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Three Essays on Human Capital in Korean Growth Path

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Abstract

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Human capital and technological progress are crucial factors in the Unified Growth Theory, which gives the most relevant answer to the crucial question of why some countries are rich, while others are poor. Although researchers have made various approaches, both historical and theoretical, toward this important question, there has been no general answer that is applicable to all of human history. Unified Growth Theory, however, covers the span of human civilization, from the Malthusian agricultural economy to the modern industrial economy, in a single dynamic system that covers the factors that other studies have focused on.

In the Unified Growth Theory, human capital is a key factor in understanding the transition toward modern industrialized economy. This thesis aims to explain Korean economic development/growth path by examining the human capital and the conditions

that promoted human capital accumulation in the framework of the Unified Growth Theory.

Before its independence in 1945, Korea was a typical agricultural society. In the agricultural society, because economic conflicts could erupt between the established landed elite and the emerging capitalist at the dawn of industrialization, the existence of a stronger landed elite often became an impediment toward industrialization. Inequality in landownership, therefore, can become an obstacle to human capital accumulation, the factor that can catalyze earlier industrialization. Chapter 3 will introduce a model that shows this pre-industrial political/economic conflict, reflecting the results of empirical analysis.

The transition from agricultural to a modern growth economy was significantly influenced by a change in the allocation of resources, a result of the decisions of households to place priority on the quality, rather than the quantity, of their children. This change in the allocation of resources triggered a demographic transition, eventually allowing the society to escape the trapped Malthusian economy. Chapter 4, then, will present the theory of demographic transition, based on empirical analysis of Korean data from 1970 to 2010.

After achieving the modern industrialized economy, a gap of income and wealth among individual diverse via human capital channel. Chapter 5 will introduce the expanded Galor-Zeira model, presenting empirical results covering the data from 1998 to 2008.

Keywords: Human Capital, Economic Growth, Unified Growth Theory, Korean Economic History

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Chapter 1. Introduction

Human capital is a significant factor in Unified Growth Theory, which explains the transition from a Malthusian economy to the Modern economy in a single dynamic system. According to the Unified Growth Theory, gradually accumulated technology triggered the Industrial Revolution, which then stimulated the demand for human capital. Increased the demand for human capital, in turn, caused the Demographic Transition. Ultimately, then, human capital was the crucial factor that linked the Industrial Revolution in the early nineteenth century and the demographic transition in the late nineteenth century in Western Europe. Accelerating technological progress and the decreasing rate of population growth are two necessary conditions to achieve modern economy, whose characteristic is increasing income per capita. To analyze this process, it is useful to understand two important historical events—The Industrial Revolution, which is related to the increasing denominator, and the demographic transition, which is related to the decreasing numerator—in a single framework. Chapter 2 introduces the Unified Growth Theory.

This thesis, which examines human capital in the context of economic development/growth, aims to explain Korean economic development/growth path by using Unified Growth Theory. Unified Growth Theory suggests that the driving force of economic growth is changing over economic stages undergo change. After escaping from the Malthusian trap, the accumulation of physical capital becomes the engine of economic growth in the early stage of industrial economy. However, in the late stage of industrial economy, which is triggered by the second industrial revolution, human capital supplies the fuel of economic growth. When you think of the fact that we live in an advanced industrial society, the study of human capital is indeed a very meaningful topic of research.

Just as the engines of economic growth changed in step to different stages of economic growth, the changing roles of human capital should also be analyzed in the context of each growth stage. Unified Growth Theory recognizes three growth stages in human history, determined by the rate of technological progress, the rate of income per capita growth, and the rate of population growth: the Malthusian Regime, the Post-Malthusian Regime and the Modern Growth Regime. In the Malthusian Regime, which has stagnant income per capita and almost zero economic growth rate, human capital doesn't contribute to the growth over the almost entire Malthusian regime. Human capital, however, plays a catalytic role at the dawn of the industrial economy, as the Malthusian Regime transitions into the industrial economy. This is because the educated worker is complementary with the physical capital, which appears in the stage of industrial economy. If, for various reasons such as religious motivation, some nations have more educated workers than others, these workers may contribute to triggering the early stage of industrialization in those nations. In the Post-Malthusian Regime, in which income per capita takes off but the Malthusian mechanism still increases population, the accelerating technological progress and accumulation of the physical capital allow the income per capita to rise, even with a high level of population growth rate. At this stage, the demand for human capital grows together with the accumulation of physical capital and technological progress. As a result, and demographic transition finally occurs as a result of the decisions made by individual households in the economy. Lastly, in the Modern Growth Regime, the economy can achieve sustained growth in income per capita, which has a higher denominator of income per capita from faster technological progress and a lower numerator of income per capita from the demographic transition.

Focusing on the role of human capital by using Unified Growth Theory framework, then, will greatly contribute to unveiling the skeleton of the development/growth path of each nation. Analyzing and testing the development/growth path of a nation through Unified Growth Theory is a significant research project because it would yield important and productive results. Not only will this research lead us to make better policies that can promote pivotal factors of a nation's development/growth. This is especially desirable because there still exist many nations in the world that are trapped in the vicious Malthusian mechanism. As the first step of this project, then, I choose Korea.

Korea achieved a dramatic economic growth out of the Malthusian Regime and into the Modern Growth Regime, in just half a century, which is considerably short compared to many Western countries. Korea, before its independence in 1945, was a typical agricultural economy operating within the Malthusian Regime. Even though some scholars argue that the process of industrialization in Korea benefitted from the period of Japanese occupation, I argue that Japanese rule rather hindered, not encouraged the accumulation of human capital that would have promoted Korea's own industrialization. Not only did the level of land inequality increase greatly during Japanese rule, but also only the Japanese and very few Koreans could obtain advanced education, preventing the rest of the population from becoming educated human resources. Korean economy under Japanese rule definitely remained agricultural securely trapped in the Malthusian mechanism. Chapter 3 presents strong evidences for my argument by showing that inequality of landownership is a non-financial hurdle for human capital accumulation. This research is the first to present evidence that inequality of landownership had an adverse effect on the level of public education in the Korean colonial period. Exploiting variations in inequality in land concentration across regions in Korea and accounting for unobserved heterogeneity across these regions, using a fixed effect model, my analysis exposes the highly significant effects of land inequality on education in Korea's colonial period. Ultimately, the Japanese regime had retarded the Korean Industrialization in terms of human capital accumulation.

After the 1960s, Korean society has experienced a fast transition from the agricultural economy to the modern growth economy. More specifically, from 1960s to 1980s, Korea has entered the Post-Malthusian Regime, whose main characteristics are triggering demographic transition accompanied by increasing investment in human capital. After the 1990s, Korea seems to have entered the Modern Growth Regime, with a low fertility rate and its engine of growth transitioning from physical capital accumulation to human capital accumulation. When an economy accumulates physical capital through industrialization, the demand for human capital increases gradually. Individual households then pick up this economic signal, reacting by reducing the quantity of offspring while increasing its quality: the quantity-quality trade-off. Chapter 4 provides empirical evidence of this quantity-quality trade-off in Korea. Exploiting variations in fertility and in human capital formation across regions in Korea during the period 1970 to 2010, chapter 4 proves that the process of development in Korea was associated with the reduction in child quantity and increase in child quality.

Chapter 5 examines the relationship between inequality and human capital in the Modern growth regime, where human capital plays a key role in economic growth. Chapter 5 suggests that the level of inequality increases via the human capital channel with credit market imperfection and that this increasing inequality negatively affects economic growth. I expand the model presented by Galor and Zeira (1993) to apply the fact that the economy benefits from endogenous technological progress and that the government provides financial aid to reduce the financial hurdles for human capital accumulation. The presented empirical results, using the data from 1998 to 2008, imply that education plays a significant role in the divergence of household wealth over time and that the government's financial aid package in the form of the new student loans program positively influences equality and short-run economic growth by promoting the number of skilled workers.

These three essays, which are in chapter 3,4, and 5, make contribution to expand application of Unified Growth Theory into that of more general setting in the sense that the development/growth path of twentieth century Asian country, Korea, can be explained using Unified Growth Theory. Because Unified Growth Theory unveils the factor that causes the Malthusian trap, underdeveloped countries, which are still trapped Malthusian agricultural economy, can focus their constrained resources on the most significant part of the growth. Also, this study contributes to understanding Korean economic development/growth path using generalized theory that covers from agricultural economy to the modern economy, in terms of the fact that Korea has experienced fast transition among the growth regimes. With understanding Korean economic history using the THEORY, this study allows us to be future oriented, though actual subject materials are the historical records, because only deep understanding of past and generalizing the historical experience can show us the way to overcome present or future crises by discerning the historical force.

Chapter 2. Overview of Unified Growth Theory

2.1 Motivation

"Why are some countries rich and others poor?" This has been a fundamental question in the field of economic history, the queen of social science. (Allen, 2011) As the words of Mokyr (1992), 'the best predictor of living standard that a newborn baby can expect to enjoy is the accident of where he or she is born,' suggest, this question is intimately related to our lives. The answer to this most essential question, however, is still unclear, and is the topic of scholarly debate.

To find the key element to the answer, researchers have pondered this question from diverse perspectives. Thanks to their efforts, various answers have hitherto been accumulated. Depending on the perspective, research so far can be largely categorized into two factions: the comparison between the North and the South, and that of the East and the West. Research focusing on the comparison between the North and the South is represented by Diamond (2005), whose primary question was: 'why did human development proceed at such different rates on different continents?' His question covered the global world both spatially and chronologically, including every continent on earth and every period in time – including even prehistory. Because his answer is centered upon the differences among continents geographically and ecologically, he allows us to broaden our perspective from beyond just the western Eurasian societies to intercontinental comparisons. The other faction, however, focuses on Western Europe around the 1800s and compares it to China. The representative work was accomplished by Landes(1999), who argued that the cultural factor was the key explaining the great divergence. Other researchers who investigated the special factors that allowed Western Europe to develop earlier than China include Acemoglu and Robinson(2012), Acemoglu et al. (2005), Mokyr (2004, 1992), North (1982), and Olson (1984). Some researchers, such as Frank (1998), tried to escape Eurocentrism by investigating the great divergence and adversely arguing that the European miracle was achieved by chance. In compromise, Pomeranz (2000) and Wong (1997) emphasize 'world history' to understand the great divergence beyond the simple west-east binary.

Nevertheless, these historical perspectives have actually restricted the formation of a general understanding in the development and economic growth of nations. This is because they delve into the special and specific circumstances of the time and space, failing to present theories that could apply beyond just that particular period and region. I believe that the purpose of a research should be to find the ways in which government policies can be used to overcome present day problems for economic development/growth. While we must discern the historical forces that led to economic growth through the historical records of the past, our attitude toward finding the answer to the question should be future-oriented. Because of this, the economic growth theory is a more suitable solution to formulate the general answer.

After seminal work by Solow (1956), the New Growth Theory appeared to overcome the shortcoming of the Solow model and to reflect the more of the real economy. (Aghion and Howitt, 2008; Lucas, 1988; Mankiw et al.,1992; Romer, 1986). The New Growth Theory, nevertheless, had a critical weak point: it failed to cover the thresholds of development from the agricultural economy to the modern economy, as it was different from research with historical perspectives(Greiner et al., 2004). Instead, they focused only on the driving force of economic growth *after* the IR, even though the critical point of understanding the great divergence was to explain the mechanism of the transition from the agricultural economy to the modern economy, and the differences in the initial conditions that allowed an earlier takeoff of the Western economy toward modern growth (Galor, 2011).

The Unified Growth Theory is the only growth theory that explains the transition of the production function from the agricultural production function to the modern capitalistic production function in one dynamic system. Explaining the cause and the process of this transition is important, because it has been the crucial factor that determined the contemporary world structure. To explain the great divergence between nations, a sufficient model must capture three points: first, the mechanism of the Malthusian trap, which had persisted for most of human history; second, the mechanism of escape from the Malthusian trap and the transition toward the modern growth era; and third, the comparative analysis that explains the differences of timing and initial conditions for taking off toward modern growth. Galor (2011) presents answer that satisfies all of these points, and the following is a summary of his work.

2.2 Unified Growth Theory

The Malthusian trapped economy has been sustained for almost the entirety of human history. This agricultural economy is characterized as being stagnant in terms of income per capita, which is closely related to the standard of living. If we recall the simple formula for calculating the income per capita – that is, income over population – we can easily guess why the income per capita has been so long stagnant. Population growth has offset the increase of income. To escape this stagnant structure, a faster progress of technology and an accelerating rate of increase in income/output are necessary, minus the counterbalancing effect of population growth. In most of human history before the Industrial Revolution, however, the rate of technological progress has been gradual and the increase in income/output per capita restricted because of a fixed production input – land – and the counterbalancing effect of population growth. After the transition of the economic structure towards modern growth, however, the main input of production changed to capital and labor instead of land and labor. This newly invented input, capital, had innovative characteristics. Thanks to the reproducible characteristic of capital, it allowed reproduction system, leading to the expansion of economy at an accelerating speed. The rate of technological progress also began to accelerate, being free from the counterbalancing effect of population growth. How did this change happen? What was the mechanism behind this transition in terms of economic structure?

Before looking more closely into the Unified Growth Theory, an overview of the three fundamental regimes of the Unified Growth Theory is necessary. The Unified Growth Theory recognizes three growth stages in human history, determined by the rate of technological progress, the rate of income per capita growth, and the rate of population growth: the Malthusian Regime, the Post-Malthusian Regime and the Modern Growth

Regime. In the Malthusian Regime, the income per capita is stagnant because of the counterbalancing effect of population against temporary growth of income. The technological progress is also slow and gradual in this regime. While the Malthusian Regime occupied most of human history, some regions in the late eighteenth century have been observed to have escaped the trapped economy, with a sustained relationship between higher income to higher population but with growth in income per capita. This was the starting point of the Post Malthusian Regme. Although the counterbalancing effect of population growth still remained, the higher speed of technological progress and income allowed the income per capita to take off and start growing. The Industrial Revolution initiated a growing demand for human capital, triggering the Demographic Transition in late nineteenth-century Western Europe by causing households to change the allocation of resources by prioritizing quality over quantity of their children. With the disappearance of the counterbalancing effect of population growth, income per capita accelerated at a greater speed. Thus began the Modern Growth Regime. In this regime, the rate of technological progress and that of income per capita accelerate in a virtuous cycle of technological innovation and increasing demand for human capital.

Keeping these regimes in mind, let us now return to human history. What was the prime cause of the Industrial Revolution? Was humankind just trapped in the agricultural economy in the Malthusian Regime? The Unified Growth Theory describes the economy before the Industrial Revolution as an economy where technology improved gradually and the population also increased gradually. The Unified Growth Theory emphasizes that this was the source of economic development in the Malthusian Regime, and that this ultimately triggered the Industrial Revolution. The population growth actually increased the possibilities of technological innovation, even though it was certainly sluggish. After population growth, accompany with the accumulation of technology, ultimately, the accumulated technology exceeded the threshold level, which meant the Industrial Revolution happened historically. This event that the level of technology exceeded the threshold means that the Malthusian steady state vanished. This change in technological environment allowed an increase in the demand for human capital, due to the complementarity of physical capital and technology. This triggered the Demographic

Transition, one of the prime forces in the transition from stagnant to sustained growth. Because the demand for human capital acted as an incentive for individuals to achieve higher levels of education, human capital began to accumulate, further accelerating technological progress and economic growth. Galor (2011) develops the process of this transition into a unified theory of economic growth harmonizing with the endogenous transition across the distinct economic regime in a single dynamic system.

2.3 Model

The model follows Galor (2011). The basic structure of model is the overlapping-generations economy with infinite discrete time. In every period, the economy produces one homogenous good using two inputs of production function, labor and land. Because this model focuses on the transition from agricultural economy, whose production inputs are land and labor, there is no room for capital input, even though adding capital into the production function leads the dynamic system of the model toward the intended results faster. Land is fixed over time. Also efficiency of labor is determined by households' decisions about the number and the level of human capital of their children.

In the Malthusian structured economy, there exists a positive effect of income on population, because of fixed factor of production, land. When labor increases, therefore, marginal productivity of labor decreases and output per capita decreases, which means that output per capita is constant in the long run.

Let's consider the production function as followed. Output per worker produced at time t is equal to

$$y_t = \left[\frac{H_t}{L_t}\right]^{\alpha}\left[\frac{A_t X}{L_t}\right]^{(1-\alpha)} = h_t^{\alpha} x_t^{1-\alpha} \tag{1}$$

where A_t is technological level, X is land and H_t is human capital. This production function suggests that positive effect of technological progress on income, and positive effect of income on population. Because of fixed factor of production function, which is land, increased labor causes decreasing output per worker. Therefore output per capita is constant in the long run.

In the early stage of development, population size positively affects technological progress by the channels, which are supply of innovation, demand for innovation, diffusion of knowledge, division of labor and extent of trade. In the later stages of development of Malthusian economy, educated individuals, who are regarded as human capital, have a comparative advantage in adopting and advancing new technologies. Here, in the Malthusian economy, the scale of population affects positively on technological progress. Therefore technological progress over time is a function of education, e_t , and population size, L_t .

$$g_{t+1} \equiv \frac{A_{t+1} - A_t}{A_t} = g(e_t, L_t) \tag{2}$$

where g_{t+1} is a rate of technological progress and $g(0, L_t) > 0$.

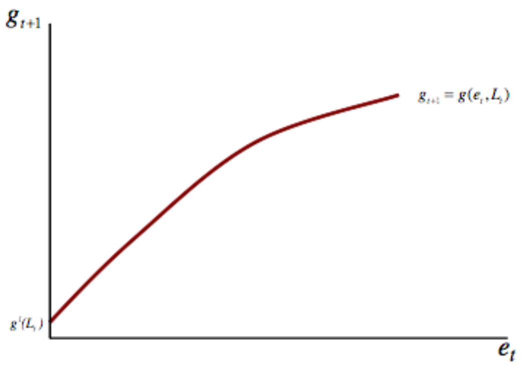


Figure 2.1 Technological progress, which is a function of education

Consider the production function of human capital. The new technology lessens the adaptability of existing human capital, which is formed previous period, but the education increases the adaptability of technology for the human capital. Therefore, human capital of children of generation t is a function of education, e_{t+1} , and rate of technological progress in their adult period, t+1.

$$h_{t+1} = h(e_{t+1}, g_{t+1}) \tag{3}$$

The rise in human capital, then, induces parents to substitute quality for quantity of their children, which is the quantity-quality trade off. At the same time, the rise in income along with the rise in potential return to human capital generates an income effect, which means parents starts spending their income on their children more, and substitution effects, which are the increase of the opportunity cost for raising children and the increase of the return to investment in children's human capital. In the early part of second phase of industrialization, the income effect dominates and population growth and human capital formation increases. Because the subsistence consumption constraint that adversely affect resources devoted to children, has a larger effect at low levels of income. In this stage, the demand for human capital is moderate. In the later part of the second phase of industrialization, because the substitute effect dominates, population growth declines and human capital formation increases further. In this stage, the subsistence consumption constraint has a lower effect at high levels of income, and the demand for human capital is more significant.

In this manner, the household's optimization can be considered. In their first period in each individual's life, they consume a fraction of their parental unit-time endowment. The required time increases with children's quality, where τ is time required to raise a child, regardless of quality, and $\tau + e_{t+1}$ is the time needed to raise a child with education e_{t+1}. In their second period, they allocate their time between childrearing and work. Also they choose the optimal mixture of quantity and quality of children. They also make consumption in this period. The utility function of individual t equals the following.

$$u^t = (1-\gamma)\ln(c_t) + \gamma \ln(n_t h_{t+1}) \quad (4)$$

where c_t is consumption of individual t, n_t is the number of children of individual t, and h_{t+1} is the level of human capital of each child. This optimization problem of generation t is that the maximization problem of their utility by allocating their consumption and investment in their children subject to the subsistence-consumption constraint, which is minimal level of consumption for their survival.

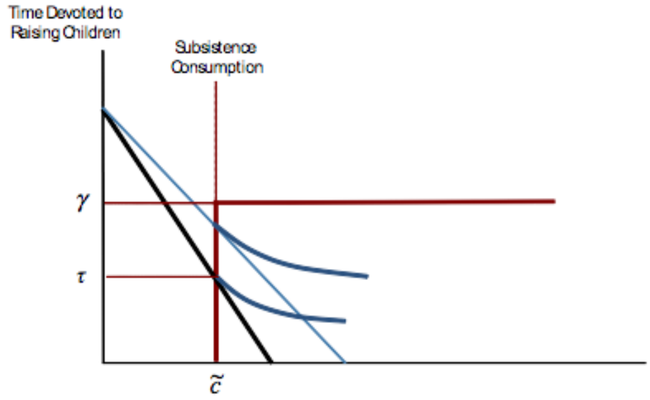


Figure 2.2 Preferences, constraint, and the income expansion path.
Summary: This figure presents the household's indifference curves with respect to budget constraints, where $\tilde{c}$ is the subsistence-consumption level. Until the subsistence-consumption level is binding, the income expansion path is vertical, and when the consumption level becomes $\tilde{c} < c$, the income expansion path is horizontal, which means the room for investment in education appears.
Source: Galor (2011), p. 153

This figure 1.2 depicts an income expansion path after the demographic transition has happened. Optimal investment in child quality, then, is following figure.

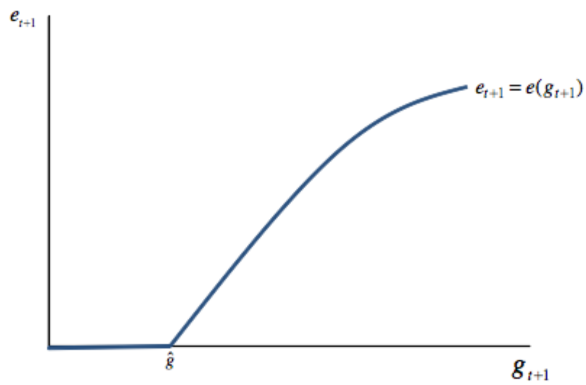


Figure 2.3 Education, which is a function of technological progress

The dynamical system, which determines the development this economy, is a sequence $\{x_t, e_t, g_t, L_t\}_{t=0}^{\infty}$ such that:

$$\begin{cases} x_{t+1} = \phi(e_t, g_t, x_t, L_t)x_t \\ e_{t+1} = e(g(e_t, L_t)) \\ g_{t+1} = g(e_t, L_t) \\ L_{t+1} = n(e_t, g_t, x_t, L_t)L_t \end{cases} \tag{5}$$

When the subsistence-consumption constraint is not binding, the dynamical system is determined by there three variable with a given population size L, the system $\{x_t, e_t; L_t\}_{t=0}^{\infty}$ is such that:

$$\begin{cases} g_{t+1} = g(e_t; L) \\ e_{t+1} = e(g_{t+1}) \end{cases} \tag{6}$$

The bellowed figures depict the dynamics of technology and education. Figure 2.4 (a) presents the dynamical system of the Malthusian economy and shows that there exists one global steady-state, which has zero growth of technology and education. As population size and the level of technology grow gradually, the curve gt+1 goes up and the dynamical system changes in the sence that there appear two more steady state, summing up two stable steady state, one unstable steady state as depicted in Figure 2.4 (b). As the economy developes more, the steady state that has low level technology and education disappears and only globally stable steady-state that has high level of technology and education remains as depicted in Figure 2.4 (c).

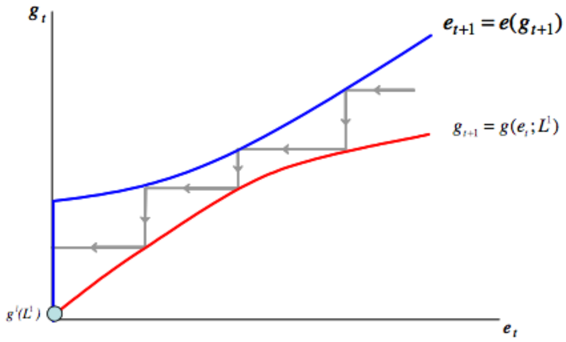


Figure 2.4 (a) Evolution of technology, education and effective resource under small population

Source: Galor (2011), p. 158

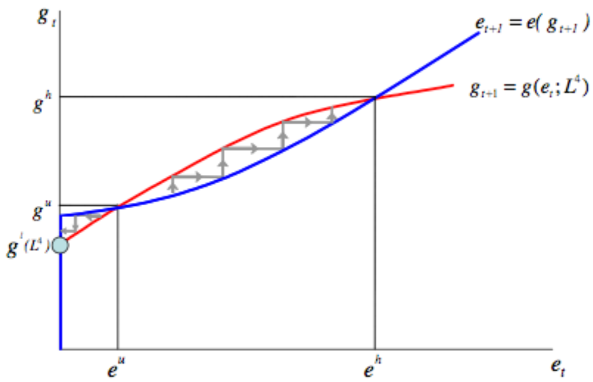


Figure 2.4 (b) Evolution of technology, education and effective resource under moderate population

Source: Galor (2011), p. 159

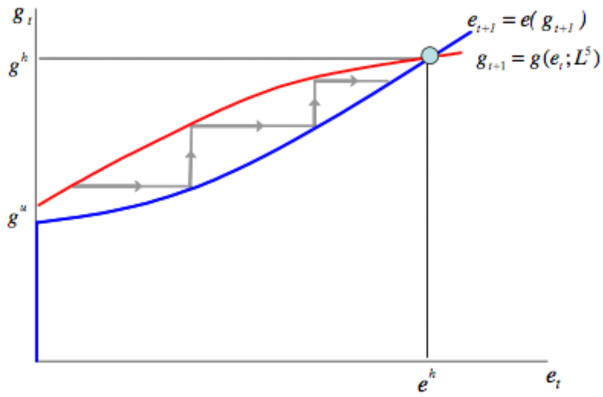


Figure 2.4 (c) Evolution of technology, education and effective resource under large population

Source: Galor (2011), p. 160

In a single dynamical system, the Unified Growth Theory covers the historical transition from agricultural economy to the modern economy. It implies that the transition from stagnation to growth is an inevitable by-product of the process of development. The inherent Malthusian interaction between technology and population, accelerated the pace of technological progress, and eventually brought an industrial demand for human capital. Human capital formation, which triggered a demographic transition, then, enables economies to convert a larger share of the fruits of factor accumulation and technological progress into growth of income per capita. Therefore, variations in the timing of the take-off among nations contributed significantly to the divergence in income per capita in the past two centuries.

2.4 Comparative Development

Using the skeleton of the Unified Growth Theory, which is explained so far, the comparison between South and North is available, because North, including Eurasia, has more populated society than that of South. To explain why the west Eurasia achieved the earlier transition than that of east Eurasia, the Unified Growth Theory put forth the expanded version of the model covering the differences in the economic performance across countries, which reflect variation in country-specific characteristics that affect the pace of technological progress and the intensity of human capital formation.

Suppose again the technological progress that expands equation (2)

$$g_{t+1}^{i} = g(e_{t}^{i}, L_{t}^{i}, \Omega_{t}^{i}) \tag{7}$$

where Ω_{t}^{i} is defined characteristics affecting technological progress in country i: the degree of protection of intellectual property rights(policy), the level of accumulated stock of knowledge within a society, and the propensity of a country to trade (geography and policy), which relates with technological diffusion and specialization/technological progress via learning by doing.

Again, suppose the function of education with new variable for the country specific characteristics

$$\Psi_{t}^{i} \equiv [\phi_{t}^{i}, \mu_{t}^{i}] \tag{8}$$

where

$$e_{t+1}^{i} = e(g_{t+1}^{i}; \Psi_{t}^{i}) \begin{cases} = 0 & \text{if} \quad g_{t+1}^{i} \leq \hat{g}(\Psi_{t}^{i}) \\ > 0 & \text{if} \quad g_{t+1}^{i} > \hat{g}(\Psi_{t}^{i}) \end{cases} \tag{9}$$

Now, using equation (7) and (9), I can explain the comparative development among nations. First, let’s consider only variations in characteristics that promote human capital formation, which is only about shift of equation (9), depending on variation equation (8) as in Figure 1.5 (a). The conditions that can affect on human capital formation, for example, are the ability of individuals to finance the cost of education and the forgone earning; the availability, accessibility, and quality of public education (policy and interest group); culture and religious composition in society relating with attitude towards education; the stock of knowledge in society; the propensity of a country to trade that relates with skill-intensity in production and its effect on the demand for human capital; the effect of geographical attributes on health that influence on return to investment in human capital; composition of religious groups within a society and their attitude towards literacy; and the social status associated with education. Depending on the conditions, the location of initial curve $e^{i}_{t+1} = e(g^{i}_{t+1};\Psi^{i}_{t})$ is decided. This difference in the initial location of the dynamical system causes the time difference in taking off.

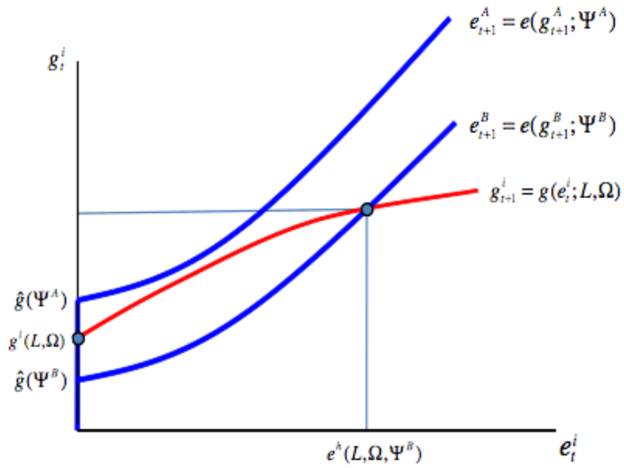


Figure 2.5 (a) Variations in country-specific characteristics that contribute to formation of human capital and comparative development

Source: Galor (2011), p. 192

Second, with the similar logic, let's consider only the shift of equation (7) that reflects variations in characteristics that stimulate technological progress as depicted in Figure 1.5 (b). The conditions that determine the initial condition of the curve $g^{i}_{t+1} = g(e^{i}_{t}, L^{i}_{t}, \Omega^{i}_{t})$ also affect the timing of taking off and ultimately the great divergence between the East and the West.

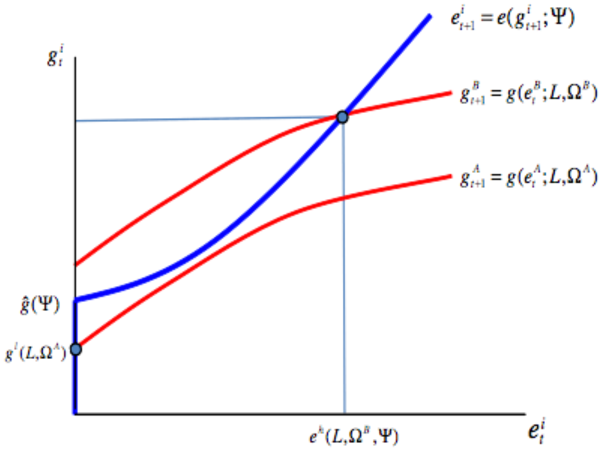


Figure 2.5 (b) Variations in country-specific characteristics that contribute to technological progress and comparative development
Source: Galor (2011), p. 190

Therefore, the Unified Growth Theory establishes the skeleton to focus on fundamental forces of economic growth and makes rooms for other factors that affect on main flow of the growth. Among factors that determine the big stream of the development, human capital plays a crucial role for linking other factors into the growth.

This thesis, which examines human capital in the context of economic development/growth, aims to explain Korean economic development/growth path by using the Unified Growth Theory. Chapter 3 and Chapter 5 show the condition of Korea that promotes human capital accumulation, before and after its industrialization respectively. Chapter 4 is about the change in resource allocating of parents in the process of transition from the Malthusian Regime to the Modern Growth Regime.

Chapter 3. Non-Financial Hurdles for Human Capital Accumulation: Landownership in Korea under Japanese Rule

3.1 Introduction

Human capital accumulation plays a crucial role in Unified Growth Theory, which explains the transition from Malthusian-trapped growth to modern growth by capturing the relationship between two historical events: the Industrial Revolution and the demographic transition (Galor and Weil 2000; Galor 2011a). The process of industrialization increases demand for human capital, which in turn encourages individuals to acquire more education. This process of accumulating human capital further accelerates economic growth. Therefore, circumstances that promote or limit human capital accumulation are crucial for explaining country-specific differences in the growth path and the timing of the transition to modern growth.

This paper confirms that inequality in landownership (land inequality hereafter) adversely affects the establishment of public elementary-level education, which promotes human capital accumulation at a primary stage of economic development, as hypothesized by Galor et al. (2009). Using evidence from Korea, I argue that in a society that has more unequal landownership as an initial condition, institutions that promote human capital accumulation are established later, leading, on average, to lower levels of education.

Galor et al. (2009) considered the economic interests of the established landed elite, the emerging industrial elite, and common workers during the industrialization process. Because of the complementarity between physical capital and technology, the accumulation of physical capital due to industrialization results in increased demand for human capital (Lucas, 1988; Uzawa, 1965). The emerging industrial elite, therefore, has a friendly attitude toward public education, which can boost human capital accumulation.

The landed elite, on the other hand, initially has a negative attitude toward education policy for two reasons. First, there is little complementarity between land and education, which means higher educated workers are not necessary to produce more agricultural products. Second, education tends to separate labor from land, resulting in a lower return on land.

Human capital accumulation requires individuals to invest in education by allocating their time to attend school or consuming their other resources to learn higher skills, but because of capital market imperfections, such investment is suboptimal (Galor and Zeira 1993). Public investment in education, therefore, lessens the individual's financial burden of accumulating human capital and reinforces economic growth. The landed elite initially impedes the implementation of policies that promote human capital, as described above. However, as the economy gradually shifts from agriculture to industry, landowners hold more physical capital and thus change their positions on public education. A society that has more equally distributed landownership or scarce land, therefore, can implement the optimal education policy earlier. Moreover, this earlier implementation of the public education policy promotes investment in human capital and thus accelerates economic growth.

The aim of this paper is to show evidence that land inequality adversely affects human capital accumulation using Korean data. My results are consistent with those presented by Galor et al. (2009) and Cinnirella and Hornung (2011), who used data from the United States and Prussia, respectively. Thus far, this adverse relationship between land inequality and human capital accumulation has only been tested using data from Western countries or from countries that industrialized independently. Korea's development in the early twentieth century, however, occurred in a different context (i.e., under colonial occupation) because Korea was under Japanese occupancy from 1905 to 1945, and its economy was thus determined by the Japanese economy. Therefore, the result of this research, namely the finding that land inequality significantly affects education, implies that the adverse effects of non-financial hurdles, such as land inequality on human capital accumulation, can be generalized to many settings.

The empirical analysis in this study uses a panel data set from the *Annual Statistical Report of the Government-General* (i.e., the previous colonial government) to demonstrate that land ownership adversely affects education. These panel data allow me to control for unobserved heterogeneity across regions at the province level. By using a fixed effects model, I find an effect of land inequality on education without unobserved heterogeneity across regions, by controlling for regional differences in the share of agriculture, the share of jobs that require more human capital (to capture the level of modernization), the population growth rate (to control for the quantity/quality trade-off effect), and the share of Japanese individuals (to test the effect of colonial occupation). Moreover, this finding is robust even when I control for the supply side of education.

The remainder of this chapter proceeds as follows. In section 3.2, I present the related literature. Section 3.3 presents a simple theoretical model based on Galor et al. (2009). Section 3.4 provides an historical background of Korea, focusing on the distinctive Korean colonial experience in terms of land inequality and education. Section 3.5 presents the empirical results using Korean data. Finally, section 3.6 offers concluding remarks.

3.2 Literature Review

The literature presents several different arguments about the relationship between inequality and human capital accumulation with respect to economic growth. Galor and Zeira (1993) constructed a macroeconomic model that shows that inequality, in the presence of credit constraints, adversely affects human capital formation and economic growth in the long-run. Becker and Tomes (1979), Mulligan (1997), Han and Mulligan (2001), Grawe and Mulligan (2002), and Grawe (2004) also constructed theoretical models of investment in human capital with respect to credit market constraints. In the absence of credit market imperfections, which means that parents can easily access the capital market in order to borrow money for their children's education, parents invest in their children's education at the optimal level. However, no households are able to invest in their children's human capital in the presence of credit market constraints, resulting in low-income families being increasingly burdened by the costs of human capital investment. Furthermore, these authors all argue that the presence of non-linearity because of the intergenerational elasticity of earnings is higher for credit-constrained families. Empirical support for this hypothesis, however, has faced difficulties because of the problems of identifying credit constraints (Black and Devereux, 2010).

In addition to credit market imperfections, non-financial hurdles can impede human capital accumulation. Galor et al. (2009) proposed a theory in which land inequality significantly influences economic growth. They showed that differences in education expenditure across the U.S. stem from variations in the state-level distribution of landownership. Similar to Galor and Zeira (1993), this theory explores the favorable conditions for human capital accumulation; however, it differs in that the hurdle for human capital accumulation is not a financial barrier but rather land inequality.

Cinnirella and Hornung (2011) used data from nineteenth century Prussia in order to find supporting evidence that land inequality adversely affects the timing of human capital formation. Becker and Woessmann (2010, 2009) had earlier shown that Protestantism in pre-industrialized Prussia promoted human capital accumulation because of widespread adherence to Biblical principles, resulting in Prussia's relatively strong literacy rate compared with other European countries. Cinnirella and Hornung (2011), however, focused on variations in land inequality and education levels across Prussia. They argued that landowners delayed the establishment of mass education through the institution of serfdom, which restricted labor mobility and therefore the benefits available from human capital accumulation. Moreover, despite the presence of schools and teachers, regions that had higher land concentration had lower education attainment. After the abolition of serfdom and the emancipation of peasants, the rise in education improved economic growth in Prussia.

3.3 The Model

In their seminal work, Galor et al. (2009) and Galor (2011a, 2011b) stressed the importance of human capital in the growth process and underlined the non-monotonic relationship between inequality and growth. Using their framework, I can derive a simple model in the spirit of Galor et al. (2009).

Consider an overlapping generations model in which each individual lives for two periods and has one parent and one child. In this model, there are two production sectors, agriculture and manufacturing, which produce the same homogenous good that is used in consumption and investment. In this model, because the decisions of established landowners at the beginning of industrialization based on their physical capital holdings were crucial to promoting human capital accumulation, the assumption of one homogenous good does not alter our quantitative results. The aggregated output in this society is thus

$$y_t = y_t^A + y_t^M \tag{1}$$

where y_t^A is the aggregate output in the agricultural sector and y_t^M is the aggregate output in the manufacturing sector.

Both sectors have a neo-classical, constant-returns-to-scale, strictly increasing, and concave production function. Specifically, the production function of the manufacturing sector is a Cobb–Douglas production function. Thus,

$$y_t^A = F(X_t, L_t) \tag{2}$$

$$y_t^M = K_t^{\alpha} H_t^{1-\alpha} = H_t k_t^{\alpha}\ , \quad k_t = K_t / H_t\ , \quad \alpha \in (0,1) \tag{3}$$

where X_t is land, L_t is the number of workers employed by the agricultural sector in period *t*, K_t is the quantity of physical capital, and H_t is the quantity of human capital (measured in efficiency units) employed in production in period *t*. Physical capital fully depreciates after one period.[1]

---

[1] This assumption is customary in the field of economic growth theory (Acemoglu, 2009), because it simplifies the model and allows us to focus on the main framework. Nevertheless, it is conservative because our results become apparent with slower capital depreciation.

The inputs are different in each production function. In the agricultural sector, the inputs are land, which is fixed over time, and labor, whereas in the manufacturing sector, the inputs are capital, which is accumulated over time, and labor. Furthermore, human capital is independent of labor productivity in the agricultural sector, whereas in the industrial sector, human capital positively affects labor productivity. Because the markets in both sectors are perfectly competitive, the results of profit maximization are as follows:

$$w_t^A = F_L(X_t, L_t), \quad \rho_t = F_X(X_t, L_t)$$

(4)

$$R_t = \alpha k_t^{\alpha-1} \equiv R(k_t), \quad w_t^M = (1-\alpha)k_t^{\alpha} \equiv w^M(k_t)$$

(5)

where w_t^A is the wage rate per worker in the agricultural sector, ρ_t is the rate of return on land, R_t is the rate of return on capital, and w_t^M is the wage rate per efficiency unit of labor.

Recall that individuals in this model live for two periods and have one parent and child. Each individual has the same preferences (so-called "warm glow preferences"), meaning that individuals only differ in their initial wealth. The utility function of individual *i* in period *t* is a log-linear utility function as follows:

$$u_t^i = (1-\beta)\ln c_{t+1}^i + \beta \ln b_{t+1}^i$$

(6)

where c_{t+1}^i is second-period consumption, b_{t+1}^i is a transfer to an individual's offspring, and $\beta \in (0,1)$, which is constant over time. In the first period of an individual's life, he spends his time accumulating human capital. A fraction, $\tau_t \geq 0$, of his capital transfers from his parent, b_t^i, and this is collected by the government for the public education system as a tax, while a fraction, $1-\tau_t$, is saved for future income. In the second period, he earns income, which includes wages, w_{t+1}, returns on capital, $b_t^i(1-\tau_t)R_{t+1}$, and returns on land, $x^i\rho_{t+1}$, and he allocates this income to consumption and bequests to his child. The entire stock of land that he receives from his parent is transferred to his child. Therefore, the second period income, I_{t+1}^{i}, of individual *i* is as follows:

$$I_{t+1}^{i} = w_{t+1} + b_{t}^{i}(1-\tau_{t})R_{t+1} + x^{i}\rho_{t+1} \tag{7}$$

The optimal transfer of individual *i* born in period *t* is $b_{t+1}^{i} = \beta I_{t+1}^{i}$, and the optimal consumption of individual *i* born in period *t* is $c_{t+1}^{i} = (1-\beta)I_{t+1}^{i}$.

I assume there are only three homogenous groups of individuals in period 0, landowners, capitalists, and workers, who have the same preferences but have different initial levels of wealth and landownership. Landowners own the entire stock of land X in the economy, and the fraction of all individuals who are landowners is given by $\lambda \in (0,1)$. Because all land holdings are transferred from parents to children, the distribution of landownership is constant over time, and each landlord possesses X/λ units of land. Capitalists possess the entire initial stock of physical capital, and their fraction in the population is given by $\mu \in (0,1)$. The remaining individuals, whose fraction is given by $1-\lambda-\mu \in (0,1)$, are workers who own neither land nor physical capital. Because every individual has one parent and one child, the fraction of each type of worker does not change over time. As this economy develops, however, every individual can accumulate physical capital.

I further assume that landowners are the pivotal force in determining the implementation of the public education policy. This assumption is not strong, considering the case that established interest groups have influenced governments' policy choices (Acemoglu and Robinson, 2000; Grossman and Helpman, 1994; Krusell and Ríos-Rull, 1996; Kuznets, 1968; Mokyr, 1990; Prescott and Parente, 1999). Then, I focus on the landowner's income evolution. The second period income of a landowner is

$$I_{t+1}^{L} = w(y_{t},\tau_{t};X) + (1-\tau_{t})R(y_{t},\tau_{t};X)b_{t}^{L} + \rho(y_{t},\tau_{t};X)X/\lambda \tag{8}$$

and his transfer to his child is

$$b_{t+1}^{L} = \beta[w(y_t,\tau_t;X) + (1-\tau_t)R(y_t,\tau_t;X)b_t^{L} + \rho(y_t,\tau_t;X)X/\lambda] \equiv b^{L}(y_t,b_t^{L},\tau_t;X,\lambda)$$
(9)

As Galor et al. (2009) showed, theoretically, there exists a critical level of total capital transfers to all landowners, $\hat{B}_t^L = \lambda b_t^L$, such that the implementation of public education becomes more profitable for landowners despite the cost of tax, τ_t. In other words, as the economy develops, the share of land in aggregate output decreases and the stakes of landowners in other sectors increase. Because of these changes in landowners' economic interests, their opposition to public education decreases until eventually they support public education. Therefore, an economy that has a politically powerful landed elite, which is akin to having higher land inequality, tends to accumulate human capital slowly. Thus, land inequality adversely affects human capital accumulation.

3.4 Historical Background

In the early twentieth century, the economy of Korea, which was under Japanese occupancy from 1905 to 1945, was determined by the Japanese economy. Under Japanese rule, land distribution in Korea became skewed, and the ratio of tenants to farming households grew from 42 percent in 1913 to 70 percent in 1945 (Eckert et al. 1991). The next-described policy of Japan and the Government-General, the chief colonial administrator, promoted this change. From the beginning of the colonial period, the Japanese government encouraged migration from Japan to Korea and suggested that becoming a landlord was the ideal pattern of Japanese settlement in Korea (Kikkawa, 1904). In 1907, the Oriental Development Company, a semi-governmental Japanese company, began to purchase large amounts of land to entice Japanese settlers to Korea and eventually became the biggest landlord in Korea (Moskowitz 1974; Eckert et al. 1991). In 1912, the Japanese Land Survey of Korean Land also encouraged an increase in the tenancy rate because this would strengthen the legal rights of landowners and increase Japanese investment in land. The interaction between strong landowners' rights, market forces, and increased population thus led to a higher tenant ratio (Kim et al. 1989; Shin 1982; Eckert et al. 1991).

Japanese rule also influenced Korean industrialization. The Government-General aimed to mold the Korean economy to fit Japan's needs by prohibiting the development of Korean industries and companies, promoting an agricultural economy in Korea, and selling Japanese industrial goods in the Korean market. However, because Japan was substantially industrialized after the First World War and because the Korean Peninsula is located between Japan and China, Japan began to promote some industrial sectors in Korea in order to establish a supply base to invade China, especially after the Japanese occupation of Manchuria. Although Korean industrialists, who were educated in the language and skills of entrepreneurs, did begin to appear after 1919, Japanese colonial policy is the most important factor in understanding Korean industrialization under Japanese rule (Eckert et al. 1991).

The implementation of the public education system in Korea under Japanese rule also differed from that of the U.S. or Prussia in the nineteenth century. The purpose of public education under Japanese occupancy was to condition Koreans to be good citizens of the Japanese Empire, by teaching them Japanese culture and language. Although the public education system operated by the Government-General coexisted with Korean private schools, these schools were oppressed. Moreover, the unequal public education system was differentiated by the quality of instruction. Korean students received a minimal level of schooling, whereas Japanese students received more advanced education. This historical context is, therefore, necessary for understanding the Korean public education system (Eckert et al. 1991; Kim 1999).

Despite the distinctive Korean colonial experience, however, the relationship between land inequality and the public education system can be generalized in the model presented in the previous chapter. Every local area reacted differently to the public education policy of the central government because of differences in their degree of industrialization, urbanization, culture, geographical character, and land inequality. Moreover, landowners were considered to be superior to tenants and controlled their tenants' farming activities, thereby affecting tenants' individual lives through their ruling power, akin to serfdom in early nineteenth century Prussia (Soh 2005). In this regard, the level of elementary education also varied with respect to the degree of inequality in land distribution. Accordingly, this paper focuses on the variations in the reactions to the central government's educational policy across different regions in Korea.

Although this paper only examines the period before independence in 1945, the Korean historical context could allow for further investigation into how land reform influenced education policy after independence. Post-independent Korea was divided into South Korea and North Korea, and land reform was included in the Constitution of the Republic of Korea (South Korea) in 1948. The Agricultural Land Reform Amendment Act was then implemented in 1950, just before the Korean War. The Act stated that only farmers who cultivated the land could possess it and that each farmer could have at most three *jung-bo*, or around 30,000 m^2, of land. Furthermore, tenancy was prohibited. Land reform reallocated land, and the ratio of tenants to landowners officially became zero in 1950. The number of agricultural households that owned their own land thus jumped from 349,000 in 1949 to 1,812,000 in 1950 (Jeon and Kim 2000).

Soaring expenditure on education accompanied land reform. South Korea regarded literacy as vital for establishing democracy, and there was a campaign to increase the literacy rate. As a result, the illiteracy rate dropped from 78 percent in 1945 to 42 percent in 1948. In 1949, a new education law was passed in South Korea that aimed to supply public education to everyone and build a skilled workforce for industrial work. The implementation of this law was postponed until 1954, however, with the start of the Korean War in 1950. Thereafter, its implementation allowed the elementary school enrollment rate to grow from 54 percent to 96 percent in 1959. Koreans also recognized the importance of a nation's technical power through their experience with Japanese rule, and thus tried to build an education system with an emphasis on technical training and science. To do so, they founded a bureau under the direct control of the president that managed education in science and technical training and established a five-year plan for practical training to fortify industrial human capital (Ministry of Education 1988). As a result, Korea industrialized quickly and it is now a member of the OECD.

Despite Korea's unique colonial experience, its history in the twentieth century provides us with a good opportunity to explore the relationship between land inequality and education. First, given that under Japanese occupancy, tenancy prevailed and reactions to public education policy varied widely, I can analyze the relationship between the two. Second, after independence in 1945 and the implementation of land reform in 1950, the soaring enrollment rate in elementary schools supplied accumulated human capital to power Korean industrialization. Therefore, I can also analyze the different reactions to public education policy for the period from independence in 1945 to the implementation of the education law in 1954, with respect to the local tradition of landownership, even though tenancy was officially abolished after land reform in 1950. In this paper, however, I focus only on the period of Japanese occupancy and leave the period after independence to future studies. Given the controlling colonial factors, I can thus test the relationship between land inequality and education.

3.5 Empirical Analysis

3.5.1 Data description

The data in this paper are sourced from the *Annual Statistical Report of the Government-General.* These data aggregate individual-level data to the regional level, thus reflecting average behavior at the province level in Korea. The Government-General, which formed the Japanese colonial government in Korea from 1910 to 1945, published the Report annually during their rule of the Korean Peninsula until 1943. As the name suggests, the Report was a compilation of the most important statistical information. These data were first collected in 1907 by the Residency-General (i.e., the data supplied information from 1906). The investigated items changed over the Japanese ruling period, but they remained consistent for the time period I consider in this paper (i.e., 1934 to 1942). My data include items such as land and weather, population and households, agriculture, manufacturing, fishery, forestry, money and banking, education, religion, and finance (Park and Seo 2003).

3.5.2 Empirical specification and results

The empirical analysis in this paper examines how land inequality affects education level by comparing variations across provinces. Inequality in the distribution of landownership, $LandInequality_{i,t-1}$, is measured as the ratio of the number of households of tenants in province *i* in period $t-1$. As shown in Table 3.1, Cinnirella and Hornung (2011) and Galor et al. (2009) also measured land inequality in order to reflect the landowner's power. Although the level of tenancy varied among tenants, for example, some farmers cultivated leased land and their own land simultaneously, the variable is unable to explain the variation among tenants. Education level, $Education_{i,t}$, is measured as the number of public elementary school students per person in province *i* in period *t,* which is the same as in Cinnirella and Hornung (2011). The data cover eight periods of observation from 1934 to 1942 and 13 provinces. A period of observation is one year, so that when *t* is 1935, $t-1$ is 1934, and so on to 1942.

I use the following empirical specification:

$$Education_{i,t} = \beta_0 + \beta_1 LandInequality_{i,t-1} + BX_{i,t-1} + \upsilon_{i,t} \quad (10)$$

where X is the vector of control variables including the share of agriculture, which is the_number of farmers relative to the total population of province *i* in period $t-1$; the share of manufacturing, which is the number of workers in the manufacturing sector relative to the total population of province *i* in period $t-1$; the share of commerce/transportation, which is the number of workers in the commerce/transportation sector relative to the total population in province *i* in period $t-1$; the rate of population growth in province i in period $t - 1$; the share of Japanese, which is the number of Japanese people relative to the total population of province i in period $t - 1$; and the number of public elementary schools per 1,000 people in province i in period $t - 1$. This formulation captures the lag in making changes to education with respect to the prevailing economic and political conditions.

(Insert Table 3.1 here)

Table 3.1 shows the control variables used in this and other research, namely Cinnirella and Hornung (2011) and Galor et al. (2009). This paper chooses the same variables as Cinnirella and Hornung (2011) in order to control for the economic environment; however, it uses the share of the commerce and transportation sector rather than that of the manufacturing sector to reflect the level of modernization/industrialization, as discussed in more detail below. To control for the supply side of education, this paper controls for school density, which is measured as the number of public elementary schools per 1,000 people, as it is in Cinnirella and Hornung (2011). To control for the historical context, this paper considers the share of Japanese, whereas Galor et al. (2009) controlled for the share of black people and Cinnirella and Hornung (2011) controlled for the share of people not using German, the share of Protestants, and differences in inheritance law. Table 3.2 provides the summary statistics of the variables used herein.

(Insert Table 3.2 here)

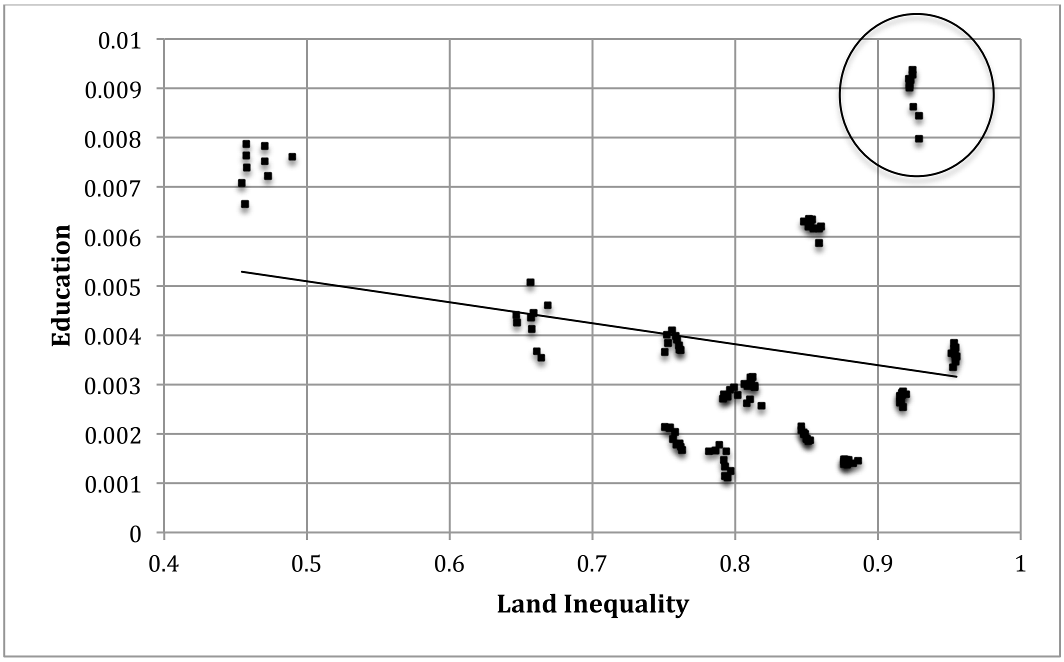
This paper uses panel data. A primary benefit of panel data is that they can solve the problem of unobserved heterogeneity, which is difficult to control when adopting cross-sectional or time series data. The error term $\upsilon_{i,t}$ can be divided into time-invariant unobserved heterogeneity across provinces at the education level, η_i, and time-variant unobserved heterogeneity at the national level, δ_t. That is,

$$\upsilon_{i,t} = \eta_i + \delta_t + \varepsilon_{i,t}$$

(11)

Because the data in this paper are not a sample of the population but rather reflect the entire population, it is reasonable to think of $\upsilon_{i,t}$ as a parameter to be estimated instead of a random variable. My model, then, is a two-way fixed effects model.

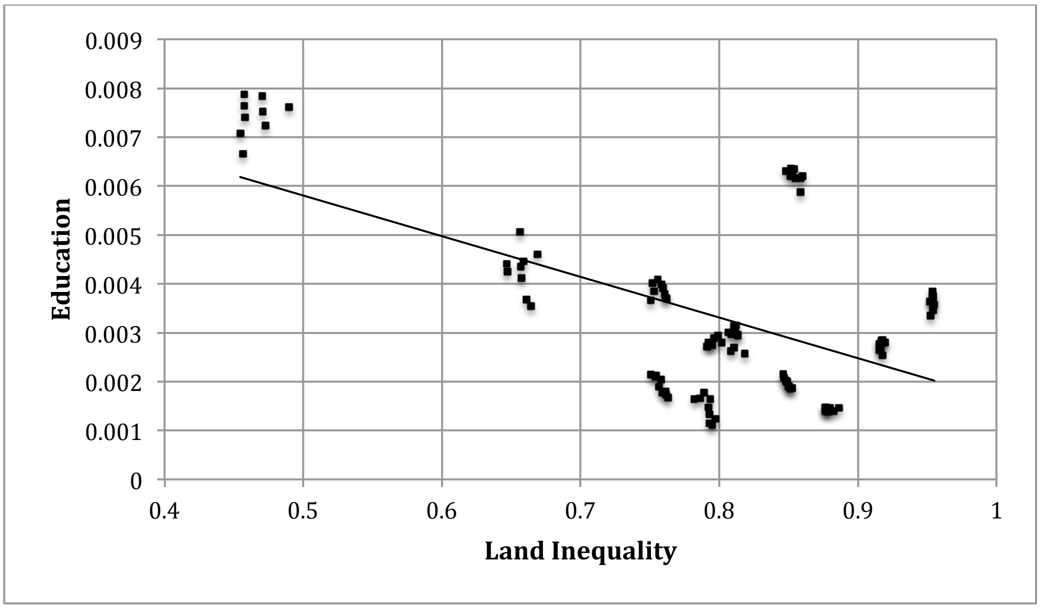
Figure 3.1 Land inequality and education in all provinces. The points in the circle represent data from the GyeongGi province, which includes Seoul, the capital city of Korea.



Source: Annual Statistical Report of the Government-General

The negative correlation between land inequality and education is apparent in Figure 1. The points in the circle represent data from the GyeongGi province, which includes Seoul, the capital city of Korea. This province had both the smallest share of farmers and the highest level of commerce and transportation, which are the two variables for which I control.

Figure 3.2 Land equality and education excluding the GyeongGi province.



Source: Annual Statistical Report of the Government-General

In Figure 3.2, I remove the data on the GyeongGi province and thus find stronger evidence of a negative correlation between land inequality and education.

(Insert Table 3.3 here)

Table 3.3 shows the correlations between the variables. Because the agriculture, manufacturing, and commerce/transportation sectors are highly correlated, these variables are used separately. The share of Japanese variable correlates with every economic co-variable, namely the share of agriculture, share of manufacturing, and share of commerce/transportation. This finding shows that the Japanese factor plays an important role in understanding Korea's economic situation during the Japanese occupation. Furthermore, it demonstrates the low correlation between the share of Japanese and the level of land inequality, which allows me to control for both variables at the same time.

(Insert Table 3.4 here)

Table 3.4 depicts the results of this estimation in columns (1)–(7). In every column, the adverse effect of land inequality on education is apparent. Lagged land inequality has an adverse and highly significant effect on education with no controls (column (1)) as well as when controlling for the share of agriculture, that of manufacturing, that of commerce and transportation, the rate of population growth, the share of the Japanese population, and the number of public elementary schools per 1,000 people. As expected, column (2) shows that the share of agriculture has a negative and highly significant effect on education, and we continue to observe a positive and significant effect of land inequality on education. The share of manufacturing, however, does not have a significant relationship with education in contrast to the prediction, even though it has a positive sign (column (3)).

When the share of commerce and transportation is controlled for rather than that of manufacturing, a significant and positive relationship can be observed, since the development of commerce and transportation tends to be ahead of that of manufacturing throughout the history of capitalism. The manufacturing sector at that time was immature and thus it was difficult to regard the Korean economy as industrialized. Because of the collinearity between the share of agricultural jobs and that of commerce and transportation, I therefore include only the latter in the regressions in columns (4)–(7).

In columns (6) and (7), the effect of the population growth rate on education is negative and highly significant, reflecting the quantity/quality trade-off in education in this period. The share of Japanese has a positive and highly significant effect, reflecting the fact that the Japanese population in Korea tended to receive more education. Even when controlling for the share of Japanese, the negative and strong effect of land inequality on education holds. The significant relationship between land inequality and education may not have held when colonial factors were controlled for if the colonial government had decided on land inequality and education simultaneously. However, the levels of land inequality and education were not highly correlated and not decided upon by the colonial government at the same time.

Although tenancy increased with the colonial government's encouragement of land inequality, according to Soh (2005), the tenancy rate stabilized before the 1930s, and land inequality during the study period herein was thus affected by the annual level of agricultural output. Moreover, because landowners were superior to tenants and controlled their production processes and economic conditions, tenants' decisions on their children's education did not result only from the education policy of the central government. In column (7), I therefore control for the number of schools per 1,000 people to isolate the effect of the supply of schools on education. I find that the coefficient of the number of schools per 1,000 people is not significant, meaning that including this control does not change my coefficient of interest.

(Insert Table 3.5 here)

(Insert Table 3.6 here)

Tables 3.5 and 3.6 present robustness checks. In both cases, the effect of land inequality on education is negative and highly significant. The main findings in Table 3.4 are consistent with the findings of Table 3.5 (lagging land inequality by two years) and Table 3.6 (no lag at all), and are thus robust.

I next performed an instrumental variables estimation, as carried out in previous studies (Cinnirella and Hornung, 2011; Galor et al., 2009). These papers used the following instrumental variables: the relative price of agricultural goods, which reflects the differential effect of agricultural prices over time on the concentration of landownership across provinces, and the climatic conditions of each province, which are province-specific but time invariant. However, because the outbreak of the Pacific War in 1941 led the Japanese colonial government to control both the price and the distribution system of food, the market price system did not work following the war. Moreover, price data at the province level are unavailable. This paper, therefore, does not have the relevant data to use this identification strategy. Nevertheless, because unobserved heterogeneity is sufficiently controlled for in the fixed effects model with panel data as well as with the time lag and the historical context, the adverse effect of land inequality on education still becomes apparent.

3.6 Conclusion

Human capital accumulation plays a crucial role both in the transition from Malthusian stagnation to modern growth and in the timing of modern growth's implementation. Institutions that promote human capital accumulation have contributed to the great divergence in per capita income across countries. Credit market imperfections provide one well-studied barrier to the accumulation of human capital, but non-financial hurdles are also important impediments for examining human capital accumulation.

The historical empirical evidence of the effects of non-financial hurdles in the current economic literature, however, is limited to Prussia in the nineteenth century and the U.S. in the early twentieth century. These two countries industrialized on their own development paths spontaneously. Korea under Japanese occupancy, by contrast, developed in a different context because of its colonial experience. Nevertheless, the adverse effect of land inequality on human capital accumulation holds, which means that the model formalized by Galor et al. (2009) can be applied to more general cases.

I used a panel data set with observations from 13 provinces in each year from 1934 to 1942 and controlled for unobserved variables using a two-way fixed effects model. Although land distribution and the public education system in Korea were driven in part by the colonial powers, reactions to the central education policy varied by province because of differences in the level of land inequality. My results, therefore, showed that land inequality, a non-financial hurdle, has a strongly significant effect on human capital accumulation.

Finally, these results could be strengthened by further research that analyzes how land inequality under Japanese occupancy influences education development after the land reform and education reform laws in 1950 were enacted. This analysis might determine the long-run effects of non-financial hurdles on human capital accumulation, one of the driving forces of Korean economic growth.

Table 3.1 Variables for estimating how land inequality affects on education -- Summary of the literature

Variables		Galor et al. (2009)	Cinnirella and Hornung (2011)	This paper
Main variables	Dependent variable	Educational expenditure	School enrollment rate	School enrollment rate
	Explanatory variable	Land concentration	Land concentration	Land concentration
Economic control	Income per capita	✓		
	Urban (share)	✓		
	Industrial (share)		✓	✓
	Agricultural (share)		✓	✓
Demographic control	Population growth rate			✓
	Population density		✓	
Education	School density		✓	✓
Historical context	Ethnicity/Language (share)	✓	✓	✓
	Religion (share)		✓	
	Law		✓	

Table 3.2 Descriptive statistics of the Annual Statistical Report of the Government-General

Variable	Definition	Mean	Std. Dev.	Min	Max
Education	The number of public elementary school students relative to the total population	0.0038	0.0023	0.0011	0.0094
Land inequality	The number of tenant households relative to the total number of farming households	0.8011	0.1248	0.4545	0.955
Agriculture	The number of farmers relative to the total population	0.7283	0.116	0.3612	0.875
Manufacturing	The number of workers in the manufacturing sectors relative to the total population	0.0344	0.024	0.0096	0.1165
Commerce and transportation	The number of workers in commerce and transportation over population	0.0898	0.0403	0.044	0.204
Rate of population growth	The increase in the province's population from year t-1 to t	0.0276	0.0273	-0.0194	0.1389
Japanese	The number of Japanese people relative to the total population	0.0271	0.0175	0.0087	0.0666
School density	The number of public elementary schools per 1,000 people	0.0117	0.0056	0.0033	0.0262

Note: These data aggregate individual-level data to the regional level, thus reflecting average behavior at the province level in Korea.
Source: the Annual Statistical Report of the Government-General

Table 3.3 Correlations among variables

	Education	Land inequality	Agriculture	Manufacture	Commerce and Transportation	Population growth	Japanese
Education	1						
Land inequality	-0.2329	1					
Agriculture	-0.7902	0.523	1				
Manufacturing	0.7186	-0.4665	-0.941	1			
Commerce and transportation	0.7297	-0.4619	-0.9413	0.9188	1		
Population growth	0.296	-0.2857	-0.5721	0.5515	0.5589	1	
Japanese	0.9857	-0.3412	-0.8574	0.7868	0.7848	0.3671	1

Table 3.4 The relationship between education and land inequality (Fixed effects model with one-year lag)

Explanatory variables	Dependent variable: Education						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Land inequality	**-0.0189***** 0.0051	**-0.0231***** 0.0048	**-0.0195***** 0.0056	**-0.0228***** 0.0048	**-0.0228***** 0.0048	**-0.0248***** 0.0044	**-0.0247***** 0.0046
Agriculture		**-0.0031***** 0.0007					
Manufacturing			**0.0009** 0.0031				
Commerce and transportation				**0.0061****** 0.0016	**0.0078***** 0.0029	**0.0029** 0.0021	**0.0029** 0.0022
Rate of population growth					**-0.0022** 0.0014	**-0.0039***** 0.0014	**-0.0038***** 0.0014
Japanese						**0.0571***** 0.0139	**0.0566***** 0.0147
School density							**0.0031** 0.0253
National time fixed effect	yes	yes	yes	yes	yes	yes	yes
Regional fixed effect	yes	yes	yes	yes	yes	yes	yes
R^2 (within)	0.3285	0.4484	0.3291	0.4314	0.4472	0.5430	0.5431
Number of observations	104	104	104	104	104	104	104

Two-way fixed effect model using country level panel data aggregated to the province level
Note: ***denotes significance at the 1% level, ** at 5%, and * at 10%.

Table 3.5 The relationship between education and land inequality (Fixed effects model with two-year lag)

Explanatory variables	Dependent variable: Education						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Land inequality	**-0.0148****	**-0.0195*****	**-0.0099**	**-0.0199*****	**-0.0198*****	**-0.0203*****	**-0.0208*****
	0.0059	0.0058	0.0064	0.0061	0.0061	0.0060	0.0063
Agriculture		**-0.0029*****					
		0.0010					
Manufacturing			**-0.0070***				
			0.0038				
Commerce and transportation				**0.0052****	**0.0046***	**0.0014**	**0.0012**
				0.0021	0.0027	0.0031	0.0032
Rate of population growth					0.0006	-0.0006	-0.0007
					0.0016	0.0017	0.0018
Japanese						**0.0340***	**0.0364**
						0.0184	0.0203
School density							**-0.0100**
							0.0337
National time fixed effect	yes	yes	yes	yes	yes	yes	yes
Regional fixed effect	yes	yes	yes	yes	yes	yes	yes
R^2 (within)	0.2707	0.3446	0.3050	0.3271	0.3286	0.3607	0.3615
Number of observations	91	91	91	91	91	91	91

Two-way fixed effect model using country level panel data aggregated to the province level

Note: ***denotes significance at the 1% level, ** at 5%, and * at 10%.

Table 3.6 The relationship between education and land inequality (Fixed effects model with no lag)

Explanatory variables	Dependent variable: Education						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Land inequality	**-0.0060**	**-0.0118*****	**-0.0070**	**-0.0100****	**-0.0105****	**-0.0143*****	**-0.0108*****
	0.0048	0.0045	0.0053		0.0046	0.0038	0.0041
Agriculture		**-0.0037*****					
		0.0007					
Manufacturing			**0.0013**				
			0.0029				
Commerce and transportation				**0.0067*****	**0.0079*****	**0.0003**	**0.0019**
				0.0017	0.0018	0.0019	0.0020
Rate of population growth					**-0.0022**	**-0.0041*****	**-0.0043*****
					0.0015	0.0012	0.0012
Japanese						**0.0871*****	**0.0782*****
						0.0132	0.0134
School density							**0.0426****
							0.0210
National time fixed effect	yes	yes	yes	yes	yes	yes	yes
Regional fixed effect	yes	yes	yes	yes	yes	yes	yes
R^2 (within)	0.2199	0.3844	0.2217	0.3367	0.3520	0.5600	0.5865
Number of observations	117	117	117	117	117	117	117

Two-way fixed effect model using country level panel data aggregated to the province level

Note: ***denotes significance at the 1% level, ** at 5%, and * at 10%.

Chapter 4. The Trade-off between Fertility and Education: Evidence from the Korean Development Path

4.1 Introduction

Unified growth theory suggests that the demographic transition and the associated rise in human capital formation were critical forces in the transition of the world economy from Malthusian stagnation to modern economic growth. The rise in the demand for human capital in the course of industrialization induced parents to increase their children's level of education and thus reduce their fertility rate (Galor, 2011, Galor and Weil, 2000).

Empirical studies of the Unified Growth Theory have primarily focused on the slow transition of Western Europe and its offshoots from the Malthusian epoch to the modern growth regime, abstracting from the important and more rapid transition process of the underdeveloped regions in Asia and African. Focusing on these important regions, this paper establishes that the demographic transition and the associated quantity-quality trade-off was indeed an important component of Korea's transition from an underdeveloped economy in the 1970s to an advanced economy in the subsequent decades.

As Figure 4.1 shows, the Korean transformation from an underdeveloped to an advanced economy was associated with a demographic transition. This chapter suggests that the quantity-quality trade-off played a critical role in this transition from a Malthusian regime in Korea to a modern economy. This trade-off is therefore likely to be a significant factor in the development process of other underdeveloped countries as well.

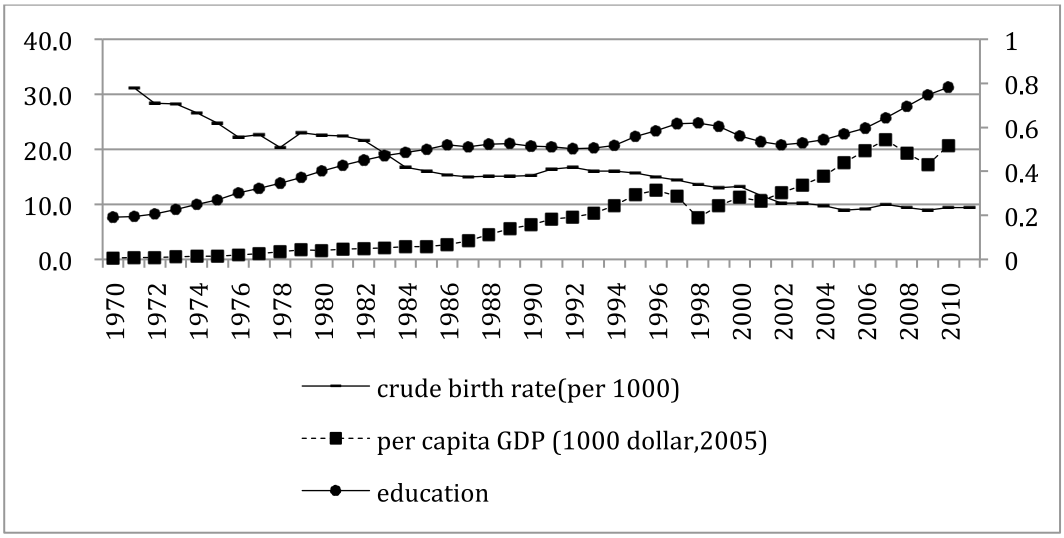


Figure 4.1 The trends in education, CBR, and GDP per capita
Source: Korean Population and Housing Census and Education Statistics

Recent research has established, using a variety of identification strategies, the importance of the quantity-quality trade-off in the transition of a wide range of European societies from stagnation to growth in the nineteenth century. This trade-off was found particularly in Prussia (Becker et al., 2010), England (Klemp and Weisdorf, 2011), Ireland (Fernihough, 2011), France (Murphy, 2010), and Spain (Basso, 2012).

I analyze panel data on fertility and school enrollment rates in 11 regions across 10 time points at 5-year intervals during the period 1970–2010. I use the high school enrollment rate (the number of high school students per person in the 15–19 age group) as an indicator of child education and the crude birth rate (CBR; number of births per 1,000 people in a year) to measure parents' fertility. As will become apparent, although the Korean government's 1961 fertility control policy contributed to a fertility decline over this period, regional variations allow us to capture the relationship between fertility and education.

The empirical analysis in this paper is based on a first-order difference model. I control for unobserved regional-level factors that may affect both fertility and education. The panel data also allow us to control for regional and national time trends. The empirical results, which are consistent with the Unified Growth Theory, show a significant negative relationship between child education and parents' fertility. These results are robust to the use of alternative measures of fertility and lagged variables. The causation between fertility and education needs further elucidation to provide a sound basis for the trade-off theory.

The remainder of this paper proceeds as follows. Section 4.2 explains the theoretical background and reviews the related literature. Section 4.3 describes the empirical analysis and presents the results. Finally, section 4.4 provides the concluding remarks.

4.2 Theoretical Background and Related Literature

A demographic transition characterized by decreasing fertility and a falling population growth rate is crucial for society to escape from the Malthusian trap and emerge as a modern economy. Without such a demographic transition, the increasing output resulting from technological progress would be canceled out by an increasing population, and GDP per capita would remain stagnant. The first such demographic transition occurred in Western Europe in the late nineteenth century and provided sustained economic benefits from the Industrial Revolution, which began in the late eighteenth century.

The time gap between the beginning of the Industrial Revolution in the late eighteenth century and the demographic transition in the late nineteenth century has several possible explanations. Becker et al. (1960) and Becker and Lewis (1973) argue that increasing income from the Industrial Revolution led to a decline in fertility because of the opportunity cost of raising children. Child quality has a higher income elasticity than does child quantity, creating a quantity-quality trade-off. This argument, however, cannot explain the historical fact that the demographic transition occurred simultaneously in most of Western Europe despite an income gap between the countries. Moreover, they postulate, in the context of this argument, that all individuals have the same preference for child quality and quantity, an assumption that potentially contains bias (Galor, 2011).

Demographers also argue that falling infant and child mortality prior to the change in fertility was the major cause of the demographic transition. According to this argument, lower infant and child mortality implies that more children survive and, thus, parents give birth to fewer children because they are chiefly concerned about the number of surviving children. However, Doepke (2005) shows empirically that the change in the net reproduction rate is explained by not only the change in infant and child mortality but another factor as well. Murphy (2010) also shows, through empirical research with French data, that decreasing infant mortality has no effect on decreasing fertility.

Following another approach, Caldwell (1976) and Morand (1999) try to explain the demographic transition using a household utility function that models old-age-support rather than parental altruism. In their argument, children are an investment good for their parents in the absence of a financial market. In the modern era, with developed financial markets, parents have fewer children because they have other ways of investing for old age. However, their argument is not logical, considering that the young of all natural species seldom care for their parents. Furthermore, the fact that financial institutions that provide insurance for old age existed before the demographic transition began weakens their argument (Hindle, 2004; Pelling and Smith, 1994). Moreover, although the rich have greater access to financial intermediaries, they do not tend to have fewer babies than the poor do. Therefore, the old-age security hypothesis is not sufficient to explain the demographic transition.

Galor and Weil (1999, 2000), Galor and Moav (2002, 2004), and Galor (2011) suggest that technological progress due to the Industrial Revolution increased the demand for human capital. This increasing demand accelerated in the late nineteenth century, inducing parents to decrease their fertility and increase their children's education level. In other words, they made a quantity-quality trade-off. Accelerating technological progress, accompanied by increasing parental income, affected the rate of population growth in two ways. First, increasing parental income released the parental budget constraint, making room for investment in both quality and quantity of children. Second, increasing technology led parents to reallocate their budget toward investments in their children's quality rather than quantity. This process created a virtuous cycle: technological progress increased demand for human capital, which promoted further technological progress, which encouraged still more human capital, which promoted parental investment in children's quality and a decreasing fertility rate. Thus released from the Malthusian trap, the economy achieved modern growth.

Empirical evidence for the quality-quantity trade-off continues to accumulate. Using data from Anglican parish registers of the period c. 1700–1830, Klemp and Weisdorf (2011) show a quantity-quality trade-off in England during the Industrial Revolution. Murphy (2010) also provides evidence of a quantity-quality trade-off in France, using data from 1876 to 1896. He shows that neither republicanism nor political participation during the French Revolution had a significant effect on fertility, whereas the proportion of children in school did. This implies that, along with cultural factors, the quantity-quality trade-off played a significant role in decreasing fertility. Moreover, he shows that financial development has a slightly negative effect on fertility, providing weak evidence for the old-age-security hypothesis. Becker et al. (2010) demonstrate a quantity-quality trade-off in nineteenth-century Prussia even before industrialization began. As instrumental variables, they use inequality in landownership and distance to Wittenberg, where Luther delivered a sermon that every Christian should be able to read the Bible. They find that education preferences have a significant relationship with fertility. Fernihough (2011) compares two Irish cities, Belfast and Dublin, using a data set of Irish families dating from 1911, and confirms the existence of a quantity-quality trade-off, particularly in industrialized cities. Basso (2012) also presents the negative and causal effect of children's education on parents' fertility using Spanish provincial-level data of the early twentieth century.

Most of this study considers Western industrialized countries, which achieved industrialization in the nineteenth century. However, an increasing demand for human capital, along with industrialization and the quantity-quality trade-off, may also have played an important role in the development paths of twentieth-century Asian countries. This question is important in that we could offer a meaningful blueprint for economic growth to countries still caught in the Malthusian trap if the newly industrialized Asian countries followed the Western-led development path.

According to Bloom and Williamson (1997), the demographic transition and its cohort effect are major factors in the Asian economic miracle, including Korean economic development. They argue that the demographic transition resulted in a growing working-age population from 1965 to 1990, temporarily expanding per capita productivity. However, they do not consider the relationship between the decreasing quantity and increasing quality of children. Analyzing the effect of human capital policies, Doepke (2004) also describes the fertility transition in Korea in the middle of the twentieth century. He shows that education reform and child labor regulation played an important role in Korea's demographic transition and growth by lowering the opportunity cost of education. He also points out that the share of skilled labor increased from 5% in 1950 to 70% in 2000. None of these papers, however, demonstrated a quantity-quality trade-off in Korea. Thus, to capture the link between the demographic transition, increasing income per capita, and increasing share of skilled labor, I must show that such a trade-off does exist.

To do so, this paper uses the quantity-quality framework described above to derive a simple model explaining this trade-off in the spirit of Galor (2012). Suppose the household's utility function is based on altruism and consists of consumption, c, number of (surviving) children, n, and the human capital of each child, h.

$$u = (1-\gamma)\ln c + \gamma[\ln n + \beta \ln h] \quad (1)$$

where $0 < \gamma < 1$ and $0 < \beta < 1$ are constant parameters. Here, β is the preference for education.

Then, the unit cost of raising a child with education level e is $\tau^q + \tau^e e$, where τ^q is the fraction of the household's unit-time endowment needed to raise a child and τ^e is the fraction of the household's unit-time endowment needed to give the child education level e.

Suppose also that the household's budget constraint is one unit of time. If the household uses its entire budget to earn income, its labor wage will be y, which is allocated toward parental consumption and the cost of raising children.

$$yn(\tau^q + \tau^e e) + c \le y \quad (2)$$

Suppose that an individual's accumulated human capital depends on his level of education and his technological environment. If technology changes rapidly, existing human capital will become less adaptable, but education can improve its adaptability. Thus, the time needed to learn new technology is shorter when the level of education is high or when the speed of technological change is low. Therefore, a child's level of human capital, h, is a function of his or her education and the technological environment.

$$h = h(e, g) \tag{3}$$

where g is the rate of technological progress and h is an increasing, strictly concave function of e and a decreasing, strictly convex function of g.

Then, the household's optimization leads to the optimal quantity and quality of children.

$$n = \gamma / (\tau^q + \tau^e e) \tag{4}$$

$$\tau^e h(e, g) = \beta h_e(e, g)(\tau^q + \tau^e e) \tag{5}$$

Given the parameters of the economy $(g, \beta, \tau^e, \tau^q)$, I can determine the household's optimal quantity and quality of children as follows:

$$e = e(g, \beta, \tau^e, \tau^q) \tag{6}$$

$$n = \gamma / [\tau^q + \tau^e e(g, \beta, \tau^e, \tau^q)] \tag{7}$$

Equations (4) and (7) show the negative relationship between the quantity and quality of children. This quantity-quality trade-off depends on the cost of child rearing, the cost of education, the household's preference for education β, and the rate of technological progress g.

4.3 Empirical Analysis

4.3.1 Data Description

The data for this analysis were obtained from the Korean Population and Housing Census for 1966–2010. Since 1925, the census has been collecting demographic, educational, and economic information on the population every 5 years. Although the census gathers data on every individual, only aggregated data, categorized into administrative division, are open to the public. I also used data from Education Statistics, which has been collecting information every year since 1963 on every educational institution, including preschools, elementary schools, middle schools, high schools of all types, colleges, graduate schools, and other advanced education institutions From these data sets, I create a panel of 11 regions and 10 time points (1970–2010, every 5 years).

The dependent variable fertility is measured by the crude birth rate (CBR), the number of births per 1,000 people per year in province i in period t. The major explanatory variable, level of education, is the high school student ratio, defined as the number of high school students divided by the number of people aged 15–19 years eligible for high school enrollment in province i in period t. The actual rate may be higher than the computed rate because the population aged 15–19 years includes some middle school students as well. This computed enrollment rate varied regionally from 15% to 25% in 1970 and from 53% to 60% in 2010. This paper argues that most of this variation stems from the variation in human capital demand across regions and time. The high school enrollment rate is more appropriate than the primary school enrollment rate for this analysis because, after the education reform in 1950, every Korean was required to enter into primary school, so the gross primary school enrollment rate was already over 100% by the 1980s. The high school enrollment rate is also more appropriate for this study than is the college enrollment rate because regional mobility for college entry is extremely high.

(Insert Table 4.1)

As shown in Table 4.1, the control variables in the model are the share of married women, defined as the number of married women aged 15–44 years divided by the total number of women aged 15–44 years in province i in period t; the share of agriculture, defined as the number of people making a living from agriculture, forestry, and fisheries divided by the number of employed people in province i in period t; and the level of urbanization, defined as the number of people employed in the service sector divided by the population of province i in period t. Table 4.2 provides the definitions and summary statistics of the variables.

(Insert Table 4.2 here)

This paper uses country-level data, which aggregate individual data to a regional level, reflecting average behavior in a province. Therefore, the variables in this study share some common features with those of Becker et al. (2012), which uses country-level data to reflect regional differences.

4.3.2 Empirical Specification: First-Difference Model

The empirical analysis examines the effect of education on fertility. I use the following empirical specification:

$$Fertility_{i,t} = \beta_0 + \beta_1 Education_{i,t} + BX_{i,t} + \upsilon_{i,t} \quad (8)$$

where the X s are vectors of the control variables described above. This formula captures the fact that the current economic, social, and educational conditions affect a household's fertility decisions.

There could be some unobserved factors that are correlated with education and affect fertility at the province level. Such factors would threaten a causal interpretation of the results. To solve this problem, I control for regional fixed effects, which represent time-invariant unobserved heterogeneity in fertility across the provinces, η_i , where

$$\upsilon_{i,t} = \eta_i + e_{i,t} \quad (9)$$

A fixed-effects or first-difference model is chosen depending on the assumptions about the idiosyncratic error, $e_{i,t}$. The estimator from the first-difference model will be more efficient if $e_{i,t}$ is autocorrelated and $\Delta e_{i,t}$, is not serially correlated. A Wooldridge test for the null hypothesis of no first-order autocorrelation in $e_{i,t}$ gives a p-value of 0.0006, which is much less than 0.01. This result implies that there is no autocorrelation in $\Delta e_{i,t}$, and the first-difference model is appropriate in this context. Therefore, I examine the first difference of equation (8) and estimate the changes in fertility resulting from changes in education.

Moreover, there could be unobserved factors at the province level that affect both changes in education and changes in fertility. To remove this problem, I consider the linear unobserved heterogeneity across the provinces in the fertility time trend using a province fixed effect. These empirical strategies assume no correlation between changes in the explanatory variables and those in the error term, whereas the explanatory variables could be correlated with the error term.

If there are no time-constant explanatory variables, the partial effects can be estimated even in the presence of omitted variables, which could be correlated with the explanatory variables, by considering the time-invariant fixed effect in the error term (Wooldridge, 2010). None of the explanatory variables in this paper, such as the geographical characteristics of each province, are time constant. Therefore, this paper can capture the partial effect of education on fertility, controlling for regional fixed effects, even if there are omitted variables.

This paper also considers the time-invariant unobserved heterogeneity in fertility across the provinces, η_i, variations in the time effect at the national level, δ_t, and the linear unobserved heterogeneity in the fertility time trend across provinces, $\theta_i t$. That is,

$$\upsilon_{i,t} = \eta_i + \delta_t + \theta_i t + \varepsilon_{i,t} \tag{10}$$

Then, the first-difference model is

$$\Delta Fertility_{i,t} = \Delta\beta_1 Education_{i,t} + \Delta BX_{i,t} + \Delta\delta_t + \theta_i + \Delta\varepsilon_{i,t} \tag{11}$$

where $\Delta Fertility_{i,t} \equiv Fertility_{i,t+1} - Fertility_{i,t}$,

$\Delta Education_{i,t} \equiv Education_{i,t+1} - Education_{i,t}$, and $\Delta\delta_t \equiv \delta_{t+1} - \delta_t$, which are calculated at 5-year intervals between 1970 and 2010. The lag operator, Δ, is applied to the other variables in vector X . Given this changed empirical specification, there are 88 observations across 11 provinces.

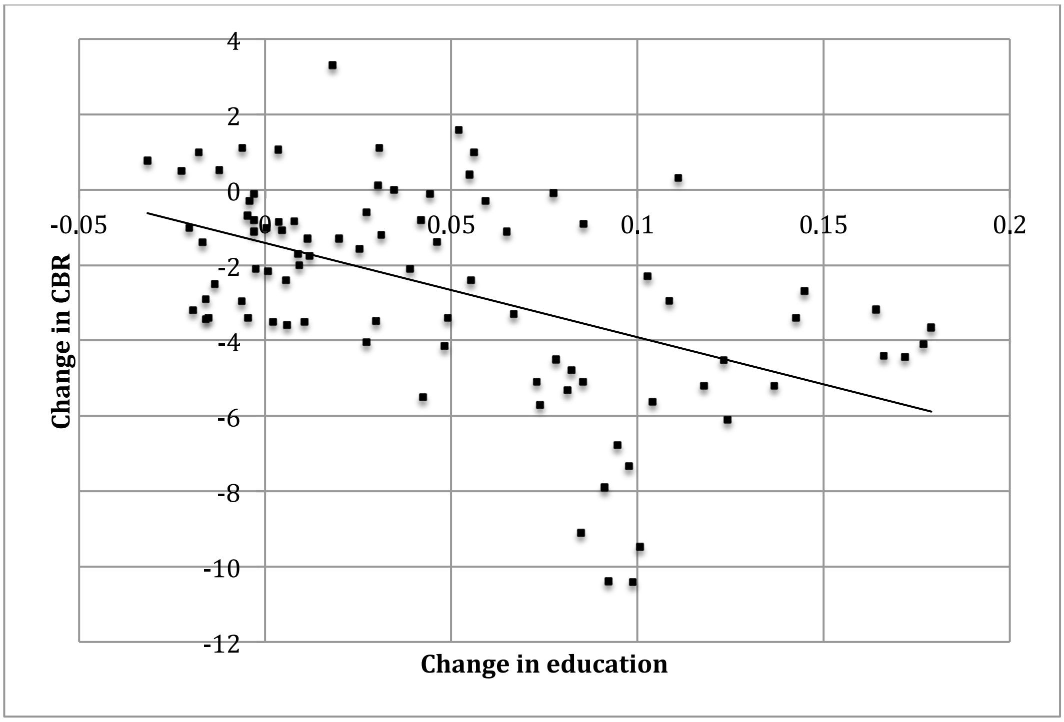


Figure 4.2 Regression analysis between education and crude birth rate (CBR)
Source: Korean Population and Housing Census and Education Statistics

The negative correlation between CBR change and education change is apparent in Figure 4.2 and is shown in the fitted values plotted from an OLS regression.

(Insert Table 4.3 here)
(Insert Table 4.4 here)

Table 4.3 presents the correlation between variables. Even without a time lag, a highly correlated relationship between CBR/child-woman ratio and education can be observed. All plus or minus signs are reasonable. However, a high correlation between the co-variables can cause a multicollinearity problem. The variance inflation factor (VIF) is tested to check for this problem. As depicted in Table 4.4, the VIF values are above 10, confirming that the multicollinearity problem does not exist.

(Insert Table 4.5 here)

Table 4.5 presents the results of these estimates from 1970 to 2010 in columns (1)–(11). A change in education causes a negative and highly significant change in the CBR when the following are controlled for: regional fixed effects only (column (1)), regional fixed effects and national time trends (column (2)), and regional fixed effects and regional time trends (column (7)). Moreover, the highly significant effect on the CBR holds when changes in the proportion of married women, farmers, and urban residents are controlled for. As one would expect, columns (3) and (8) present a positive effect on the CBR of a change in the proportion of married women and a negative and highly significant effect of the change in education.

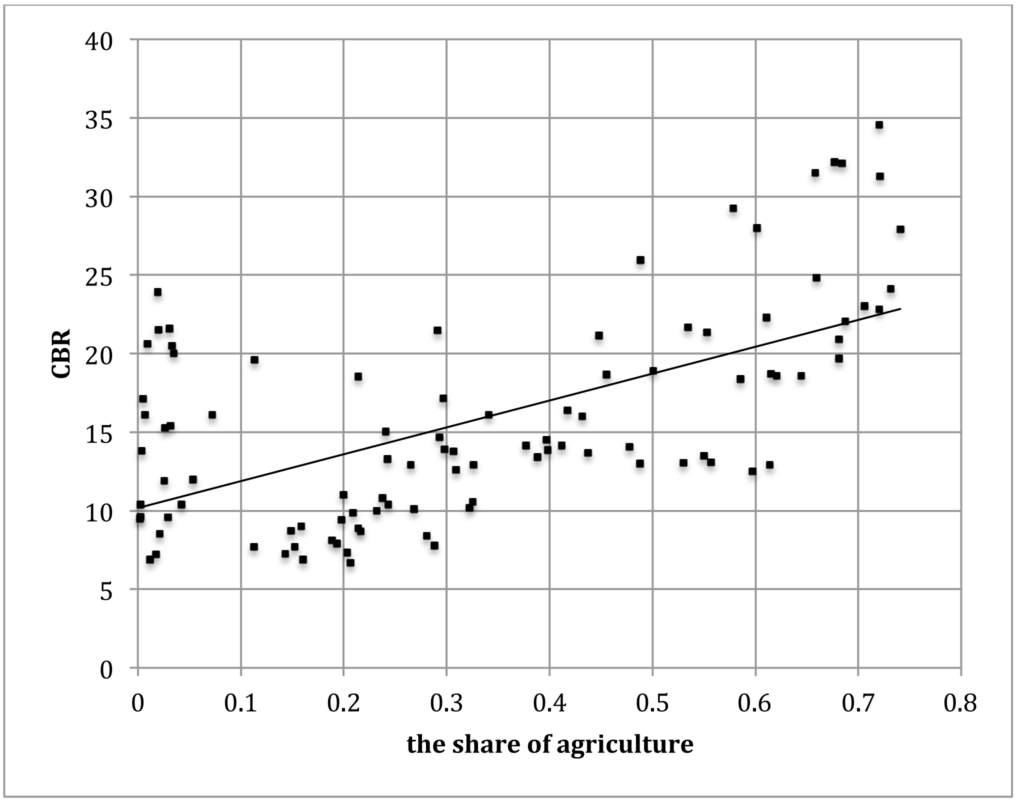


Figure 4.3 Regression analysis between agricultural population and crude birth rate (CBR)
Source: Korean Population and Housing Census

Contrary to my expectation, columns (4) and (9) present a negative but insignificant effect of the change in the share of agriculture on the CBR. Figure 4.3 shows that the relationship between the share of agriculture and the CBR is positive, but when regional fixed effects, the national time trend, and regional linear time trends are controlled for, the causal effect disappears. In columns (5) and (10), I observe a negative and significant effect on the CBR of a change in the proportion of urban residents. These results are reasonable because the proportion of urban residents, which measures the share of human-capital-demanding occupations, should encourage decreasing fertility. However, the significant effect disappears when the regional time trend is controlled for.

(Insert Table 4.6 here)

(Insert Table 4.7 here)

Table 4.6 shows how a change in education affects the CBR during the years 1970–1990. As Figure 1 shows, the CBR and the education level were stagnant over the late 1980s and early 1990s and changed again after the late 1990s. In the 1970s and 1980s, Korea transitioned from a Malthusian agricultural regime to a modern industrialized economy. As Young (1995) argues, from the 1960s to the 1990s, 84 percent of Korean output growth could be explained by factor accumulation, which is one of the characteristics of the transition period from a Malthusian to a modern growth economy, while only 7 percent of Korean output growth was explained by human capital accumulation, which is one of the driving forces of modern growth. Singh et al. (1996) also show that the driving force of growth changed from factor accumulation to TFP growth after the 1980s. Thus, the Korean growth regime has experienced a phase change since the 1990s, and human capital has become a prime engine of growth. As Porter (1990) points out, Korea's commitment to education is the most important and distinct factor in an analysis of the Korean economy of the 1980s. Because the quantity-quality trade-off is particularly important in the transition, I examine only the 1970–1990 period to test whether the trade-off existed during the transition period. I find that the highly significant effect of the change in education on the CBR holds in every case, as shown in Table 4.6.

Table 4.7 presents the results for the years 1990–2010. In this case, the absolute value of the coefficient representing the negative effect of the change in the education level on the CBR is lower compared to the 1970–1990 value. Moreover, the significance disappears with the regional time trend controlled for. This means that the quantity-quality trade-off observed in the transition from a Malthusian economy to a modern growth regime occurred in Korea from 1970 to 1990.

(Insert Table 4.8)

As shown in Table 4.8, I measure fertility as the child-woman ratio, defined as the number of children aged 0–4 per woman of child bearing age (15–44), as in Becker et al. (2010), to check the robustness of the above results. The highly significant effect on fertility of the change in education holds.

I further test the robustness of the results using the following empirical specification to capture lags in fertility changes with respect to current economic, social, and educational conditions.

$$Fertility_{i,t} = \beta_0 + \beta_1 Education_{i,t-1} + BX_{i,t-1} + \upsilon_{i,t} \tag{12}$$

where the period of observation is 5 years, so when t is 1975, t-1 is 1970, and so on, through 2010.

In the same way, I try to control for time-invariant unobserved heterogeneity in fertility across provinces, η_i ; variations in the time effect at the national level, δ_t ; and linear unobserved heterogeneity in the time trend of fertility across provinces, $\theta_i t$. Then, the first-difference model is

$$\Delta Fertility_{i,t} = \Delta\beta_1 Education_{i,t-1} + \Delta BX_{i,t-1} + \Delta\delta_{t-1} + \theta_i + \Delta\varepsilon_{i,t} \tag{13}$$

where $\Delta Fertility_{i,t} \equiv Fertility_{i,t+1} - Fertility_{i,t}$

$\Delta Education_{i,t-1} = Education_{i,t} - Education_{i,t-1}$, and $\Delta\delta_{t-1} = \delta_t - \delta_{t-1}$, which are calculated at 5-year intervals between 1970 and 2010.

The negative correlation between a CBR change and the lagged change in education is apparent in Figure 4.4 and is shown in the fitted values plotted from an OLS regression.

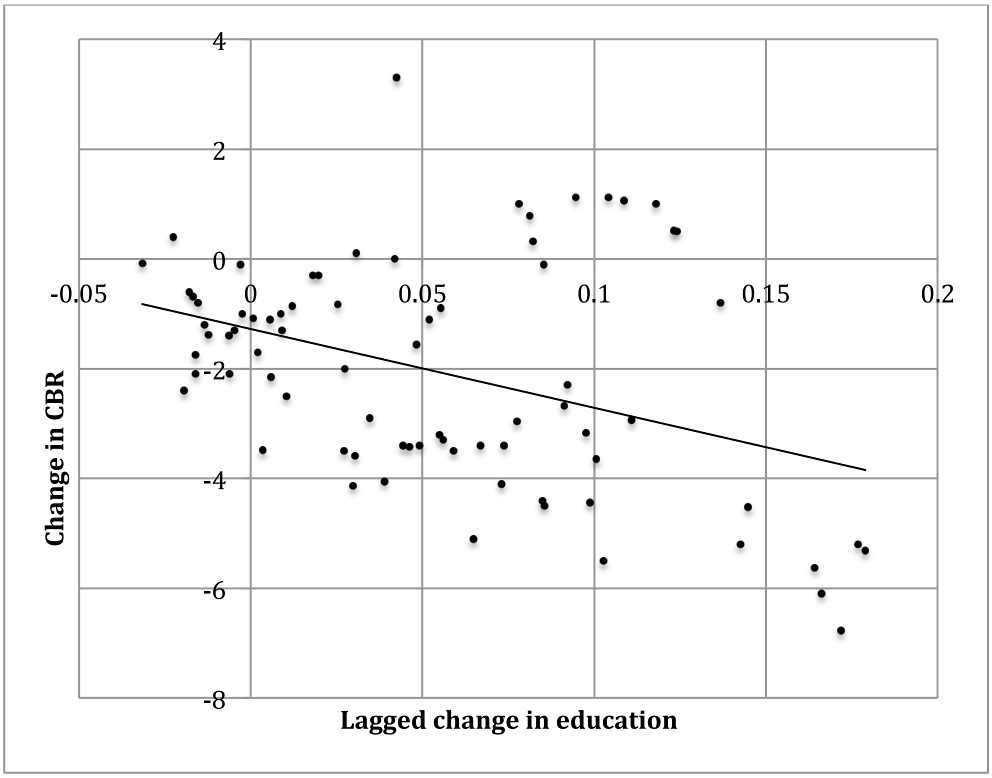


Figure 4.4 Regression analysis between lagged change in education and crude birth rate (CBR)
Source: Korean Population and Housing Census and Education Statistics

(Insert Table 4.9 here)
(Insert Table 4.10 here)

Tables 4.9 and 4.10 show the effects of lagged changes in education on the CBR for 1970–2010 and 1970–1990, respectively. The highly significant effect on the CBR of the lagged changes in education holds in every case in both Tables 4.6 and 4.7.

(Insert Table 4.11 here)

As Table 4.11 shows, measuring fertility using the child-woman ratio instead of the CBR also indicates that changes in education have a highly significant effect on fertility.

4.4 Conclusion

The transition from a Malthusian economy to a modern growth economy, first triggered in late eighteenth-century England, was one of the most significant events in human history. Even though productivity increased before the transition, it was counterbalanced by an increasing population (Ashraf and Galor, 2011). With the emergence of the modern economy, however, GDP per capita could now substantially increase. Unified growth theory suggests that the transition from stagnation to modern growth is associated with a rise in the demand for human capital in the course of industrialization and its adverse effect on fertility rates, which allows income per capita to increase (Galor, 2011, Galor and Weil, 2000, Galor and Moav, 2002).

Consistent with previous empirical findings, primarily from the European continent, this paper aims to show the existence of a quantity-quality trade-off in Korea. It finds that regions with higher levels of education have lower fertility. Using a first-difference model with panel data on 11 provinces for the years 1970 to 2010, controlled for unobserved heterogeneity, the study finds a significant correlation between increasing education and decreasing fertility. The finding, however, does not indicate causality between the variables. Further research is necessary to confirm the quantity-quality trade-off. An index of change in the technological environment, which is a driver of human capital demand in Korea, might be a possible and favored instrument variable in a future study. This analysis found a virtuous cycle in the Korean development path, where technological progress increased the demand for human capital, leading to an increase in the level of education and, in turn, to a demographic transition. Furthermore, I hope that the Korean development path, unveiled in this paper, will suggest important policy implications for underdeveloped countries still trapped in a Malthusian economy.

Table 4.1 Variables to estimates of the quantity-quality trade-off -- Summary of previous literature

Variables		Becker et al. (2012)	Fernihough (2011)	Murphy (2010)	Klemp and Weisdorf (2011)	This paper
Main Variables	Quantity	Child-women ratio	Sibship size	Fertility	Sibship size	CBR/Child-woman ratio
	Quality	School enrollment rate	School attendance	School enrollment rate	Literacy	School enrollment rate
Economic control	Income			✓		
	Savings			✓		
	Industry	✓		✓	✓	
	Agriculture	✓				✓
	Urban	✓		✓		✓
	Retail				✓	
	Social class	✓			✓	
Demographic control	Population density	✓				
	Infant mortality		✓	✓		
	Net immigration			✓		
	Foreigners	✓	✓	✓		
	Married women	✓				✓
	Marital duration		✓		✓	
	Parental age		✓		✓	
	Life expectancy	✓				
Education	Parental Literacy		✓	✓	✓	
Culture	Religious group	✓	✓	✓	✓	
	Political group			✓		
Data	Data level	Country	Individuals	Département	Family	Country
	Data type	Cross sectional data	Cross sectional data	Panel data	Cross sectional data	Panel data
	Control for endogeneity	IV	IV	IV	IV	None
Instrument Variables		Distance from Wittenberg/Landownership inequality	The presence of twin or multiple births	Climate	Fecundability	None

Table 4.2 Descriptive statistics of the Korean Population and Housing Census and Education Statistics

Variable	Definition	Mean	Std. Dev.	Min	Max
Crude Birth Rate	The number of births per 1,000 people per year	15.7564	6.7014	6.7	34.55
Child-woman ratio	The number of children aged 0-4 per each woman of child bearing age (15-44)	0.3766	0.1704	0.1558	0.8585
Education	The number of high school students divided by the number of people aged 15-19who are eligible for high school	0.4636	0.1390	0.1505	0.6079
Married woman	The number of married woman in age 15-44 per the number of woman in age 15-44	0.5681	0.0584	0.3819	0.7014
Agriculture	The number of people making their living of agriculture, forestry and fisheries per the number of employed people	0.3264	0.2352	0.0020	0.7406
Urban	The number of people employed in service sector per population	0.0775	0.0448	0.0229	0.2078

Source: Korean Population and Housing Census and Education Statistics

Table 4.3 Correlation between variables

	Crude Birth Rate	Child-woman ratio	Education	Married woman	Agriculture	Urban
Crude Birth Rate	1					
Child-woman ratio	0.9316	1				
Education	-0.9219	-0.9092	1			
Married woman	0.6484	0.6813	-0.5216	1		
Agriculture	0.6005	0.7529	-0.5431	0.5127	1	
Urban	-0.7372	-0.7206	0.6099	-0.7402	-0.6462	1

Note: Variables are from country-level data aggregates individual-level to a regional-level, thus reflect average behavior in a province-level.
Source: the Korean Population and Housing Census and the Education Statistics

Table 4.4 Variance Inflation Factor between the variables

Variable	VIF	1/VIF
Education	1.72	0.581551
Married Woman	2.25	0.443701
Agriculture	1.83	0.546424
Urban	3.02	0.330973
Mean VIF	2.21	

Table 4.5 The Relationship between education and fertility over 1970-2010 (First-differencing Model)

Explanatory variables	Dependent variable: ΔCBR										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Δeducation	**-37.8918*** **	**-58.5187*** **	**-44.8540*** **	**-45.6221*** **	**-44.3851*** **	**-44.1441*** **	**-25.5423*** **	**-27.0925*** **	**-26.6165*** **	**-27.1001*** **	**-23.4707*** **
	4.2904	8.7894	8.2499	8.3700	8.0210	7.9759	4.3425	4.6549	4.7471	4.6539	4.7710
Δmarried woman			**35.5249*** **	**34.4878*** **	**38.0224*** **	**38.4501*** **		**14.3905** **	**8.2834**	**14.3854** **	**9.0657**
			9.1899	9.3314	7.8491	7.8434		6.0925	5.9272	6.3506	6.0102
Δagriculture				**-2.8670**		**0.8033**			**-15.3305**		**-18.4484** **
				2.3644		3.4311			9.5728		8.2869
Δurban					**-21.6762** **	**-22.8663***				**-0.0510**	**20.3270**
					10.7633	13.5047				9.2311	13.1871
National time trend		yes	yes	yes	yes	yes					
Regional linear time trend							yes	yes	yes	yes	yes
R^2	0.5325	0.7918	0.8286	0.8302	0.8387	0.8387	0.6224	0.6433	0.6916	0.6433	0.7014
Number of observations	88	88	88	88	88	88	88	88	88	88	88

Note: ***denotes significance at the 1% level, ** at 5%, and * at 10%

Table 4.6 The Relationship between education and fertility over 1970-1990 (First-differencing Model)

Explanatory variables	Dependent variable: ΔCBR										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Δeducation	**-38.8965*** **	**-63.4733*** **	**-43.6047*** **	**-43.5099*** **	**-44.6289*** **	**-44.6214*** **	**-31.0558*** **	**-31.2697*** **	**-18.7598*** **	**-29.2295*** **	**-19.0152*** **
	4.6450	8.8088	8.4688	8.8911	8.7281	9.1580	7.1132	6.2804	4.1775	6.2342	4.2778
Δmarried woman			**51.5131*** **	**52.9084*** **	**48.9903*** **	**50.2589*** **		**62.5890*** **	**-14.1701**	**61.5847*** **	**-15.5869**
			9.2092	9.9073	9.9803	10.7075		18.5965	16.7736	18.4908	17.8475
Δagriculture				**-6.3647**		**-6.8495**			**-58.2885*** **		**-59.562*** **
				7.5044		7.6879			7.7523		8.3144
Δurban					**-14.8643**	**-16.2376**				**30.7769** **	**-7.9758**
					14.8237	13.7786				11.8847	11.3843
National time trend		yes	yes	yes	yes	yes					
Regional linear time trend							yes	yes	yes	yes	yes
R^2	0.6317	0.8046	0.8577	0.8602	0.8598	0.8627	0.6794	0.7456	0.8958	0.7559	0.8964
Number of observations	44	44	44	44	44	44	44	44	44	44	44

Note: ***denotes significance at the 1% level, ** at 5%, and * at 10%

Table 4.7 The Relationship between education and fertility over 1990-2010 (First-differencing Model)

Explanatory variables	Dependent variable: ΔCBR										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Δeducation	**-25.5463****	**-21.1081****	**-22.1035*****	**-23.2604****	**-22.5524*****	**-22.6944****	**9.1213**	**12.9467**	**-0.5602**	**9.6385**	**-4.0277**
	10.0949	7.8818	7.7460	9.1304	7.6010	8.5442	14.5222	18.2140	19.0650	19.3880	19.4284
Δmarried woman			**4.7257**	**3.2283**	**8.2949**	**8.0563**		**-4.8794**	**-6.8153**	**-5.5244**	**-7.4882**
			6.2576	5.7537	7.6398	6.9807		5.2522	4.4623	5.4265	4.8774
Δagriculture				**-1.7092**		**-0.2185**			**-40.9974****		**-41.1822****
				4.5191		4.2982			16.6275		15.9681
Δurban					**-7.4510**	**-7.3527**				**-9.6183**	**-9.9043**
					9.4946	9.2981				18.8612	18.9489
National time trend		yes	yes	yes	yes	yes					
Regional linear time trend							yes	yes	yes	yes	yes
R^2	0.1020	0.8577	0.8598	0.8601	0.8630	0.8630	0.6451	0.6543	0.7135	0.6630	0.7227
Number of observations	44	44	44	44	44	44	44	44	44	44	44

Note: ***denotes significance at the 1% level, ** at 5%, and * at 10%

Table 4.8 Robustness check: The Relationship between education and fertility over 1970-2010 using child-woman ratio to measure the fertility (First-differencing Model)

Explanatory variables	Dependent variable: Δ child-woman ratio										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Δeducation	**-0.8777*** **	**-1.0403*** **	**-0.5399*** **	**-0.5272*** **	**-0.5340*** **	**-0.5219*** **	**-0.5471*** **	**-0.6054*** **	**-0.6080*** **	**-0.5761*** **	**-0.5769*** **
	0.0810	0.1079	0.0889	0.0884	0.0877	0.0872	0.0921	0.0835	0.0834	0.0903	0.0902
Δmarried woman			**1.3007*** **	**1.3176*** **	**1.3323*** **	**1.3478*** **		**0.5423*** **	**0.5911*** **	**0.5618*** **	**0.6140*** **
			0.1325	0.1315	0.1318	0.1309		0.1209	0.1292	0.1232	0.1317
Δagriculture				**0.1322**		**0.1280**			**0.1436**		**0.1498**
				0.0817		0.0906			0.1348		0.1351
Δurban					-0.2736*	**-0.2666***				**0.1959**	**0.2086**
					0.1520	0.1506				0.2277	0.2277
National time trend		yes	yes	yes	yes	yes					
Regional linear time trend							yes	yes	yes	yes	yes
R^2	0.5806	0.8180	0.9181	0.9207	0.9213	0.9238	0.7117	0.7721	0.7755	0.7743	0.7780
Number of observations	88	88	88	88	88	88	88	88	88	88	88

Note: ***denotes significance at the 1% level, ** at 5%, and * at 10%

Table 4.9 The Relationship between education and fertility over 1970-2010 (First-differencing Model with 5-years lag)

Explanatory variables	Dependent variable: ΔCBR										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Δeducation	**-25.9921*****	**-26.4383*****	**-27.2200*****	**-28.2181*****	**-27.1895*****	**-28.1813*****	**-15.6149*****	**-15.8948*****	**-16.0330*****	**-17.6326*****	**-17.7369*****
		2.9435	3.6238	3.4328	3.6509	3.4573	4.1576	4.1698	4.1668	4.4215	4.4188
Δmarried woman			**-2.0201**	**-3.4977**	**-1.8457**	**-3.2752**		**-7.9375**	**-11.9402**	**-7.5641**	**-11.4906**
			5.3976	5.1129	5.4833	5.1901		8.2196	9.0150	8.2045	9.0030
Δagriculture				**-10.1399*****		**-10.1664*****			**-7.2759**		**-7.1253**
				3.2766		3.2993			6.7697		6.7555
Δurban					**-1.5124**	**-1.9571**				**-13.0925**	**-12.8589**
					6.2836	5.9262				11.3092	11.3014
National time trend		yes	yes	yes	yes	yes					
Regional linear time trend							yes	yes	yes	yes	yes
R^2	0.4788	0.8897	0.8899	0.9035	0.8900	0.9037	0.5712	0.5773	0.5848	0.5860	0.5931
Number of observations	77	77	77	77	77	77	77	77	77	77	77

Note: ***denotes significance at the 1% level, ** at 5%, and * at 10%

Table 4.10 The Relationship between education and fertility over 1970-1990 (First-differencing Model with 5-years lag)

Explanatory variables	Dependent variable: ΔCBR										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Δeducation	**-23.5527*****	**-29.6308*****	**-24.6452*****	**-30.1001*****	**-24.2491*****	**-30.1759*****	**-34.6856****	**-49.6315*****	**-49.7014*****	**-49.4978*****	**-50.2811*****
	3.8203	3.5287	4.9420	3.8642	5.1015	4.0296	13.3867	13.5059	15.0868	13.7894	15.4777
Δmarried woman			**11.9187**	**8.1019**	**12.8135**	**7.9519**		**56.8043****	**56.6598****	**56.0911*****	**54.3801***
			0.4108	6.3430	8.7941	6.6843		23.0511	26.6817	23.5963	27.8275
Δagriculture				**-21.4251*****		**-21.4782*****			**-0.1962**		**-2.2330**
				4.3941		4.5154			16.8533		17.9307
Δurban					**4.8359**	**-0.7595**				**-10.3406**	**-11.3086**
					11.5054	8.7219				26.0449	27.8188
National time trend		yes	yes	yes	yes	yes					
Regional linear time trend							yes	yes	yes	yes	yes
R^2	0.5416	0.9124	0.9181	0.9557	0.9186	0.9557	0.5884	0.6808	0.6808	0.6833	0.6835
Number of observations	33	33	33	33	33	33	33	33	33	33	33

Note: ***denotes significance at the 1% level, ** at 5%, and * at 10%

Table 4.11 Robustness check: The Relationship between education and fertility over 1970-2010 using child-woman ratio to measure the fertility (First-differencing Model with 5-years lag)

Explanatory variables	Dependent variable: Δ child-woman ratio										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Δeducation	**-0.7343*** **	**-1.0361*** **	**-0.7906*** **	**-0.7894*** **	**-0.7833*** **	**-0.7826*** **	**-0.4958*** **	**-0.4746*** **	**-0.4868*** **	**-0.4870*** **	**-0.4964*** **
	0.0693	0.1158	0.1263	0.1277	0.1247	0.1262	0.0903	0.0830	0.0676	0.0888	0.0723
Δmarried woman			**0.6345*** **	**0.6362*** **	**0.6763*** **	**0.6772*** **		**0.6024*** **	**0.2493***	**0.6051*** **	**0.2519***
			0.1881	0.1903	0.1873	0.1894		0.1636	0.1462	0.1648	0.1473
Δagriculture				**0.0114**		**0.0065**			**-0.6418*** **		**-0.6409*** **
				0.1219		0.1204			0.1098		0.1105
Δurban					**-0.3607***	**-0.3604***				**-0.0938**	**-0.0728**
					0.2146	0.2163				0.2272	0.1849
National time trend		yes	yes	yes	yes	yes					
Regional linear time trend							yes	yes	yes	yes	yes
R^2	0.5962	0.7572	0.7916	0.7916	0.7999	0.7999	0.6843	0.7387	0.8297	0.7394	0.8301
Number of observations	77	77	77	77	77	77	77	77	77	77	77

Note: ***denotes significance at the 1% level, ** at 5%, and * at 10%

Chapter 5. Financial Hurdles for Human Capital Accumulation: Revisiting the Galor-Zeira Model

5.1 Introduction

The relationship between inequality and growth has still been unsolved. In addition, an implicit linkage of them is ongoing debate. After Kuznets (1955), a number of researches, like Deininger and Squire (1996) and Banerjee and Duflo (2003), insisted that inequality and growth have correlated negatively and show inverted U-curve relationship using cross-country data, respectively. However, more important thing in terms of making policy for growth or reallocation is not just an interrelation itself but finding a channel from inequality to growth inside of reduced relationship. After finding the channel, we can get the answers of questions for growth; Is inequality good thing for growth? How does reallocation policy affect growth?

The channel from inequality to growth, in fact, has been studied in various ways. According to Alesina and Rodrik (1994) and Persson and Tabellini (1994), inequality affects growth via fiscal channels, which are taxation and government expenditure. By the fiscal policy that decided by the major voting, government distributes the money to all people evenly and gathers the tax from individuals' income. Therefore in more equally distributed societies, there are less demand for the reallocation, which means less taxation, and more investment resulting in more growth. Alesina and Perotti (1996) also argued the importance of sociopolitical stability as the channel. They insisted that there is a tendency of pursuing the lent-seeking activity in more instable sociopolitical circumstance and, then, there is more uncertainty and disturbance of market economy. Therefore, inequality is harmful for growth from their point of view. The previous studies, which focus on the fiscal channel and sociopolitical channel, used cross-country data to prove their model.

Human capital channel, which is accumulated by education, with credit market imperfection provides famous explanations of inequality. Galor and Zeira (1993) constructed a macroeconomic model, referred to as Galor-Zeira model, showing that under credit constraint and different initial condition of wealth, there can be divergence of dynasty's wealth. They assume that there exists a wage gap between skilled and unskilled workers, which relies on individuals' level of education. However, few researches have verified the model empirically. Although Papageorgiou and Razak (2009) supports the model empirically, they used cross-country data to prove the model in the long run perspective, while Galor-Zeira model tells us more than the reduced relationship between inequality and growth. To prove the channel in detail of Galor-Zeira model, panel data at a national level is required for an accurate analysis on the intergenerational mobility through education. Moreover, if there exists ongoing divergence of wage gap in society, while the model assume to be constant wage of skilled worker and unskilled worker, there will happen faster divergence of dynasty's wealth.

In labor economics, of course, there have been lots of studies about intergenerational transfer of wealth with various channels using micro data, which contains the information of individuals. As Black and Devereux (2011) explained, economists and social scientists have been interested in intergenerational mobility including one stream that focuses on credit constraints, on which we also focus in this paper. In the context of researches such as Han and Mulligan (2001) and Grawe and Mulligan (2002), investment in human capital and existence of credit constraints are important in the channel of intergenerational mobility, even though they could not provide an evidence on the interrelation between inequality and growth.

In this paper, we expanded the Galor-Zeira model so that the economy had an endogenous technological progress and the government provided a financial aid to support a college attendance. Furthermore, we verified our model using Korean panel data. Our research is attractive because of several reasons. First, being different from macro researches using cross-country data, we use national panel data to show the relationship between inequality and growth. To the best of our knowledge, there has not been any research to investigate the feasibility of the Galor-Zeira model empirically at a national level. Second, being different from original Galor-Zeira model, our research covers the growth rate of national economy, which is also proved empirically through Korean panel data. Although the original model of Galor and Zeira (1993) suggested that larger ratio of skilled labor would be beneficial to the size of the economy, it could not give clear statement about the growth rate of economy. Third, because we add the government side into the expanded model, we can get a standard of the reallocation policy in terms of growth, even though many people think that the policy for growth and that of inequality are contrary to each other.

The remainder of this paper proceeds as follows: In section 5.2, we present our model which expands the original Galor-Zeira model. In section 5.3, we present our empirical results using Korean data. Finally, concluding remarks are made in section 5.4.

5.2 Model

5.2.1 Basic model

Our model is an extension of the macroeconomic model of Galor and Zeira (1993). As in the original model, we consider a small open economy, which consisted of two-periods overlapping generations. Workers are divided into two heterogeneous categories, educated skilled labor and unskilled labor. Furthermore, the model in this paper deals with two more issues. One is education subsidy and the other is technological progress.

Skilled and unskilled labor sectors produce homogeneous goods and the price is a numeraire. The production functions are given by

$$Y_t = Y_t^s + Y_t^u$$
$$\begin{cases} Y_t^s = (A_t^s L_t^s)^{\alpha} (K_t^s)^{1-\alpha} \\ \quad Y_t^u = A_t^u (L_t) \end{cases} \tag{1}$$

where Y_t^s and Y_t^u are outputs in skilled and unskilled sectors. K_t and L_t represent physical capital and labor input and A_t is labor-augmenting technology. The physical capital is assumed not to suffer from depreciation over time. The technological progress in skilled labor sector can be described by

$$\Delta A_t^s = A_{t+1}^s - A_t^s = \beta L_t^s (A_t^s)^\phi, \quad 0 < \phi < 1 \tag{2}$$

where ϕ means decreasing returns to knowledge which characterize semi-endogenous growth models of Jones (1995), Kortum (1997) and Segerstrom (1998). For simplicity, we ignore duplication effects. Due to the diminishing returns to knowledge, positive growth of national economy requires sustained growth of skilled labor. Similarly, the technology of unskilled labor sector increases although the growth rate is slower as follows.

$$\Delta A_t^u = A_{t+1}^u - A_t^u = \chi L_t^s (A_t^u)^\phi, 0 < \phi < 1 \tag{3}$$

where χ is initially smaller than β. Wage in skilled labor sector and rental price of capital, which is same as interest rate in this model, are derived from profit maximization problem as follows.

$$\max_{L_t^s, K_t^s} (A_t^s L_t^s)^\alpha \cdot (K_t^s)^{1-\alpha} - w_t^s L_t^s - r_t K_t^s \tag{4}$$

Solution to this problem gives wage and rental price of capital as

$$\begin{aligned} w_t^s &= \alpha A_t^s \left(\frac{K_t^s}{A_t^s L_t^s} \right)^{1-\alpha} \\ r_t &= (1-\alpha) \cdot \left(\frac{A_t^s L_t^s}{K_t^s} \right)^\alpha \end{aligned} \tag{5}$$

Provided that capital is perfectly mobile and the world interest rate is constant over time, the above equations can be replaced by

$$\begin{aligned} w_t^s &= \alpha A_t^s \Gamma^{1-\alpha} \\ r &= (1-\alpha) \Gamma^{-\alpha} \end{aligned} \tag{6}$$

where $\Gamma = \frac{K_t}{A_t^s L_t^s} = \left(\frac{1-\alpha}{r} \right)^{1/\alpha}$. In the same way, the wage in the unskilled labor sector is derived from

$$\max_{L_t^u} A_t^u L_t^u - w_t^u L_t^u \tag{7}$$

Consequently, the unskilled labor wage is given by

$$w_t^u = A_t^u \tag{8}$$

Proposition 1 The wage gap between skilled and unskilled labor becomes larger as technology makes gradual progress.

Proof) From equations (6) and (8), incomes of skilled and unskilled labor are given by

$$w_t^s = \alpha A_t^s \Gamma^{1-\alpha}$$
$$w_t^u = A_t^u$$

Differentiating the ratio of w_t^s to w_t^u by the ratio of technologies, we can find positive relation between the two ratios as follows.

$$\partial\left(\frac{w_t^s}{w_t^u}\right) / \partial\left(\frac{A_t^s}{A_t^u}\right) = \alpha\Gamma^{1-\alpha} > 0$$

Therefore, the larger technology gap between sectors becomes, the more inequality in the economy there is.

(Q.E.D)

Each individual has one child so that the total population in one generation is kept as one. People maximize their utilities by consuming goods in the second period and leaving their children bequests as “warm glow” altruism.

$$u_t = \gamma \log c_{t+1} + (1-\gamma)\log b_{t+1}, \quad 0 < \gamma < 1 \tag{9}$$

where c_{t+1} is consumption in the second period and b_{t+1} means bequest. Utility maximization with a budget constraint is given by

$$\max_{c_{t+1}, b_{t+1}} \{\gamma \ln c_{t+1} + (1-\gamma)\ln b_{t+1}\}$$
$$s.t. c_{t+1} + b_{t+1} \le W_{t+1} \tag{10}$$

where wealth in the second period is denoted by W_{t+1}. From the solution, we can know that an individual uses the wealth as

$$\begin{aligned} c_{t+1} &= \gamma \cdot W_{t+1} \\ b_{t+1} &= (1-\gamma) \cdot W_{t+1} \end{aligned} \tag{11}$$

Moreover, we can derive the indirect utility function by substituting consumption and bequest in the equation (9) with (11) as

$$v_t = \{\gamma \ln \gamma + (1-\gamma)\ln(1-\gamma)\} + \ln W_{t+1} \tag{12}$$

This means that an individual utility is determined by the second period wealth.

5.2.2 Bequest dynamics

An individual decide to work as skilled or unskilled by taking into account the second period wealth. Unskilled workers receive wages for two periods and have bequest from their parent so that total wealth is represented as

$$\begin{aligned} W_{t+1}^u &= w_t^u \cdot (1+r) + w_{t+1}^u + b_t \cdot (1+r) \\ &= A_t^u \cdot (1+r) + A_{t+1}^u + b_t \cdot (1+r) \end{aligned} \tag{13}$$

Similarly, skilled workers invest in their education in the first period and receive higher wage in the second period than unskilled and also have bequest. Wealth of skilled workers is presented by

$$W_{t+1}^s = \begin{cases} (1-\tau)w_{t+1}^s + (b_t - c_t^e + s_t) \cdot (1+i) & \text{if } b_t \le c_t^e - s_t \\ (1-\tau)w_{t+1}^s + (b_t - c_t^e + s_t) \cdot (1+r) & \text{if } b_t \ge c_t^e - s_t \end{cases} \tag{14}$$

where c_t^e means the education costs and i is a higher interest rate for borrowers due to the credit market imperfection. Education subsidy in the first period is denoted by s_t and skilled workers can pay for that in the second period by a certain portion of their wages, τ. In reality, we can think the subsidy as student loans secured by government. After completing the college education, skilled workers can repay loans by means of wages. Substituting equation (6) into (14), wealth of skilled labor is represented by technology as

$$W_{t+1}^s = \begin{cases} (1-\tau) \cdot \alpha A_{t+1}^s \cdot \Gamma^{1-\alpha} + (b_t - c_t^e + s_t) \cdot (1+i) & \text{if } b_t \le c_t^e - s_t \\ (1-\tau) \cdot \alpha A_{t+1}^s \cdot \Gamma^{1-\alpha} + (b_t - c_t^e + s_t) \cdot (1+r) & \text{if } b_t \ge c_t^e - s_t \end{cases} \tag{15}$$

The education expenditure is assumed to increase with wages as

$$
\begin{aligned}
c_t^e &= \theta w_t^s + (1-\theta)\cdot w_t^u \\
&= \theta \cdot \alpha A_t^s \Gamma^{1-\alpha} + (1-\theta)\cdot A_t^u, \qquad 0 \le \theta \le 1
\end{aligned} \tag{16}
$$

As in Eicher et al. (2009), the government borrows the amount of total student loans in the former period from the international capital market and provides financial aids. In the latter period, it repays a debt and interest using collected revenues from the income of skilled workers, L_{t+1}^s. Hence, the government's budget constraint is given by

$$
\tau L_{t+1}^s \cdot w_{t+1}^s = s_t(1+r)\cdot L_{t+1}^s \tag{17}
$$

Likewise the previous model of Galor and Zeira (1993), we make two assumptions additionally. One is that all individuals who inherit more than the education cost select to be skilled workers, which is more beneficial to their wealth.

$$
(1-\tau)\cdot \alpha A_{t+1}^s \cdot \Gamma^{1-\alpha} + (b_t - c_t^e + s_t)\cdot(1+r) > A_t^u(1+r) + A_{t+1}^u + b_t \cdot (1+r) \tag{18}
$$

Another is for individuals who have to borrow entire education cost as

$$
(1-\tau)\cdot \alpha A_{t+1}^s \Gamma^{1-\alpha} - (c_t^e - s_t)\cdot(1+i) < 0 \tag{19}
$$

From equations (13) and (14), we can find a level of bequest from which an individual determines whether to be a skilled or unskilled worker. The level of bequest is given by

$$
f_t(A_t^s, L_t^s) = \frac{\left[\theta(1+i)A_t^s - (1+i\cdot\tau)\cdot A_{t+1}^s\right]\cdot \alpha \cdot \Gamma^{1-\alpha} + \left[(2+r-\theta+i-i\cdot\theta)A_t^u + A_{t+1}^u\right]}{i-r} \tag{20}
$$

Proposition 2 Government's financial aid for education make lower the threshold, f, that makes more individuals, who were not eligible before, be able to have education.

Proof) From (20), we can write

$$
\frac{\partial f_t}{\partial s_t} = \frac{\partial f_t}{\partial \tau}\frac{\partial \tau}{\partial s_t} = -\frac{1+r}{i-r} < 0
$$

The result shows that the threshold, f, is a decreasing function for government's financial aid, s_t. (Q.E.D)

From the solution to the utility maximization, i.e. the equation (11), any individual transfer a fraction of $(1-\gamma)$ of the second period wealth. So, an inherited bequest (b_t) from previous generations and a left bequest (b_{t+1}) to next generations have a following relationship.

$$b_{t+1} = \begin{cases} (1-\gamma)\left\{A_t^u(1+r) + A_{t+1}^u + b_t \cdot (1+r)\right\} & b_t \in [0, f_t] \\ (1-\gamma)\left\{(1-\tau)\cdot\alpha\cdot A_{t+1}^s \cdot \Gamma^{1-\alpha} + (b_t - c_t^e + s_t)\cdot(1+i)\right\} & b_t \in \left[f_t, c_t^e - s_t\right] \\ (1-\gamma)\left\{(1-\tau)\cdot\alpha\cdot A_{t+1}^s \cdot \Gamma^{1-\alpha} + (b_t - c_t^e + s_t)\cdot(1+r)\right\} & b_t \in \left[c_t^e - s, \infty\right] \end{cases} \quad (21)$$

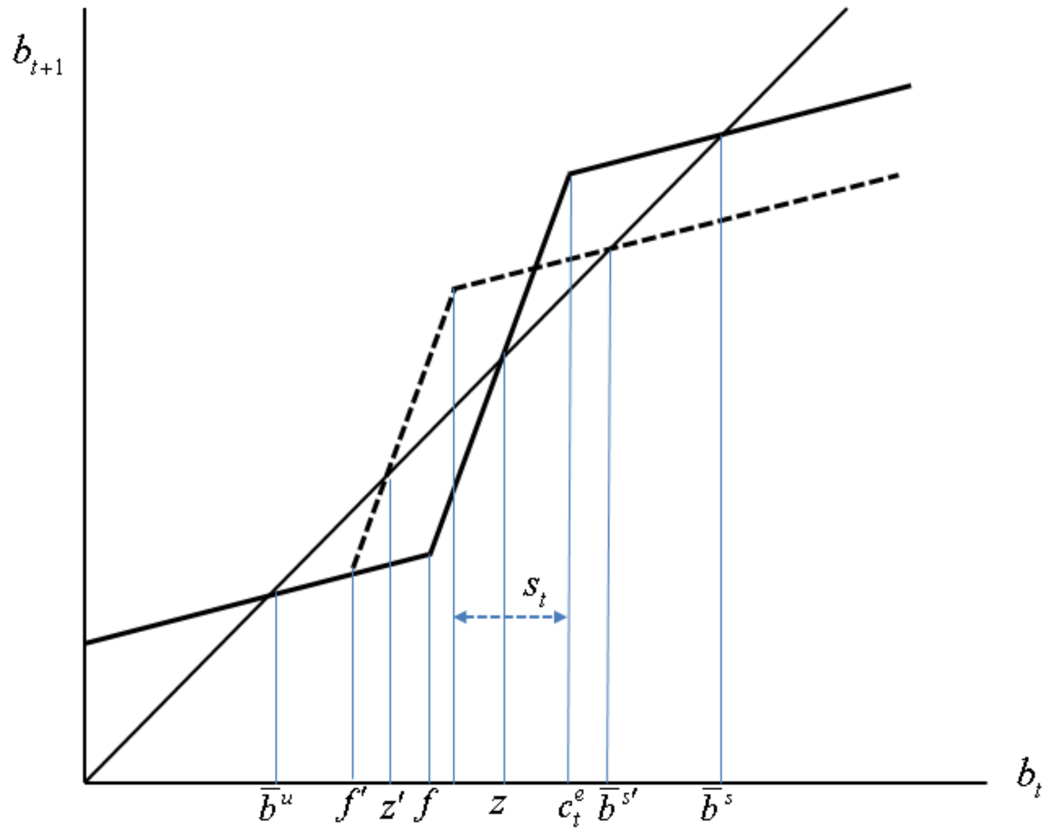


Figure 5.1 Bequest dynamics of expanded Galor-Zeira model

Government's financial aid reduces the education cost (c_t^e) by student loans (s_t) and this leads to shifts an initial threshold, f, downwards to a new level of f' as depicted in Figure 4.1. In other words, more people are eligible to be educated because of lowing effective education cost. Although more financial aid increases a size of skilled labor, it decreases disposable income of skill labor shifting the bequest level $\bar{b}^{s\prime}$ instead of $\bar{b}^s$. Furthermore, if the new threshold level is lower than the convergent level of bequests of unskilled labor ($\bar{b}^u$), bequests of all individuals converge to the only level, $\bar{b}^{s\prime}$.

5.2.3 Steady state equilibrium

As technologies evolves over time, the effective bequest of skilled labor who borrow for education is as follows

$$\hat{b}_{t+1} = \frac{b_{t+1}}{A_{t+1}^s} = (1-\gamma)\left\{\left((1+i\cdot\tau) - \frac{\theta(1+i)}{(1+\beta L_t^s (A_t^s)^{\phi-1})}\right)\cdot \alpha\Gamma^{1-\alpha} + \frac{b_t}{A_t^s}\cdot\frac{(1+i)}{(1+\beta L_t^s (A_t^s)^{\phi-1})} - \frac{A_t^u\cdot(1-\theta)(1+i)}{A_t^s(1+\beta L_t^s (A_t^s)^{\phi-1})}\right\} \quad (22)$$

From $\lim_{t\to\infty}\beta L_t^s (A_t^s)^{\phi-1} = \lim_{t\to\infty}\frac{A_{t+1}^s - A_t^s}{A_t^s} = g^A$, the critical level of bequest in the long run is given by

$$z = \lim_{t\to\infty}\frac{b_t}{A_t^s} = \lim_{t\to\infty}\hat{b}_t = (1-\gamma)\left\{\left((1+i\cdot\tau) - \frac{\theta(1+i)}{(1+g^A)}\right)\cdot\alpha\Gamma^{1-\alpha} - \frac{\Phi(1-\theta)(1+i)}{(1+g^A)}\right\} \Big/ \left(1 - \frac{(1+i)(1-\gamma)}{1+g^A}\right) \quad (23)$$

where g^A is a growth rate of technology in steady state and $\Phi = \lim_{t\to\infty}\left(\frac{A_t^u}{A_t^s}\right)$ should be constant so that there is a balanced growth path[2]. In other words, the growth rate of technology in a skilled labor sector is ultimately equal to that in an unskilled labor sector. Now, we can find a bequest level that separates unskilled and skilled labor in the long run. Given the distribution of inheritance at time t, $D_t(b_t)$, the critical level of bequest, z, determines the long-run composition of the labor force. The size of unskilled and skilled labor converged to $\hat{L}^s$ and $\hat{L}^u$, respectively.

[2] The proof is at appendix I.

$$\lim_{t\to\infty} L_{t+1}^{u} = \int_0^{\hat{g}} D_t(\hat{b}_t)d\hat{b}_t \equiv \hat{L}^u$$
$$\lim_{t\to\infty} L_{t+1}^{s} = \int_0^{\hat{g}} D_t(\hat{b}_t)d\hat{b}_t \equiv \hat{L}^s \qquad (24)$$

The steady state equilibrium level of bequest is equal to

$$\lim_{t\to\infty}\hat{b}_t = \begin{cases} \bar{b}^u \equiv \dfrac{(1-\gamma)(2+r+g^A)}{1+g^A-(1-\gamma)(1+r)} \\ \bar{b}^s \equiv (1-\gamma)\left\{\left((1+r\cdot\tau)-\dfrac{\theta(1+r)}{(1+g^A)}\right)\cdot\alpha\Gamma^{1-\alpha}-\dfrac{\Phi(1-\theta)(1+r)}{(1+g^A)}\right\}/\left(1-\dfrac{(1+r)(1-\gamma)}{1+g^A}\right) \end{cases} \qquad (25)$$

The income level of a skilled worker in the second period consists of wage income and as follows.

$$\begin{aligned} I_{t+1}^s &= (1-\tau)\cdot w_{t+1}^s + (b_t^s - c_t^e + s_t)\cdot r \\ &= (1-\tau)\cdot \alpha A_{t+1}^s \cdot \Gamma^{1-\alpha} + (b_t - c_t^e + s_t)\cdot r \end{aligned} \qquad (26)$$

On the other hand, the income level of an unskilled worker in the second period is represented by

$$\begin{aligned} I_{t+1}^u &= w_{t+1}^u + b_t\cdot r \\ &= A_{t+1}^u + b_t \cdot r \end{aligned} \qquad (27)$$

and the income level of an unskilled worker in the first period is given by

$$I_t^u = A_t^u \qquad (28)$$

Therefore, the aggregate income level in the whole economy is

$$\begin{aligned} Y_t &= I_{t+1}^s L_{t+1}^s + I_{t+1}^u L_{t+1}^u + I_t^u L_t^u \\ &= \left[(1-\tau)\cdot\alpha A_{t+1}^s\cdot\Gamma^{1-\alpha} + (b_t - c_t^e + s_t)\cdot r\right]L_{t+1}^s + \left[A_{t+1}^u + b_t\cdot r\right]L_{t+1}^u + A_t^u L_t^u \end{aligned} \qquad (29)$$

The income per capita is $y = Y_t/2$. Provided that there is a balance growth path, the growth rates of technology in the two sectors would become same in the steady state. The income per capita divided by technology converges to a constant as $\lim_{t\to\infty}\frac{Y_t}{A_t^s} = \lambda$. From an equation (2), we can know that a growth rate of technology can be represented as

$$g_t^A = \beta L_t^s (A_t^s)^{\phi-1} \qquad (30)$$

Taking logs of equation (30) and differentiating with respect to time we obtain the relation between a growth rate of skilled labor, g^{L^s}, and a growth rate of technology, g^A, in steady state as $g^A = \frac{1}{1-\phi} g^{L^s}$. Hence, the growth rate of income per capita, g^{y^*}, can be defined by

$$g^{y^*} = g^A = \frac{1}{1-\phi} g^{L^s} \tag{31}$$

As a result, the economic growth rate is dependent on the growth rate of skilled labor. Moreover, government's education policies will have transitory effects on national economy. That is, the long-run economic growth rate would not be affected by education policy.

5.3 Empirical analysis

In this section, we verify the expanded Galor-Zeira model from three aspects. First, we show that parents' asset affect the child's level of education in Korea's after 1990s. If parents' wealth is an important determinant for educational attainment of children in Korea, it proves that education takes a substantial role in diverging inequality to a certain extent. Second, we test whether wage gap between skilled and unskilled workers diverges in Korea, harmonized with the growth rate of technological progress. This analysis, together with the first empirical test, explains the increased polarization of wealth. Suppose that rich people raise their children as skill workers more probably than the poor. In turn, if there exists a significant difference between skill and unskilled labor, the former would become rich parents than the latter. In other words, wealth is passed down through education from generation to generation. Finally, we examine effectiveness of government's student loan, which intends to increase the opportunity of education for the poor by making credit market imperfection lessen. If the effect of government policy is valid, it can encourage education for more skilled workers, although the policy temporarily increases the growth rate of economy.

5.3.1 Data description

The main data used in empirical analyses come from the Korea Labor and Income Panel Survey (KLIPS) and Youth Panel (YP).

The Korea Labor and Income Panel Survey (KLIPS)

KLIPS is an annual panel survey of around 5000 households and 11000 individuals, which started in 1998. It can be thought Korean version of National Longitudinal Survey (NLS) or Panel Study of Income Dynamics (PSID) in Unites States. The survey asks various questions on the labor market, income and asset of individuals and households. Preserving original sample in each wave is important in a panel survey and the so does it in the KLIPS; sustainably having the rate of original sample is 74% in the 11th wave in 2008.

We make a data combining the parental household data of 1st and 2nd waves and children's household data of from 7th to 11th wave, only in case of parental household with moving out child between the year of 7th wave and that of 11th wave. We, then, can make 418 parent-child pairs, which include all the information about parental and child's house, respectively. We include all the gender of child that moved out.

The Youth Panel (YP)

The YP is an annual panel survey that follows up the transition from school to work and from adolescence to adulthood. It can be thought as Korean version of National Longitudinal Survey of Youth (NLSY) in United States. As the individual survey approved by National Statistical Office in Korea, the samples represent Korea youths from 15 to 29 years old. The YP gathers detailed information on respondents' labor market behaviors and educational experiences.

The first wave is YP2001, which started from 2001 and ended in 2006. The second wave is YP2007, starting from 2007, which has been built with 10000 youth with an age range of 15 to 29 years as of 2007. We focused on the cross-section data of the 4th investigation in YP2007, which hold 81.7% of initial samples and were collected in 2010.

5.3.2 Background of Korea in the 1990s

As Rodrik (1994) mentioned, economic development of Korea took off with the low level of inequality initially and had sustained it during its growth trajectory in spite of its sharp growth rate. However, after 1990s, the level of inequality has increased significantly as demonstrated in Figure 4.2. Even though there was the foreign exchange crisis in 1997 though the global financial crisis, the trend of increasing inequality seems already take off in the early 1990s. We argue that the reason of the diverging inequality after the late 1990s is related with the human capital channel. As Young (1995) insisted, in the period from 1960 to 1990, 84 percent of Korean output growth was explained by factor accumulation, while 7 percent for human capital accumulation. However, Singh et al. (1996) show that Korean driving force of growth is on transfer from factor accumulation to TFP growth after the 1980s. This means that Korean growth regime has changed after the 1990s and human capital gradually has appeared as a prime engine of economic growth in Korea, instead of physical capital accumulation, which accords with the argument of Galor and Moav (2004). Human capital channel of inequality, then, can operate stronger when human capital becomes significant in growth. Moreover, because from the early 1990s the burden of college tuition for households has become greater and greater with the fact that the level of tuition was liberalized after 1989, the human capital channel can be more effective after the 1990s. At the same time, that period, after the 1990s, match well with the time period of our data, which the mean of child's birth year is 1976 and most of children were educated in the 1990s.

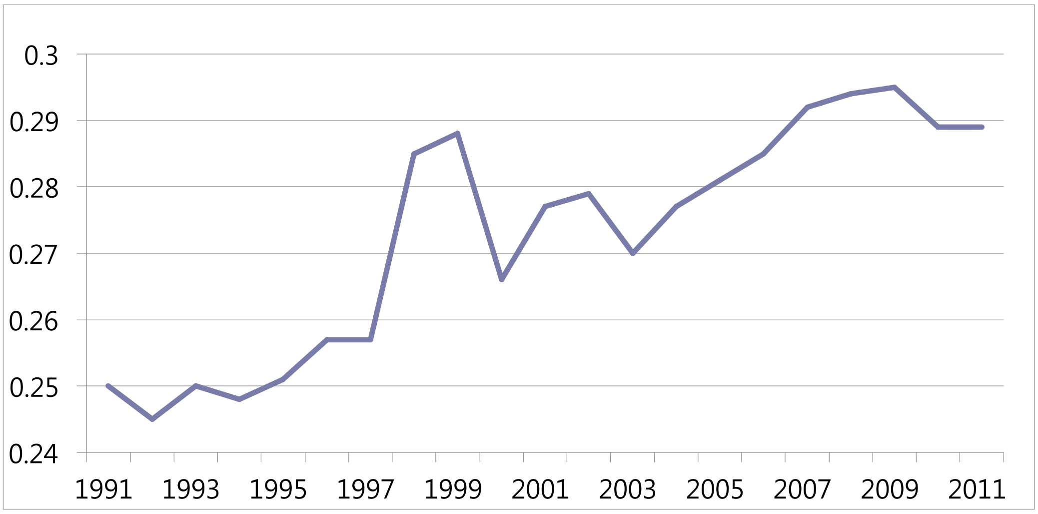


Figure 5.2 Gini index of South Korea (urban households with two or more household members), *Source*: National Statistical Office

5.3.3 Results

5.3.3.1. The relationship between parents' wealth and children's educational attainment in Korea

To test existence of human capital cannel in inequality, this study shows that the parental asset leads child's level of education. After this step, next chapter shows that because of technological progress, the wage gap between educated worker and unskilled worker, and in turn, it diverge each household's wealth again.

A child's education, which is represented as years of schooling, is expressed as a linear function of his or her parental asset that measured in logarithms. Our ordinary least square (OLS) equation is following form:

$$edu_t^i = \beta_0 + \beta_1 asset_{t-1}^i + \mathbf{\beta X} + \varepsilon^i \tag{32}$$

where edu_t^i represents child's educational experience and $asset_{t-1}^i$ parental asset. Here, parents' and their offspring's generation are defined by $t-1$ and t, respectively. The data are at the each household level *i*, I denote a father and a child pair, and ε^i is a random component usually assumed to be distributed as $N(0,\sigma^2)$. Covariates and their coefficients are denoted by $\mathbf{X}$ and $\boldsymbol{\beta}$, respectively. The constant term represents the level of education common to generation, t, while a coefficient β_1 indicates the extent to which child's education levels are related to the parent's level of asset.

The variable edu_t^i is a measure for child's years of schooling. We don't tell between graduation of school and dropping out of school; if data inform some child graduated a high school and some other child dropped out a high school, we count twelve as years of schooling in both case. Also it represents the highest level of education of each individual considering the point of time when the Survey was conducted each individual's age. The mean of parental year of birth is 1947 and that of children is 1976 at the time of the Survey.

The variable $asset_{t-1}^i$ is logarithms of parental asset, which includes real estate, financial asset and depts. We include a price of house, in which the households live, in the real estate asset. The asset data are likely to be contaminated by measurement errors. To deal with this problem, we use an average level of asset over 1998 and 2002 survey years.

The covariates $\mathbf{X}$ include following variables: (a) a logarithm of father's annual wage, (b) a father's education, (c) a mother's education, (d) a grandfather's education, (e) an indicator of child's health and (f) the number of children that parental households have. The father's annual wage is also likely to have a measurement error. To solve this problem we use the averaged father's wage income over 1998 and 2002 survey years. The reason why we exclude other sources of income is the collinearity between incomes from real estate or financial asset and the asset variable. Variables (b), (c) and (d), representing the level of education, are measured with a years of schooling. An indicator of child's health can get through the answer of each individual in the survey; there are 5 numbers in the indicator, from 1 to 5, and if the child feels their health is good, then, they answer 5 and vice versa. We treat it as a continuous variable between 1 and 5. Table 4.1 shows the descriptive statistics of variables.

(Insert Table 5.1 here)

(Insert Table 5.2 here)

Table 5.2 presents estimates the channel of inequality, obtained using the sample of father-child pair. Every column in Table 5.2 presents cross sectional estimates of the effects of parental asset on child's education with variation of covariates; father's annual wage, father's years of schooling, mother's years of schooling, indicator of child's health and the number of children in each household *i*. In all columns the effect of parental asset on child's years of schooling is strongly significant.

Unlike general concern, parental asset and father's annual wage do not show higher collinearity with the value 0.0349. This is because the data comes from the time after divergence between dynastys' asset already has happened, the correlation between parental asset and income is not that high. In addition, the price of asset in Korea, especially that of real estate, has increased sharply along with industrialization and urbanization. Hence, the person who had real estate easily can accumulate their asset, not related to their wage income in Korean development context.

Both father's and mother's level of education, measured in years of schooling, have significant relationship with the children's level of education. When both parents' level of education is considered at the same time, each coefficient slightly become decreased because of assortative mating. The coefficient of father's level of income becomes insignificant when the variable for the father's education added. That is because the father's income is explained by the father's level of education.

The coefficient of the number of children was expected negative because if the number of children is higher, the resource for human capital investment per child will be lower. However, different with our prediction, the coefficient turns out positive and insignificant. This is a consistent result with Lee (2004) which insisted that there is insignificant quantity-quantity trade off in Korea after 1990s. We read it that after the 1990s the cost per raising child has been increasing, owing to the rising cost of education and parental opportunity cost, income effect dominates in giving birth to the child.

(Insert Table 5.3 here)

We also test the channel of inequality by ordered logistic regression. It is reasonable that the choice of having more education is discrete choice. Because we want to distinguish differences between entering college and entering graduate school, we use ordered logistic regression. We put 0, 1, 2 and 3 when child just graduate high school, graduate college, getting a master's degree and getting a doctor's degree, respectively. In Table 5.3, the variables of Logarithms of parental asset, Father's years of schooling, Mother's years of schooling and the number of children are significant and have positive relation same as OLS results. The positive coefficient for a logarithm of parental asset means that the likelihood of getting higher education of child increases with parental asset. Similarly, the positive coefficient of the level of father's and mother's level of education, which is measured in years of schooling, and the number of children implies that higher level of parental education and more children in each household increase the level of child's level of education, which is represented by one of the digit between 0 and 3.

Furthermore, the ordered logistic regression allows us calculating the probability of outcomes. In average value of variables, which means household has 12.6 as logarithms of parental asset, 10.1 of father's schooling, 8.6 as a mother's schooling and 2.8 as a number of children, then Z is

$$Z=0.1622\times12.6 + 0.0804\times10.1+0.0953\times8.6+0.1714\times2.8=4.1553 \quad (33)$$

then,

$$p(Y=0)=\frac{1}{1+\exp(Z_i-\kappa_1)}=0.2171 \quad (34)$$

$$p(Y=1)=\frac{1}{1+\exp(Z_i-\kappa_2)}-\frac{1}{1+\exp(Z_i-\kappa_1)}=0.6921 \quad (35)$$

$$p(Y=2)=\frac{1}{1+\exp(Z_i-\kappa_3)}-\frac{1}{1+\exp(Z_i-\kappa_2)}=0.0813 \quad (36)$$

$$p(Y=2)=1-\frac{1}{1+\exp(Z_i-\kappa_3)}=0.0095 \quad (37)$$

for average households, where κ_i is particular threshold of Y with κ_1, κ_2 and κ_3 are 2.8726, 6.4586 and 8.7993. This result means that in the average household in Korea, their child is most likely to graduate college with the probability of 0.6921.

Now, we are interested in the value of parental asset that can be threshold for the children's education. With ceteris paribus condition of all average values of household, except the parental asset, we simulate an effect of change in the parental asset on children's level of education.

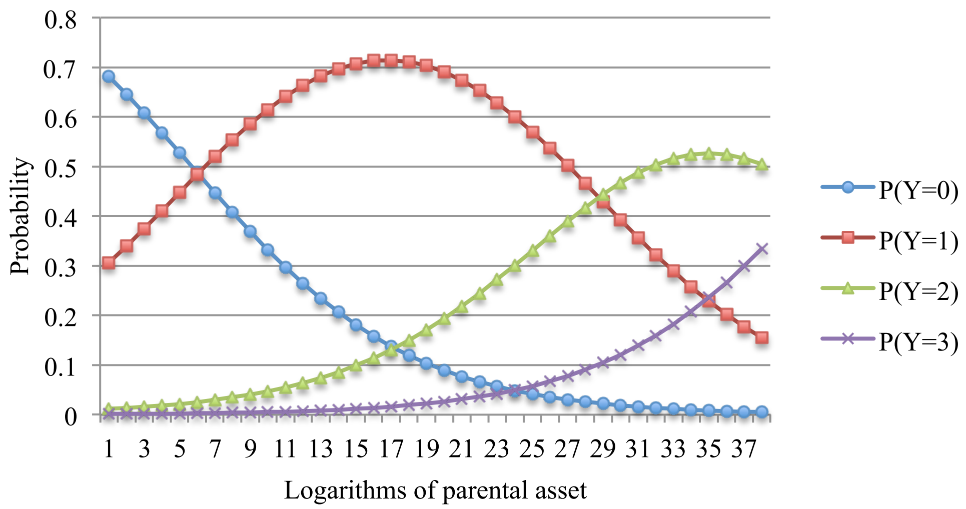


Figure 5.3 Changes of children's educational choice with respect to different parents' asset

As illustrated in Figure 5.3, increasing parental asset induces higher probability of higher education of child. If all the conditions, except the level of parents' asset, are fixed in the average level, households that have an asset less than around five million won are likely to graduate only a high school. However, the level of asset for getting master's or doctor's degree is so high that the level of parental asset is critical in the choice of entering the college in Korea with other variables fixed.

(Insert Table 5.4 here)

We analyzed the marginal effect when each choice having the highest possibility. The result supports that the marginal effect of all the variables including parental asset on the child's education is the biggest in the case of households that choose high school ($Y = 0$) as their child's final school. The more parental asset leads less marginal effect of explanatory variables on their child's level of education.

Through OLS and ordered logistic regression, we confirm that parents' asset has significant role in the choice of children's level of education, especially in the decision of entering college.

5.3.3.2. The relationship between wage gap and technological progress.

Greiner et al. (2004) expressed 'college premium' as the wages of employees with some college degrees over employees with high school education. In this study, we define wage differences between skilled and unskilled labor as college premium, which is the ratio of average wage per hour earned by college graduates (bachelor's degree and higher) to average wage per hour earned by high school graduates. Data on employment and wage can be obtained from Ministry of Employment and Labor (MEL) and other data on national economy are gathered from Bank of Korea (BOK). In particular, the Survey on Labor Conditions by Type of Employment, released by MEL, provides annual information from 1980 to 2010 on the number of employees by schooling attainment, working hours, years of consecutive service, monthly payment, etc. Figure 4.4 shows growing trends of employees where the number of employees in 1980 is defined as one. Employees who have college degrees have increased sharply to thirteen times during last three decades. Consequently, the percentage ratio of college graduates in total employees has risen from 12.2% in 1980 to 56.3% in 2010, whereas the percentage ratio of high school graduates has increased only from 30.4% in 1980 to 37.2% in 2010.

We examine **Proposition 1** that technological difference between skilled and unskilled sector has induced cross-sectoral income inequality. In other words, wage gap, $(W^{s'} / W^{u'})$, increased in proportion to technological gap, (A^s / A^u). The technological gap is represented by the growth rate of technology as in Murphy et al. (1998), because technological progress generally increases the cross-sectoral technological difference. From the equation (31), the growth rate of skilled labor can play a role as a proxy for representing the growth rate of technology. Therefore, comparing trends between the wage gap and the increase rate of skilled workers demonstrates the relation of two variables, i.e. college premium and technological progress.

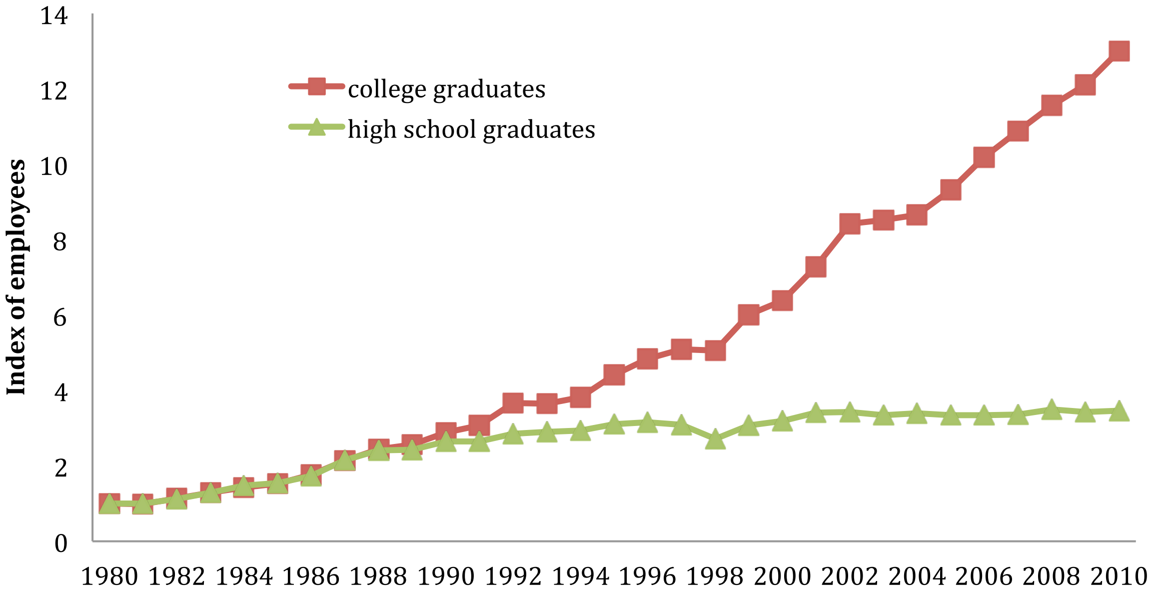


Figure 5.4 Employees of college graduates and high school graduates, Korea 1980-2010, *Source*: Ministry of Employment and Labor

Figure 5.5 shows that the college premium in Korea has decreased on the whole. To remove fluctuations and clarify general trends, the Hodrick-Prescott filter is applied to growth rates of skilled labor and income per capita. The smoothness parameter of the HP filter was set to 100. From the figure, it is noticeable that there has been a significant correlation between the wage gap and the growth rate of skilled workers through last three decades. This verifies the validity of the proposition 1 at least in Korea. However, since the foreign exchange crisis in 1997 through the global financial crisis, the trends between them start to diverge. The disaccord stems mainly from mass unemployment due to a large-scale restructuring in Korea. Moreover, the economic aftereffects have continued until another obstacle, i.e. the global financial crisis in around 2008.

It is important fact that the growth rate of skilled labor leads the growth rate of income per capita in the figure. It seems to be strong correlation between them through all the periods. While the size of income per capita is dependent on the fraction of skilled labor according to Galor (2011) the growth rate of income per capita is dependent on the growth rate of skilled labor as predicted by the equation (31).

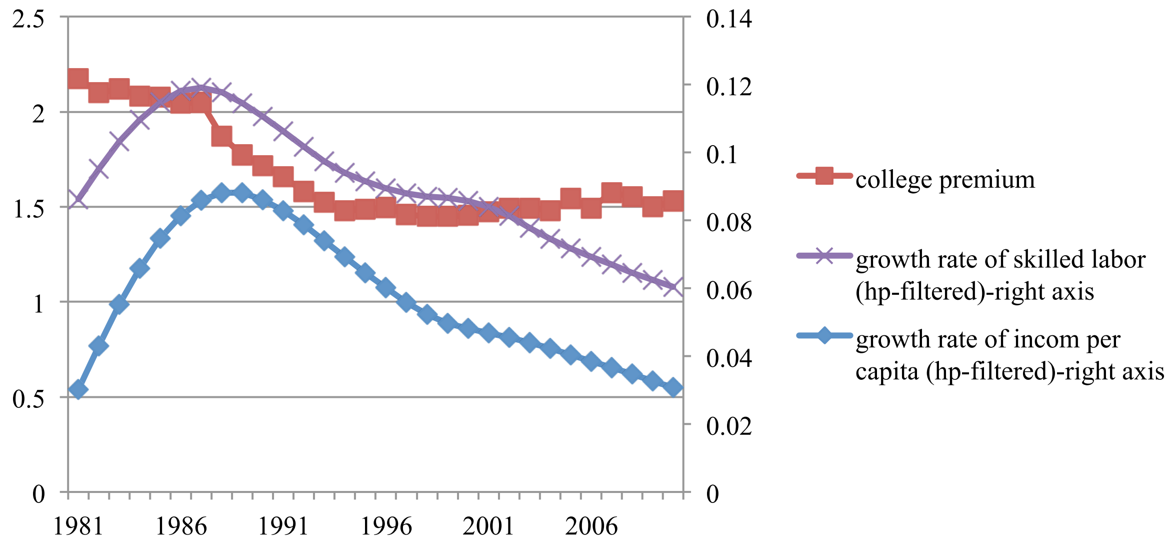


Figure 5.5 The trends of college premium, growth rate of skilled labor and growth rate of income per capita, Korea 1981-2010, *Source*: Ministry of Employment and Labor and Bank of Korea.

5.3.3.3 The impact of college student loans secured by government on the college attendance

The Korean government conducted college student loans secured by government from the second half of 2005. Before then, parents should stand surety for their children to receive student loans from general banks. Although the student loans are not direct support, they are clearly characterized by some type of financial aid. After the loan policy, more students who were not eligible due to their parents' credit status have eligibility for the student loans. Moreover, the new policy extended the longest term of the loan from 14 to 20 years and increase borrowing limits considerably.

There have been few researches on the effect of the new student loans in Korea. In this subsection we examine **Proposition 2** that the change of student loan system affects schooling decision of college attendance. Although the change might have more significant effect on completion of schooling rather than attendance of schooling, most of male students who entered colleges after conducting new loans have not graduated due to compulsory military service in Korea. As explained earlier, data is the 4th investigation of YP2007 and Table 4.5 shows means of data. The data is very useful because it covers a wide range of cohorts that become seniors in high school in close years of 2005. Interviewees who were born from 1987 to 1991 are considered to be in the "after" period. The cohorts have decided whether to attend a college or not after the loan policy. On the other hand, interviewees who were born from 1982 to 1986 are considered to be in the "before" period.

In order to verify the effect of financial aid, we used difference-in-differences (DD) methodology as in Dynarski (2003) and Long (2007). This methodology requires two comparable groups, which are called as control group and treatment group, respectively. Compared to the control group, the treatment group means newly eligible individuals for the new policy. In this study, we regarded those with a deceased or unemployed father as a treatment group because they were difficult to receive general bank loans before the new policy. The most important thing for borrowing student loans of banks is parents' financial status, which can give an assurance. In this sense, we added children who belonged to households in livelihood protection to the treatment group.

(Insert Table 5.5 here)

Table 5.5 shows that individuals in treatment group have lower college attendance rates. As expected, they belong to relatively low-income families. Besides, their parents have less educational attainments consistently although there is some difference between two periods.

The equation for ordinary least squares (OLS) and logistic regression estimation is the following:

$$y_i = \alpha + \beta(Treat_i \times After_i) + \delta(Treat_i) + \lambda(After_i) + \boldsymbol{\beta}\mathbf{X_i} + u_i \qquad (38)$$

where college attendance of an individual, i, is denoted by y_i and other control variables are denoted by a vector, $\mathbf{X}_i$. The control variables include household income and parents' educational attainment. Treatment effect is captured by a coefficient, β. To be more specific, if the sign of the coefficient is positive, probability of attending college for new eligible individuals becomes higher. Coefficients δ and λ explains the difference of college attendance between two groups and between two periods before and after altering loans policy, respectably.

(Insert Table 5.6 here)

Table 5.6 presents that college enrollment increased for new eligible students. Estimates for effects of student loans secured by government are significant and robust in presence of other covariates as well as in case of logistic regression. The results suggest that the proposition 2 is valid in Korea. We can also find several interesting results in Table 5.6. Compared to the control group, the treatment group has relatively low probability to attend a college, but there is no significant difference before and after new loan system. In addition, father's college attendance affects children's schooling significantly rather than mother's college attendance.

5.4 Conclusions

Galor-Zeira model is a well-known macroeconomic model, which shed light on the relationship among inequality, human capital and growth, but the empirical evidence for the model is not sufficient, especially in-depth longitudinal study for one country. In this paper we show that education channel is a key factor for inequality in Korea using the Galor-Zeira model. Furthermore, this paper expanded the original model by adding the technological progress and educational policy and verified the model through Korean panel data.

This study finds several meaningful results. First, this paper finds the fact that not the parental wage but the parental wealth has relationship with child's level of education using OLS and ordered logistic regression with the data which contains the information on both parents' and children's household. With the diverging wage gap between skilled and unskilled labor, which is dependent on the level of education, the inequality would be increasing further. Through the ordered logistic regression, which presents the fact that the lower asset induces the higher marginal effect of parental asset on children's level of education, this study shows that parental wealth plays more critical role in determining of households whether their children become skilled worker by the college attendance. Moreover, this paper shows that the government financial aid make the threshold for higher education decreased so that more people can be skilled workers, which is ultimately positive effect on the equality and economic growth.

The empirical results imply that education plays an important role in the divergence of wealth by upholding income levels from generation to generation. Our conclusion can give meaningful implication to policy maker; even though it is commonly regarded that policy intending economic growth and that intending to solve the inequality problem are contrary, there can exist the policy intending to boost economic growth and to lessen inequality at the same time. Because human capital channel is main channel of growing inequality, if government implements policy that expands the opportunity of education and that make the number of skilled worker increased, government can kill two birds with one stone. Moreover, policy maker can get the standard in making policy for growth and inequality; that is the direction of changing threshold that determine the ratio of skilled worker to unskilled worker.

The limitation of our research is the fact that empirical analysis is carried out with just Korean data. If more researches that deal with another country's data are accumulated, the expanded Galor-Zeira model can become more convincing. In addition, if advanced empirical research, using cross-country data, covers the human capital channel and the reduced relationship between inequality and growth at the same time, the Galor-Zeira model will become more confident.

Appendix I.

In order to have a balance growth path in a small economy, the following condition should be satisfied.

$$(b_t^s - c_t^e) \cdot L_t^s + b_t^u L_t^u = K_{t+1} - K_t \tag{A.1}$$

In equation (A.1), the left side represents investment into physical capital and the right side means an increase of physical capital stock. In the long run, bequest of unskilled and skilled labor increase in proportion to technology progress as

$$\lim_{t\to\infty} b_t^s = A_t^s \overline{b}^s, \ \lim_{t\to\infty} b_t^u = A_t^u \overline{b}^u \tag{A.2}$$

In addition, since the interest rate is assumed to be constant and the composition of each labor converges over time, the increase rate of physical capital is same to the growth rate of technology.

$$K_{t+1} - K_t = \beta L_t^s K_t \tag{A.3}$$

As time goes by, substituting equations (A.2) and (A.3), the equation (A.1) is presented as follows.

$$\left(A_t^s \overline{b}^s - \theta\alpha A_t^s \Gamma^{1-\alpha} - (1-\theta) A_t^u \right) \hat{L}^s + A_t^u \overline{b}^u \hat{L}^u = \beta \hat{L}^s \cdot \Gamma A_t^s \hat{L}^s \tag{A.4}$$

And from (A.4), we can find the following relationship.

$$\lim_{t\to\infty} \left(\frac{A_t^u}{A_t^s} \right) = \frac{\left(\overline{b}^s - \theta\alpha\Gamma^{1-\alpha} - \beta \hat{L}^s \Gamma \right) \cdot \hat{L}^s}{\left((1-\theta) \cdot \hat{L}^s - \overline{b}^u \cdot \hat{L}^u \right)} = \Phi \tag{A.5}$$

(Q.E.D)

Table 5.1 Korea Labor and Income Panel (KLIPS) Descriptive Statistics

Variable	Definition	Mean	Std. Dev.	Min	Max
Child's education	Child's years of schooling	14.78708	2.208578	9	23
Parental asset	Logarithms of parental asset including real estate, financial asset and depts.	12.59667	2.429663	6.802395	15.76194
Parental annual wage1)	Logarithms of parental wage income	7.88558	0.6602219	5.298317	9.519445
Father's education	Father's years of schooling	10.10287	3.714182	1	18
Mother's education	Mother's years of schooling	8.562201	3.190545	1	16
Grandfather's education	Grandfather's years of schooling	3.282297	4.989843	1	18
Child's health	Indicator for child's health 5 numbers from 1 to 5	2.669856	0.6793285	1	4
The number of children	The number of children that parental households have	2.856459	1.124597	0	7

Notes) 1) No responded or missing data are excluded in calculation.

Table 5.2 Relation between child's education and parental asset (OLS result)

Explanatory variables	Dependent variable: Child's education									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Parental asset	**0.1658*** **		**0.1575*** **	**0.1455*** **	**0.1475*** **	**0.1435*** **	**0.1373*** **	**0.1423*** **	**0.1383*** **	**0.1319*** **
	(0.0464)		(0.0462)	(0.0456)	(0.0459)	(0.0456)	(0.0467)	(0.0460)	(0.0456)	(0.0470)
Parental annual wage		**0.2567** **	**0.1957**	**0.1151**	**0.1563**	**0.1144**	**0.1115**	**0.1151**	**0.1212**	**0.1195**
		(0.1213)	(0.1211)	(0.1153)	(0.1146)	(0.1120)	(0.1119)	(0.1120)	(0.1139)	(0.1137)
Father's education				**0.1483*** **		**0.1165*** **	**0.1211*** **	**0.1171*** **	**0.1135*** **	**0.1181*** **
				(0.0294)		(0.0334)	(0.0335)	(0.0333)	(0.0330)	(0.0330)
Mother's education					**0.1414*** **	**0.0645***	**0.0660***	**0.0641**	**0.0908** **	**0.0906** **
					(0.0345)	(0.0391)	(0.0391)	(0.0391)	(0.0422)	(0.0420)
Grandfather's education							**-0.0195**			**-0.0164**
							(0.0204)			(0.0205)
Child's health								**0.0382**		**0.0497**
								(0.1652)		(0.1630)
The number of children									**0.1892***	**0.1820***
									(0.1044)	(0.1052)
Constant	**12.6986*** **	**12.8106*** **	**11.3068*** **	**10.5757*** **	**10.5231*** **	**10.3746*** **	**10.4802*** **	**10.2789*** **	**9.6536*** **	**9.6440*** **
	(0.5977)	(0.9439)	(1.0669)	(1.0598)	(1.0379)	(1.0459)	(1.0569)	(1.0497)	(1.1581)	(1.2636)
R^2	0.0333	0.0115	0.0400	0.1008	0.0813	0.1066	0.1084	0.1067	0.1146	0.1160
Number of observations	418	419	418	418	418	418	418	418	418	418

Table 5.3 Relation between children's education and parents' asset (ordered logistic regression)

Variable	Dependent variable: child's education (Y=0,1,2,3)	
	(1)	(2)
Parental asset	**0.1519*** **	**0.1622*** **
	(0.0444)	(0.0434)
Father's education	**0.0282** **	**0.0804** **
	(0.0344)	(0.0337)
Mother's education	**0.0954** **	**0.0953** **
	(0.0417)	(0.0416)
The number of children	**0.1672* **	**0.1713* **
	(0.1009)	(0.1001)
Parental wage	**0.0942**	
	(0.1126)	
Grandfather's education	**-0.0178**	
	(0.0213)	
Child's health	**0.0437**	
	(0.1549)	
/cut1	3.5284	2.8726
/cut2	7.1245	6.4586
/cut3	9.4651	8.7993
LR chi^2	40.87	39.40
Prob>chi^2	0.0000	0.0000
Pseudo R^2	0.0549	0.0529
Number of observations	418	418

Table 5.4 Marginal effects of variables in each child's educational choice

	P(Y=0)	P(Y=1)	P(Y=2)	P(Y=3)
Parental asset	-0.0270***	0.0140***	0.0119***	0.0015***
	(0.00727)	(0.0047)	(0.0034)	(0.0008)
Father's education	-0.0147***	0.0070**	0.0059**	0.0008*
	(0.0057)	(0.0032)	(0.0025)	(0.0005)
Mother's education	-0.0157**	0.0082**	0.0070**	0.0009*
	(0.0070)	(0.0039)	(0.0032)	(0.0006)
The number of children	-0.0290*	0.0148	0.0126*	0.0016
	(0.0169)	(0.0091)	(0.0075)	(0.0012)

Table 5.5 Youth Panel (YP2007-4th) summary statistics

Variable	Before		After		Difference-in-differences
	Control Group	Treatment Group	Control Group	Treatment Group	
Attend college	0.8717	0.7112	0.8745	0.8367	0.1227
Household income[1)]	4888	3588	4613	2750	563
Female	0.5305	0.5	0.6109	0.6776	0.0972
Father attended college	0.2932	0.205	0.4031	0.2449	-0.07
Mother attended college	0.1127	0.1118	0.216	0.1388	-0.0763
Number of observations	1917	322	2431	245	4515

Notes) 1) No responded or missing data are excluded in calculation.

Table 5.6 Effect of eligibility for student loans on probability of attending college

	OLS		Logistic regression	
	DiD	Add covariates	DiD	Add covariates
(Treat)X(After)	**0.1227***** -0.031	**0.1317***** -0.0315	**0.7072***** -0.2311	**0.7904***** -0.2372
Treat	**-0.1605***** -0.0207	**-0.1412***** -0.021	**-1.0147***** -0.1407	**-0.8805***** -0.1441
After	**0.0029** -0.0105	**-0.002** -0.0108	**0.0258** -0.0917	**-0.0171** -0.0951
Log (Household income)		**0.0381***** -0.0079		**0.2714***** -0.0571
Female		**0.0129** -0.0101		**0.1126** -0.0861
Father attended college		**0.0683***** -0.0122		**0.6571***** -0.1166
Mother attended college		**0.0131** -0.0156		**0.1816** -0.1576
R^2	0.0136	0.031	-	-
Number of observations	4915	4752	4915	4752

Notes) 1) Samples with no responded or missing data are excluded in estimation.

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Abstract (Korean)

인적자본의 축적과 기술진보는 Unified Growth Theory 를 통하여 '왜 어떤 나라는 잘살고 어떤 나라는 빈곤한가?'에 대한 대답을 도출하는데 있어서 핵심적인 요소이다. 지금까지 많은 연구자들이 이 질문에 대한 해답을 역사적 관점이나 성장론적 관점에서 천착해왔으나 인류역사의 모든 경제 단계를 관통하는 해답을 얻지못하였다. 그러나 Unified Growth Theory 는 인류가 대부분 위치해있던 맬서스 경제에서부터 지금의 근대적 산업경제 구조를 하나의 동태모형으로 구현하였다. 게다가 이 이론은 지금까지 쌓인 국가의 부와 빈곤에 관한 연구성과를 모두 포괄하여 국가의 부와 빈곤에 영향을 미칠 수 있는 요인들의 체계를 마련하였다.

어떤 나라가 부유하고 어떤 나라가 빈곤한지를 이해하기 위한 여정에서 핵심은 근대적 산업경제로 이행하는 과정에서 인적자본이 어떤 역할을 했는지를 살펴보는 것이다. 이 논문은 20 세기 한국의 경제성장과정에서 인적자본과 인적자본 축적을 촉진하는 제도들이 어떠한 맥락을 가지는지 Unified Growth Theory 의 관점에서 살펴보는 것이다.

1945 년 일본의 지배로부터 독립하기 전까지 한국경제의 구조는 전형적인 농업경제 구조였다. 18 세기와 19 세기의 서유럽의 산업화 과정에서 나타난 기존의 농업적 엘리트와 산업화로 새롭게 등장하는 자본가 사이의 이해관계 충돌을 되뇌여보면, 어떠한 국가에 더 강한 농업사회의 엘리트들이 존재할 수록 이들이 그 국가의 경제구조가 산업경제로 진화하는 데 방해물이 될 수 있다는 사실을 쉽게 인지할 수 있다. 그러므로 농업사회 엘리트의 힘을 대변할 수 있는 토지소유의 불평등도/집중도가 높을수록 그 사회의 산업경제구조로의 이행은 더 더뎌질 수 있다. 제 3 장에서는 산업화 직전시기의 농업경제 엘리트와 신생 자본가들 사이의 정치 사회적 충돌과 인적자본 축적간의 관계에 대한 모델을 살펴보고 이 모델을 이용하여 1938 년에서 1943 년 조선총독부 자료로 독립이전 한국경제를 실증 분석한다.

농업경제에서 산업경제로 이행하는 동안, 사회의 자본 축적과 함께 과학기술에 대한 수요가 증가하고 이에 동반하여 인적자본에 대한 수요가 증가한다. 이러한 인적자본 수요에 발맞추어 가계의 부모는 자녀에게 할당하는 자원의 배분을 바꾸는데 농업경제 구조하에서와는 다르게 자녀의 수가 아닌 자녀의 교육에 더 많은 자원을 할당하게 된다. 이러한 가계에서 일어나는 자원할당의 변화가 사회 전체의

인구학적 변화를 야기하는데 이 인구학적 변화는 인당 소득이 정체된 맬서스 트랩에서 그 사회의 경제가 벗어나는데 핵심적인 역할을 한다. 제 4 장에서는 경제의 이행기동안 일어나는 인구학적 변화에 대한 모델을 살펴보고 1970 년에서 2010 년 사이의 한국 경제에 이 모델을 적용해본다.

경제가 과학기술의 진보와 인구학적 변화로 근대경제로 이행한 이후에 각 가계간의 부의 격차는 인적자본 경로로 발산한다. 제 5 장에서는 인적자본 경로에 대한 Galor-Zeira model 을 확장하여 1990 년대 이후의 한국 경제의 불평등도 심화에 대해 논의한다.

주요어: 인적자본, 경제성장, 한국 경제사
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