital Accumulation Model

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Abstract

This paper establishes a human capital accumulation model for both basic education and higher education, and analyses the effect of public education policies on economic growth. The analysis suggests that: the overall increase in public education spending crowds out the overall private education spending and enlarges the share of basic education in household budget; the increase in public spending on basic education may stimulate the private spending on both stages of education, and brings about greater public spending on higher education. Through the empirical research on the relevant data of China, it is revealed that the economic growth of China is mainly driven by physical capital accumulation, but the economic growth effect of education investment, especially basic education investment, must not be ignored. Moreover, the public policies favouring basic education investment has significant positive effect on the economic growth, while the expansion of higher education enrolment has negative effects.

Keywords

Public education policy, Human capital accumulation, Economic growth.

1. Introduction

As a longstanding matter of concern, the impact of public education policy on economic growth is often analysed in the context of the endogenous growth theory. Uzawa-Lucas model or overlapping generations (OLG) model are two of the most commonly used models in the

theoretical analysis. The key to the analysis lies in the input-output relationship between education investment and human capital accumulation. Despite the agreement among theoretical analyses, there is yet no coincident conclusion on the input-output relationship in empirical studies. Some scholars discovered that a rise in public education spending may stimulate human capital accumulation, and, in turn, boost economic growth [1-2]. Tournemaine and Tsoukis suggested that the relationship curve between public education spending and economic growth is not linear but in the shape of an inverted-U [3]. However, some other scholars argued that public education spending makes a very limited, and even negative, contribution to economic growth [4-6].

The real-world education system involves multiple stages, each of which has its unique connotations and emphasis, making the human capital accumulation heterogeneous among the stages. Owing to the difference in knowledge level and structure, there is a great deal of difference among those from different educational backgrounds. In recent years, a number of scholars have started to analyse how the allocation of public spending across different education stages affects human capital accumulation and economic growth [7-10]. Among them, Su constructed a successive generations model for people with heterogenous initial qualifications, and utilized the model to explore the economic growth and inequality impacts from public education spending [8]. The result shows that funding basic education is constrained by a lower bound, and funding higher education brings Pareto improvement to the initial qualifications of the entire population and the scale of public education spending. Probing into the combination of free compulsory education and subsidized higher education, Blankenau argued that the basic education should be allocated with all available resources in the early phase of development, while the higher education should be funded in part by the government in the later phase [9]. Artige and Cavenaile concluded that the economic growth effect of public education spending hinges on both the scale of spending and the composition of human capital [11]. Exploring the 1992-2002 panel data on the states in the US, Deskins et al. suggested that public education spending has a significant negative impact on economic growth [12]; if the basic education is funded inadequately, the overdevelopment of higher education will only hinder economic development. Zhou and Li (2012) analysed the 1996-2009 provincial-level panel data in China, revealing that public spending on basic education has a significant positive effect on economic growth while the effect of public spending on higher education is uncertain. Based on the research above, policymakers must rationalize both the size and composition of public spending across different education stages. This requires a better funding balance between basic and higher education.

Education is both a merit good and an impure public good. Therefore, it should be funded by the government, but only partially. The public funding of education should be supplemented with the education investment of the private sector. The public investment in education aims to maximize the social welfare, and depends mainly on the economic level and education demand of the citizens. By contrast, the education investment of the private sector focuses on the expected rate of return, seeking to maximize utility and life-cycle income. To achieve the different investment objectives, the government and the private sector may focus on different aspects of education. In this case, the human capital accumulation efficiency and human capital stock in each stage of education are under the influence of the size and structure of public and private education investments. Focusing on the provincial-level panel data in China, Qian et al. held that public education investment is more effective in the stage of basic education [13], while the private education investment is preferable in the stage of higher education. Arcalean and Schiopu discovered that increasing public education spending can crowd out private education spending and enlarge the share of resources allocated to basic education, and prioritizing basic education in the allocation of public resources is conducive to economic growth [10]. Gamlath and Lahiri observed that the economic growth is positively correlated with the mutual substitutability between public and private education investments [14]. After analysing the data in rural areas of Zambia and India, Das et al. learned that rural households spend less on textbooks and learning materials when the public spending is expected to rise. Based on the survey data on Chinese urban households [15], Yuan and Zhang pointed out that high public education spending may supress household spending, as evidenced by the significant reduction in school tuition [16]. The existing research on the relationship between public and private education investments mainly focuses on whether public education spending crowds in or crowd out the private education spending on the overall level or in a specific education stage. Rarely has any scholars investigated the interaction between the public and private education investments at different education stages.

At present, higher educational resources are too scarce to meet the demand of Chinese citizens. The enrolment rate of higher schools, an indicator of the popularity of higher education, indirectly affects the household investment in higher education. Through the analysis of a hierarchical education system, Guo and Jia discovered that families from different educational background compete to spend more on basic education so that their children have more chances to enjoy higher education [17]; the competition directly bears on the human capital accumulation of their children. Arcalean and Schiopu considered the scarcity of higher education resources [10], and developed a long-term endogenous solution called the equilibrium enrolment rate. However, the solution does not apply to China, where the enrolment rate of higher education is exogenous

and prescribed by the government.

In light of the above, this paper attempts to explain the public and private resource allocation across different education stages, and disclose the implications of public education policies to household decision on education spending, human capital accumulation and economic growth. For this purpose, the author created a hierarchical education system model that incorporates the public spending on both basic and higher educations, and the household decisions on education enrolment, education budget and resource allocation across the stages.

The remainder of this paper is organized as follows. Chapter 2 sets up the model and derives analytical results. Chapter 3 analyses the impacts of policy parameter variations on private resource allocation across education stages. Chapter 4 outlines the empirical model and performs the regression analysis. Chapter 5 wraps up the research with some meaningful conclusions.

2. Modelling

The OLG model was built on a closed economy populated by N identical households, a representative company, and a government. To keep the population constant, a household has a young agent (child) and an adult agent (parent) in each stage.

2.1 Government

The government levies on the total income Y_t at the tax rate τ_t and spends a fraction of the tax revenue on public education G_t. $G_t = \Theta_t \cdot Y_t \ (\Theta_t < \tau_t)$, where Θ_t is the share of the total income allocated to public education. Denote θ_t as the fraction of total public education spending diverted to the basic education and 1-θ_t as the fraction diverted to higher education. Then, the public education investments at the basic and higher education stages are respectively expressed as:

$$g_{b,t} = \theta_t \cdot \frac{G_t}{N} = \theta_t \cdot \Theta_t \cdot \frac{Y_t}{N} \quad (1)$$

$$g_{h,t} = (1-\theta_t) \cdot \frac{G_t}{\Pi_t \cdot N} = (1-\theta_t) \cdot \Theta_t \cdot \frac{Y_t}{\Pi_t \cdot N} \quad (2)$$

where $g_{b,t}$ and $g_{h,t}$ are the public education investments per student at the basic and higher education stages, respectively; Π_t is the enrolment rate of higher education.

2.2 Production Sector

The representative company produces the final goods based on physical capital and human

capital. The production function is:

$$Y_t = \mathrm{A} \cdot H_{b,t}^{\alpha_1} \cdot H_{h,t}^{\alpha_2} \cdot K_t^{1-\alpha_1-\alpha_2} \quad (3)$$

where $\mathrm{H_{b,t}}$ and $\mathrm{H_{h,t}}$ are the aggregate supplies of unskilled and skilled labours; α_1, α_2 and $1-\alpha_1-\alpha_2$ are the output elasticities of $\mathrm{H_{b,t}}$, $\mathrm{H_{h,t}}$ and $\mathrm{K_t}$, respectively. Thus, the aggregate supplies of unskilled and skilled labours can be separately described as $\mathrm{H_{b,t}} = (1-\Pi_t)\cdot \mathrm{N}\cdot \mathrm{h_{b,t}}$ and $\mathrm{H_{h,t}} = (1-\mathrm{u})\cdot \Pi_t \cdot \mathrm{N}\cdot \mathrm{h_{h,t}}$, where $\mathrm{h_{b,t}}$ and $\mathrm{h_{h,t}}$ represent the human capital stock at the basic and higher education stages, respectively, and u is the exogenous fraction of the working hours that an adult must give up to finish college.

To maximize the profit, the representative company has to carefully arrange the amount of skilled labour, unskilled labour and physical capital at each stage. The equilibrium rate of return on physical capital $1+\mathrm{r_t} = (1-\alpha_1-\alpha_2)\cdot(\mathrm{Y_t}/\mathrm{N})$, unskilled labourer's wage $\mathrm{w_{b,t}} = \alpha_1 \cdot (\mathrm{Y_t}/\mathrm{H_{b,t}})$ and skilled labourer's wage $\mathrm{w_{h,t}} = \alpha_2 \cdot (\mathrm{Y_t}/\mathrm{H_{h,t}})$. The skilled labourer refers to those who have accomplished higher education, while the unskilled labourer stands for those who only received basic education.

2.3 Households

As mentioned previously, each household has an adult agent engaged in economic activities and a young agent receiving basic education. The human capital accumulation is a two-stage process: the compulsory basic education (i.e. primary education and secondary education) and the optimal higher education. The higher education resources are so scare that only a fraction of young agents receive higher education.

(1) The Young Agent

The young agent devotes all the time to receiving basic education. At the stage of basic education, the human capital accumulation relies on the per capital public and private education investment. Public education spending is externalized as educational service, which is not a pure public good but a merit good. The educational service that each young agent enjoys is affected by the size of public education spending and the number of students. Under the combined effect of the large school-age population and the paucity of education resources, almost every school of basic education in China is thronged with students. To depict the congestion situation in basic education, the $\mathrm{N}^{\Phi_b}\cdot \mathrm{g_{b,t}}$ was introduced as the congestion coefficient of basic education, where $\Phi_b \in [0,1]$ is valued 1 if the basic education service is purely public, 0 if the basic education service is purely private, and between 0 and 1 if the basic education service is predominantly private or public. Hence, the human capital accumulation in the stage of basic education can be

expressed as:

$$h_{b,t+1} = B_1 \cdot \left(e_{b,t}\right)^{\rho} \cdot \left(N^{\Phi_b} \cdot g_{b,t}\right)^{1-\rho}, B_1 > 0, \rho \in (0,1) \quad (4)$$

where $e_{b,t}$ and $g_{b,t}$ are the public and private investments per student in basic education, respectively; B_1 and ρ are the productivity parameter and the human capital accumulation elasticity of $e_{b,t}$.

After finishing the compulsory basic education, the young agent has to decide whether to pursue higher education. Blankenau assumed that an agent prefers to earn a degree in higher education if the present value of the higher education output exceeds the private cost of college [9]. Under the condition of perfect information symmetry and market competition, the human capital output between labourers from different educational backgrounds will disappear in the long run. According to Blankenau, young agents of the same generation normally acquire the same amount of human capital, and decide whether to attend college by comparing the income of skilled and unskilled labourers [9]. In addition, it is assumed that each agent may refer to the decisions of others in the decision-making process. Given the public policies, income levels of the skilled and unskilled labourers, and the proportion of skilled labourers in his/her generation Π_t, the probability that a young agent decides to pursue higher education and become a skilled labourer is expressed as:

$$\pi_t \begin{cases} = 0, & I_{b,t} > I_{h,t} \\ \in (0,1), & I_{b,t} = I_{h,t} \\ = 1, & I_{b,t} < I_{h,t} \end{cases} \quad (5)$$

where $I_{b,t}$ and $I_{h,t}$ are the lifetime labour incomes of unskilled and skilled labourer, respectively. The two incomes are calculated as: $I_{b,t} = w_{b,t} \cdot h_{b,t}$ and $I_{h,t} = (1-u) \cdot w_{h,t} \cdot h_{h,t}$. The young agent decides to become a skilled labourer if the skilled labourer earns more than the unskilled labourer; otherwise, the young agent decides to remain unskilled. The decision is randomized if there is no income gap between skilled and unskilled labourers. Most of the existing studies have shown that public and private education investments are complementary in basic education, and substitutable in higher education. In view of the above, the human capital of a college educated agent is:

$$h_{h,t+1} = B_2 \cdot \left(h_{b,t+1}\right)^{\gamma} \cdot \left[e_{h,t} + (N \cdot \Pi_{t+1})^{\Phi_h} \cdot g_{h,t}\right]^{1-\gamma}, B_2 > 0, \gamma \in (0,1) \quad (6)$$

where $e_{h,t}$ and $g_{h,t}$ are the public and private investments per student in higher education,

respectively; B_2 and γ are the productivity parameter and the human capital accumulation elasticity of $h_{b,t+1}$. The congestion coefficient of higher education Φ_h was introduced, as the higher education also faces limited resources.

(2) The Adult Agent

As mentioned in Section 2.3.1, the probability that a young agent decides to become a skilled labourer is π_t. After completing human capital accumulation, every adult agent enters the production sector and earns the labour income. The disposable income is consumed, deposited or spent on education for his/her child in the two stages of education. Thus, the budge of the adult agent is constrained by the following factors:

$$c_{b,t} + s_{b,t} + e_{b,t} = (1 - \tau_t) \cdot I_t \tag{7}$$

$$c_{h,t} + s_{h,t} + e_{b,t} + e_{h,t} = (1 - \tau_t) \cdot I_t \tag{8}$$

where $c_{b,t}$ and $c_{h,t}$ are the consumption levels of a parent with an unskilled and a skilled child, respectively; $s_{b,t}$ and $s_{h,t}$ are the corresponding savings in these two scenarios. If the child has only completed basic education, the budget of the adult agent is constrained by the factors in (7). If the child has completed higher education, the budget of the adult agent is constrained by the factors in (8). The budget constraints of a retired adult agent are expressed as follows:

$$c_{b,t+1} = (1 + r_{t+1}) \cdot s_{b,t} \tag{9}$$

$$c_{h,t+1} = (1 + r_{t+1}) \cdot s_{h,t} \tag{10}$$

where $c_{b,t+1}$ and $c_{h,t+1}$ are the consumption levels of a retired parent with an unskilled and a skilled child, respectively.

For simplicity, the decision variables of the adult agent are defined as follows:

$$e_{b,t} = \epsilon_{b,t} \cdot (1 - \tau_t) \cdot I_t = \eta_t \cdot \Psi_t \cdot (1 - \tau_t) \cdot I_t \tag{11}$$

$$e_{h,t} = \epsilon_{h,t} \cdot (1 - \tau_t) \cdot I_t = (1 - \eta_t) \cdot \Psi_t \cdot (1 - \tau_t) \cdot I_t \tag{12}$$

$$c_{b,t} = \kappa_t \cdot (1 - \tau_t) \cdot I_t \text{ or } c_{b,t} = \kappa'_t \cdot (1 - \tau_t) \cdot I_t \quad (13)$$

where τ_t is the constant income tax rate; $\epsilon_{b,t}$ and $\epsilon_{h,t}$ are the fractions of disposable income allocated to the two stages of education, respectively. Define κ_t and κ'_t as the fractions of disposable income consumed by the adult agent with an unskilled and a skilled child, respectively. Besides, define Ψ_t as the share of disposable income spent on education, and η_t as the fraction of total private education investment spent on basic education.

Given the constant tax rate τ_t, the probability that a young agent decides to become a skilled labourer π_t, and the public education investments per student at stage $g_{b,t}$ and $g_{h,t}$, respectively, the probability that the adult agent maximizes the expected utility can be derived from consumption and the human capital acquired by his/her child:

$$\begin{aligned} \max U = {} & (1 - \pi_{t+1}) \cdot \left[\ln c_{b,t} + \mu_1 \cdot \ln c_{b,t+1} + \mu_2 \cdot \ln h_{b,t+1}\right] \\ & + \pi_{t+1} \cdot \left[\ln c_{h,t} + \mu_1 \cdot \ln c_{h,t+1} + \mu_2 \cdot \ln h_{h,t+1}\right] \\ & \text{s.t. (4), (6), (7), (8), (9) and (10).} \end{aligned} \quad (14)$$

where μ_1 is the discount rate of future consumption; μ_2 is the utility weight the parent acquires from the human capital of his/her child.

2.4 Competitive Equilibrium

Given the public policies $\{\tau_t, \theta_t, \Theta_t, g_{b,t}, g_{h,t}, \Pi_t\}$, a competitive equilibrium is a set of allocations $\{c_{b,t}, c_{h,t}, e_{b,t}, e_{h,t}, \pi_{t+1}, K_{t+1}, H_{b,t+1}, H_{h,t+1}\}$ and a set of factor prices $\{w_{b,t}, w_{h,t}, r_t\}$ that obey the following preconditions:

1. The probability that a young agent decides to pursue higher education satisfies (5) at the given enrolment rate of higher education Π_t, wages $w_{b,t}$ and $w_{h,t}$, private education expenditure $e_{b,t}$ and $e_{h,t}$, and public investments $g_{b,t}$ and $g_{h,t}$.

2. The individual and aggregate decisions are in equilibrium: $\pi_t = \Pi_t$;

3. The household problem is solved by $\{c_{b,t}, c_{h,t}, e_{b,t}, e_{h,t}, \pi_{t+1}\}$ at the given factor prices and the policies;

4. The company problem is solved by $\{H_{b,t+1}, H_{h,t+1}\}$;

5. The public budget constraint is satisfied;

6. The physical capital in the market satisfies: $K_{t+1} = (1 - \Pi_t) \cdot N \cdot s_{b,t} + \Pi_t \cdot N \cdot s_{h,t}$.

Substituting (11), (12) and (13) into (14), it is possible to obtain how much share of the disposable income should be consumed in working age and in retirement (κ_t, κ'_t) and how much

should be spent on education at the two stages$(\epsilon_{b,t}, \epsilon_{h,t})$ to achieve the maximum utility:

$$\kappa_t = \frac{1}{1+\mu_1} \cdot \left(1 - \epsilon_{b,t}\right) \tag{15}$$

$$\kappa_t' = \frac{1}{1+\mu_1} \cdot \left(1 - \epsilon_{b,t} - \epsilon_{h,t}\right) \tag{16}$$

$$\frac{\mu_2 \cdot \rho}{\epsilon_{b,t}} \cdot [1 - \Pi_{t+1} \cdot (1-\gamma)] = \frac{(1-\Pi_{t+1}) \cdot \mu_1}{1-\kappa_t - \epsilon_{b,t}} + \frac{\Pi_{t+1} \cdot \mu_1}{1-\kappa_t' - \epsilon_{b,t} - \epsilon_{h,t}} \tag{17}$$

$$\frac{\mu_1}{1-\kappa_t' - \epsilon_{b,t} - \epsilon_{h,t}} = \frac{\mu_2 \cdot (1-\gamma) \cdot (1-\tau_t)}{\epsilon_{h,t} \cdot (1-\tau_t) + (N \cdot \Pi_{t+1})^{\Phi_h} \cdot \frac{(1-\theta_t) \cdot \Theta_t}{\Pi_{t+1} \cdot (\alpha_1 + \alpha_2)}} \tag{18}$$

To find the equilibrium solution of the decision variables, we have to solve the equilibrium enrolment rate Π_{t+1}. Since the college enrolment rate equals the probability that a young agent decides to pursue higher education, the equilibrium enrolment rate can be derived from the no-income-gap scenario: $w_{b,t} \cdot h_{b,t} = (1-u) \cdot w_{h,t} \cdot h_{h,t}$. The equilibrium enrolment rate is obtained based on wages and aggregate supplies of skilled and unskilled labours:

$$\Pi_t = \Pi = \frac{\alpha_1}{\alpha_1 + \alpha_2}, \forall t > 0 \tag{19}$$

2.5 Balance Growth

The balance growth means that the output, physical capital and two types of human capitals grow at the same constant rate, and the share $\{\Theta_t, \theta_t, \Psi_t, \eta_t\}$ is constant. Substituting (11), (12) and (13) into (4) and (6), we can obtain the human capitals accumulated at basic and higher education stages, respectively:

$$h_{b,t+1} = B_1 \cdot \left[\epsilon_{b,t} \cdot (1-\tau_t) \cdot (\alpha_1 + \alpha_2)\right]^{\rho} \cdot (N^{\Phi_b} \cdot \theta_t \cdot \Theta_t)^{1-\rho} \cdot y_t \tag{20}$$

$$\begin{aligned} h_{h,t+1} = B_2 \cdot \left\{B_1 \cdot \left[\epsilon_{b,t} \cdot (1-\tau_t) \cdot (\alpha_1 + \alpha_2)\right]^{\rho} \cdot (N^{\Phi_b} \cdot \theta_t \cdot \Theta_t)^{1-\rho}\right\}^{\gamma} \\ \cdot \left[\epsilon_{h,t} \cdot (1-\tau_t) \cdot (\alpha_1 + \alpha_2) + (N \cdot \Pi_{t+1})^{\Phi_h} \cdot (1-\theta_t) \cdot \Theta_t\right]^{1-\gamma} \cdot y_t \end{aligned} \tag{21}$$

Combining (3) and the aggregate supplies of unskilled and skilled labours, we have:

$$\begin{aligned} y_{t+1} = A \cdot \left[(1-\Pi) \cdot h_{b,t+1}\right]^{\alpha_1} \cdot \left[(1-u) \cdot \Pi \cdot h_{h,t+1}\right]^{\alpha_2} \\ \left[(1-\Pi) \cdot s_{b,t} + \Pi \cdot s_{h,t}\right]^{1-\alpha_1-\alpha_2} \end{aligned} \tag{22}$$

Plugging (20) and (21) into (22), it is possible to acquire the economic growth rate:

$$g_t = \frac{y_{t+1}}{y_t} = \Omega \cdot [\epsilon_b \cdot (1-\tau) \cdot (\alpha_1 + \alpha_2)]^{\rho \cdot (\alpha_1 + \alpha_2 \cdot \gamma)} \cdot (N^{\Phi_b} \cdot \theta \cdot \Theta)^{(1-\rho) \cdot (\alpha_1 + \alpha_2 \cdot \gamma)} \cdot \{[(1-\Pi) \cdot (1-\epsilon_b - \kappa) + \Pi \cdot (1-\kappa' - \epsilon_b - \epsilon_h)] \cdot (1-\tau) \cdot (\alpha_1 + \alpha_2)\}^{1-\alpha_1-\alpha_2} \left[\epsilon_{b,t} \cdot (1-\tau) \cdot (\alpha_1 + \alpha_2) + (N \cdot \Pi)^{\Phi_h} \cdot (1-\theta) \cdot \Theta\right]^{\alpha_2 \cdot (1-\gamma)} \quad (23)$$

where $\Omega = \mathrm{A} \cdot B_1^{\alpha_1 + \alpha_2 \cdot \gamma} \cdot B_2^{\alpha_2} \cdot (1-\Pi)^{\alpha_1} \cdot [(1-u) \cdot \Pi]^{\alpha_2}$.

3. Equilibrium Solution and Comparative Static Analysis

3.1 Equilibrium Solution

Given all public policies, Proposition 1 lays down the conditions for the existence of interior solution.

Proposition 1. For all public policy allocations $\tau<\Theta<0$ and $0<\theta<1$, there exist unique private education spending allocations $\epsilon_{b,t}$ and $\epsilon_{h,t}$. Moreover, $\mu_2 > \bar{\mu}_2$ is a sufficient and necessary condition for the existence of interior solution.

$$\bar{\mu}_2 = \frac{(1+\mu_1) \cdot (N \cdot \Pi)^{\Phi_h} \cdot \frac{(1-\theta) \cdot \Theta}{\Pi \cdot (\alpha_1 + \alpha_2)}}{(1-\gamma) \cdot (1-\tau) - (1+\mu_1) \cdot (N \cdot \Pi)^{\Phi_h} \cdot \frac{(1-\theta) \cdot \Theta}{\Pi \cdot (\alpha_1 + \alpha_2)}} \quad (24)$$

(1) If $\mu_2 \leq \bar{\mu}_2$, then

$$\epsilon_b = \frac{\mu_2 \cdot \rho \cdot [1 - \Pi \cdot (1-\tau)]}{(1+\mu_1) + \mu_2 \cdot \rho \cdot [1 - \Pi \cdot (1-\tau)]}, \ \epsilon_h = 0 \quad (25)$$

(2) If $\mu_2 > \bar{\mu}_2$, then ϵ_b can be obtained by the following equation:

$$\frac{n}{\epsilon_b} = \frac{m_1 - z_1 \cdot \epsilon_b}{(1-\epsilon_b) \cdot (m_2 - z_2 \cdot \epsilon_b)} \quad (26)$$

where $m_1 = 1 - \frac{(1-\Pi) \cdot [\mu_2 \cdot (1-\gamma) \cdot (1-\tau) - q]}{(1-\tau) \cdot [1 + \mu_1 + \mu_2 \cdot (1-\gamma)]}$, $m_2 = 1 - \frac{\mu_2 \cdot (1-\gamma) \cdot (1-\tau) - q}{(1-\tau) \cdot [1 + \mu_1 + \mu_2 \cdot (1-\gamma)]}$,

$z_1 = 1 - \frac{(1-\Pi) \cdot \mu_2 \cdot (1-\gamma)}{1 + \mu_1 + \mu_2 \cdot (1-\gamma)}, z_2 = 1 - \frac{\mu_2 \cdot (1-\gamma)}{1 + \mu_1 + \mu_2 \cdot (1-\gamma)}$,

$n = \frac{\mu_2 \cdot \rho \cdot [1 - \Pi \cdot (1-\tau)]}{1 + \mu_1}, q = (1+\mu_1) \cdot (N \cdot \Pi)^{\Phi_h} \cdot \frac{(1-\theta) \cdot \Theta}{\Pi \cdot (\alpha_1 + \alpha_2)}$

ϵ_h can be obtained by the following expression:

$$\epsilon_h = \frac{\mu_2 \cdot (1-\gamma) \cdot (1-\tau) \cdot (1-\epsilon_b) - (1+\mu_1) \cdot (N \cdot \Pi)^{\Phi_h} \cdot \frac{(1-\theta) \cdot \Theta}{\Pi \cdot (\alpha_1 + \alpha_2)}}{(1-\tau) \cdot [1 + \mu_1 + \mu_2 \cdot (1-\gamma)]} \quad (27)$$

If the adult agent is not very altruistic ($\mu_2 \leq \bar{\mu}_2$), he/she may be reluctant to cover the cost of higher education for the child. Then, the higher education will be entirely financed by the government, due to the substitutability between the public and private education investments. If the adult agent is sufficiently altruistic, he/she will allocate private resources to higher education.

If (25) holds, a household is only willing to cover the cost of basic education, and its spending is no longer a function of education policies; if (24) holds, the size and structure of public education spending exert an impact on those of private education spending, indicating that both ϵ_b and ϵ_h are functions of θ and Θ. Moreover, the adult agent is more willing to spend money on higher education if a smaller share of the aggregate public spending is spent on basic education, because the latter brings about a higher enrolment rate and a weaker congestion situation in higher education.

According to (27), a household is more likely to invest in higher education if the aggregate public spending Θ and the share of public spending on higher education θ are sufficiently low. Besides, the probability of private investment is in basic education is proportional to the elasticity of private spending per student ρ in human capital accumulation at the basic education stage. The same holds for the elasticity of private spending $(1-\gamma)$ in the human capital accumulation at the stage of higher education.

3.2 Comparative Static Analysis

This section carries out a comparative static analysis of (26) and (27) in an attempt to ascertain how the household decision-making on allocating a share of income on education varies with the total public education spending Θ, public spending structure θ and the tax rate τ.

Proposition 2. Given θ and τ, we can get the following by changing the total public education spending Θ: $\frac{\partial \Psi}{\partial \Theta} < 0, \frac{\partial \epsilon_b}{\partial \Theta} < 0, \frac{\partial \epsilon_h}{\partial \Theta} < 0, \frac{\partial \eta}{\partial \Theta} < 0$

Hence, an increase in the total public education spending (Θ) drags down the private investment on education, and pushes a greater share of total private spending towards basic education. Under the fixed share of public education spending θ, a higher public budget Θ leads to more public spending across the education stages, because public and private education investments are complementary in basic education and are substitutable in higher education.

Then, the accumulation functions of the two kinds of human capitals were combined to identify the marginal output of the factors. It is concluded that more public spending on basic education promotes the human capital accumulation efficiency of private spending on basic education, while more public spending on higher education lowers the human capital

accumulation efficiency of both private spending and total education resources on higher education. Thus, the household is more likely to invest in basic education, resulting an increase in η.

The complementarity in basic education, combined with the substitutability in higher education, means the overall investments on the two types of educations are interchangeable. Therefore, the overall private education spending Ψ goes down as Θ increases. Moreover, as the overall human capital increases with Θ, leading to a decline in its marginal product and marginal utility, and then the decrease in Ψ.

Proposition 3. Given Θ and τ, we can get the following by changing the share of public spending on basic education θ: $\frac{\partial \Psi}{\partial \theta} > 0, \frac{\partial \epsilon_b}{\partial \theta} > 0, \frac{\partial \epsilon_h}{\partial \theta} > 0, \frac{\partial \eta}{\partial \theta} < 0$

Given the size of public budget for education, a higher share of public spending on basic education not only betters the basic education quality, but also improves the human capital accumulation efficiency of private spending on basic education, creating a favourable environment for human capital accumulation of unskilled labour. In this scenario, the households are willing to allocate a larger share of their income to basic education.

The increase of public spending on basic education affects ϵ_h in two ways. First, human capital accumulation in higher education becomes more efficient with the growth in the human capital stock of unskilled labour. Second, a higher share of public spending on basic education leads to the drop of public spending on higher education, provided that the public budget for education is fixed. Based on the principle of diminishing marginal product and the substitutability between public and private investments in higher education, the decline in public spending on higher education is bound to improve the human capital accumulation efficiency of private spending on higher education. Both kinds of impacts can stimulate the private spending on higher education.

Then, the increase of private spending on basic education influences η both directly and indirectly. On the on hand, the decline of 1-θ (the rise of θ) implies that fewer public investments are available in higher education, given the constant size of public budget for education, forcing households to cut down η. On the other hand, the growth in θ expands the human capital stock in basic education, pushes up the marginal productivity of private investment in higher education, and, in turn, lowers the value of η. In short, the direct and indirect impacts reinforce each other, causing the equilibrate decline of *c*.

Proposition 4. Given Θ and θ, we can get the following by changing the tax rate τ: $\frac{\partial \Psi}{\partial \tau} < 0, \frac{\partial \epsilon_b}{\partial \tau} < 0, \frac{\partial \epsilon_h}{\partial \tau} < 0, \frac{\partial \eta}{\partial \tau} > 0$

At a high tax rate, a household has a small disposable income, and is less willing to invest in education in either stage. In the meantime, a high tax rate forces the household to allocate more resources to basic education, where private resources can yield more human capital and has higher utility.

4. Case Study and Regression Analysis

This chapter estimates the impact of education investments and public policies on economic growth based on 1997~2013 time series data in China, and verifies some of the conclusions drawn from the model. All of the original data were extracted from the *Statistical Yearbook of China*, the *China Labour Statistical Yearbooks*, and the National Statistics Database.

According to (23), the economic growth is directly influenced by physical capital and human capital, and human capital accumulation is the result of education investment. In this research, the human capital is either acquired by unskilled labourers or skilled labourers, and the education spending is divided into basic education spending and higher education spending. The education investment comes from both the government and the households. The total education spending at each stage equals the sum of public and private investments. Ranging from public resource allocation to higher education enrolment rate, the public policies influence the economic growth indirectly via the human capital accumulation. Based on these preconditions, we construct the following regression function:

$$\Delta y_t = a_0 + a_1 \cdot \Delta k_t + a_2 \cdot \Delta exp_t^b + a_3 \cdot \Delta exp_t^h + a_4 \cdot \Delta pctG_t + a_5 \cdot \Delta rtoS_t + \varepsilon_t \quad (28)$$

where the Δy_t is the increment of real GDP per capita; Δk_t is the increment of per-capita physical capital calculated by perpetual inventory method; Δexp_t^b and Δexp_t^h are increments of education spending per student at the basic education stage and higher education stage, respectively; $\Delta pctG_t$ is the variation in the public education spending structure, i.e. the ratio of government education spending on basic education to the total government education spending on both stages; $\Delta rtoS_t$ is the variable in higher education enrolment rate, measured by the ratio of the number of student admitted to higher education institutions to national employment. Δy_t is the dependent variables, and other parameters are independent variables.

The independent variables were subject to simple regression in (28) one after another. The regression results show that all of independent variables, except the per-student public spending on higher education, have significant impact on economic growth, and the signs of the estimated values are consistent with those derived by the theoretical model. The positive influencing factors

on economic growth include physical capital accumulation, increase in per-capita spending on basic education, and increase in the share of total public spending on basic education, and the negative influencing factor is the expansion of enrolment in higher education.

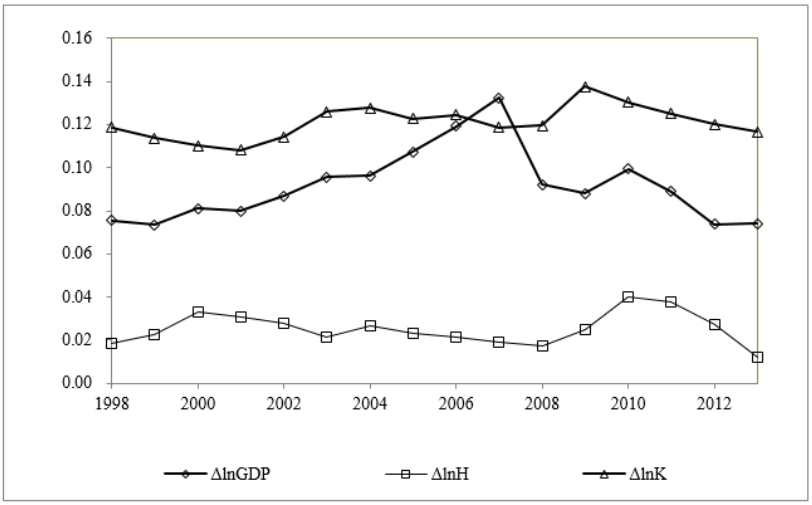

Fig.1. The Growth Rate of GDP, the Accumulation of Physical and Human Capital

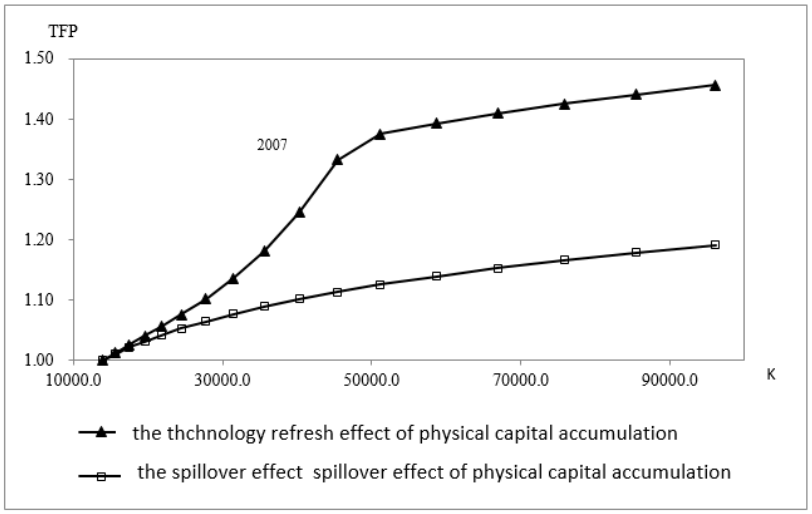

Fig.2. The Technology Refresh Effect and Spillover Effect of Physical Capital Accumulation

As shown in Table 1, column 1 reports the estimated response of multiple regressions. The regression result is unsatisfactory: physical capital has an insignificant negative output effect and the output effect of per-student spending on basic education is also insignificant. This is because the regression overlooks the output variation with the total factor productivity (TFP). The TFP growth is a determinant on economic growth, other than the accumulation of physical and human capitals. Figure 1 shows that the GDP had maintained a greater order of integration than physical and human capital accumulations until 2007 in China. This means the rapid economic growth in

China from 1997 to 2007 is closely related to the TFP growth. Whereas the TFP has not increased substantially since 2007, Feng held that human capital accumulation had an insignificant impact on the TFP, and the TFP growth benefited from the "reform bonus" and "learning in investing" before 2007 in China [18]. Thus, the TFP growth rate is not a constant. The dummy variable Dum_t^{TFP} (0 for 1997~2007 and 1 for the other years) was introduced to depict the end of the remarkable TFP growth in 2007. According to Figure 2, 2007 is the turning point in the technology refresh effect of physical capital accumulation; The effect was significant before 2007, but was drastically weakened after that year. On this basis, the interaction term $Dum_t^{TFP} \cdot \Delta k_t$ was introduced to illustrate the effect of physical capital accumulation on TFP growth, and another dummy variable Dum_t^{FC} was introduced to depict the large decline in per-capita GDP in 2008 and 2009 due to the US financial crisis.

Through the above analysis, the regression function (28) can be rewritten as:

$$\Delta y_t = a_0 + a_1 \cdot \Delta k_t + a_2 \cdot \Delta exp_t^b + a_3 \cdot \Delta exp_t^h + a_4 \cdot \Delta pctG_t + a_5 \cdot \Delta rtoS_t + a_6 \cdot Dum_t^{TFP} + a_7 \cdot Dum_t^{TFP} \cdot \Delta k_t + a_8 \cdot Dum_t^{FC} + \varepsilon_t \quad (29)$$

According to the estimated result of (29) in column 2 of Table 1, both the estimated physical capital and estimated public spending on basic education are significant at the 5% level after introducing two dummy variables and one interaction term; the estimated values of the dummy variables and the interaction term are significant and their signs are as expected. Nevertheless, the regression results are still unsatisfactory because of the significant negativity of the higher education spending, and the insignificance of the public education spending structure and the higher education enrolment rate.

Some of the estimated values are insignificant owing to the high correlation between $\Delta pctG_t$ and $\Delta rtoS_t$. In Table 2, column 1 records the regression of $\Delta pctG_t$ on $\Delta rtoS_t$. The results demonstrate that the expansion of higher education enrolment narrows down the share of public spending on basic education (R^2=0.75). With the increase of enrolment rate, the government has to provide more financial support to higher education to ensure teaching quality. Columns 2 and 3 present the regressions of Δk_t on $\Delta pctG_t$ and on $\Delta rtoS_t$, respectively. It can be seen that Δk_t has a high positive correlation with $\Delta pctG_t$ and a high negative correlation with $\Delta rtoS_t$. There might be multicollinearity in the regression if some variables with strong correlation are added in regression function. Since the behaviour of $\Delta pctG_t$ can be partly explained by $\Delta rtoS_t$, $\Delta pctG_t$ and $\Delta rtoS_t$ were added separately in the regression function to eradicate multicollinearity in the two regressions. As shown in columns 3 and 4, the dependent

variables $\Delta pctG_t$ and $\Delta \mathrm{rtoS_t}$ are retained in the regression function, respectively. Compared to the column 1, columns 3 and 4 show better goodness of fit; all independent variables are significant at least at the significance level of 5%, and the signs of them are as expected. The results of the two regressions verify the effectiveness of the proposed model, and provide good explanations to the economic growth in China over the past decade.

Tab.1. Economic Growth Effect of Educational Investment

explanatory variable	Explained variable： Δy_t			
	(1)	(2)	(3)	(4)
Δk_t	-0.1465	0.7617*	0.3787**	0.4928***
	(0.0872)	(0.2255)	(0.0802)	(0.0464)
Δexp_t^b	0.0050	0.1495*	0.1523*	0.1490*
	(0.1031)	(0.0534)	(0.0612)	(0.0552)
Δexp_t^h	0.0104*	-0.0014 ·	0.0042*	0.0025*
	(0.0043)	(0.0034)	(0.0015)	(0.0012)
$\Delta pctG_t$	956.4685**	-399.4967	171.1403*	
	(227.7289)	(328.3124)	(67.2655)	
$\Delta rtoS_t$	10834.9265*	-9092.4540		-3069.3778*
	(3982.9226)	(5088.6249)		(1220.1219)
Dum_t^{TFP}		5385.1213***	4378.5347**	4669.782***
		(895.9168)	(798.3347)	(698.8936)
Dum_t^{FC}		-3662.8358**	-3263.3768*	-3368.3551**
		(898.7293)	(997.5438)	(894.7544)
$Dum_t^{TFP} \cdot \Delta k_t$		-1.1732**	-0.8830***	-0.9698***
		(0.1987)	(0.1313)	(0.1111)
Constant	986.2992**	-540.3947	-149.3362*	-146.1729*
	(270.4566)	(345.4466)	(57.0872)	(53.9308)
Observations	16	16	16	16
R^2	0.9379	0.9932	0.9896	0.9915
Adjusted R^2	0.9069	0.9830	0.9776	0.9818
Residual S.E.	162.9541	69.7082	79.8835	72.0617
F-Statistic	30.2220	97.1569	82.9261	102.1055
Significance F	9.9796E-06	8.3358E-06	3.0435E-06	1.4862E-06

Note: Values in parentheses are standard error; 10%<"•"<5%<"*"<1%<"**"<0.1%<"***"<0.

Tab.2. Multicollinearity Test

explanatory	$\Delta pctG_t$	Δk_t	Δk_t

variable	(1)	(2)	(3)
$\Delta rtoS_t$	-39.0361*** (6.2501)	-70777.6562*** (8329.7906)	
$\Delta pctG_t$			1598.6651*** (165.0127)
Constant	2.1091*** (0.3605)	7127.0416*** (480.4754)	3322.2775*** (190.5939)
Observations	16	16	16
R^2	0.7500	0.8474	0.8783
Adjusted R^2	0.7308	0.8357	0.8690
Residual S.E.	0.6184	824.1664	735.9052
F-Statistic	39.0085	72.1978	93.8599
Significance F	2.9923E-05	1.1490E-06	2.5953E-07

Note: Values in parentheses are standard error; 10%<"•"<5%<"*"<1%<"**"<0.1%<"***"<0.

In view of the closeness in the values of independent variables estimated in the two regressions, we combined the estimates in columns 3 and 4 to analyse the effect of education investment and public education policy on the output. It is found that physical capital had the greatest influence over per capita output, followed by public spending on basic education, while the public spending on higher education had the least influence. The result reveals that physical capital accumulation is the main contributor to China's economic growth. Of course, the effect of education investment should not be ignored: education investment promotes human capital accumulation and ultimately affects economic growth.

The popularization of compulsory education and rapid industrialization add to the importance of unskilled human capital in production, as the former transforms the abundant human resources into talent dividend and the latter demands a huge amount of unskilled labourers. Through the impact on human capital accumulation, the government policies on education can also determine the economic output. China is a developing country with a large population and low average education level. Facing the national situation, the government has to attach importance and give priority to basic education. The enrolment expansion of higher education has a much more complicated impact on economic growth. First, the massive expansion offers unprecedented opportunities for students to pursue higher education; the resulting increase in skilled labourers will promote economic growth. Second, the congestion situation and quality of higher education get worse in that the higher education spending grows slower than the enrolment scale. The gloomy trend does not favour the accumulation of skilled human capital. Furthermore, the drop of higher education quality eases the competition pressure of basic education, and lowers the premium of higher education expected by the adult agent. Thus, the households may restrain the spending on education, making it hard to accumulate human capital or develop the economy. The weak output effect of higher education spending and negative output effect of college expansion manifest that the massive expansion of higher education does more harm than good.

Conclusion

One of the hot topics on political agenda is the education quality improvement. In the last decade or so, the competitiveness of higher education has received lots of attention. While the public funding is often touted as a panacea, the incentives to private investment should be given serious consideration. This paper studies how public spending triggers private responses in education funding at different education stages. It is discovered that both the size and composition of public education spending have an impact on the household decision-making on education spending at different stages of education. With the increase in public education spending, the households will step up investment in basic education, and reduce the investment in higher education. Overall, the private education spending will shrink. Besides, a larger share of public investment in basic education will increase the private spending on each stage of education, and push the households to invest more resources in the higher education.

The basic education stage boasts more efficient human capital accumulation and more contribution to economic growth than higher education. However, the proportion of government education spending on basic education exhibits a decline trend, especially on compulsory education. The overemphasis on higher education over basic education is obviously detrimental to coordinated development of education and talent training, making it hard for employers to find labourers with necessary skills.

Despite alleviating social stratification, the expansion of higher education enrolment hinders the cultivation of well-educated and high-qualification talents. Over the past two decades, the expansion of higher education and the number of college students have been growing much faster than incremental education investment, resulting in lower education spending per student and poorer quality of higher education. In light of the poor output effect of higher education spending, the government should cautiously formulate enrolment policy based on the level of economic development and labour demand.

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