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Bogang Jun

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Abstract

Unified Growth Theory suggests the demographic transition and the associated rise in human capital formation were critical forces in the transition from Malthusian stagnation to modern economic growth. This paper provides empirical evidence in support of this hypothesis based on the development process in Korea. Exploiting variations in fertility in human capital formation across regions in Korea over the period 1970 to 2010, the study establishes that the process of development in Korea was associated with a reduction in child quantity and increase child quality.

Keywords Demographic transition, Quantity-quality trade-off, Unified Growth Theory

JEL Classification I25, J13, N15

Bogang Jun

Technology Management, Economics, and Policy Program, Seoul National University, Building 37, Gwanak-gu, Seoul, 151746, South Korea E-mail: bogang33@gmail.com

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1. Introduction

Unified Growth theory (UGT) suggests 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 to reduce their fertility rate (Galor, 2011, Galor and Weil, 2000).

Empirical studies of UGT have focused primarily 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. This paper focuses on these important regions and 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 depicted in Figure 1 Korea transition from an underdeveloped country into an advanced economy was associated with a demographic transition. The quantity-quality trade-off played a critical role in this transition from a Malthusian regime to a modern economy in Korea, and thus, it is likely to be a significant part of the development process of other underdeveloped countries as well.

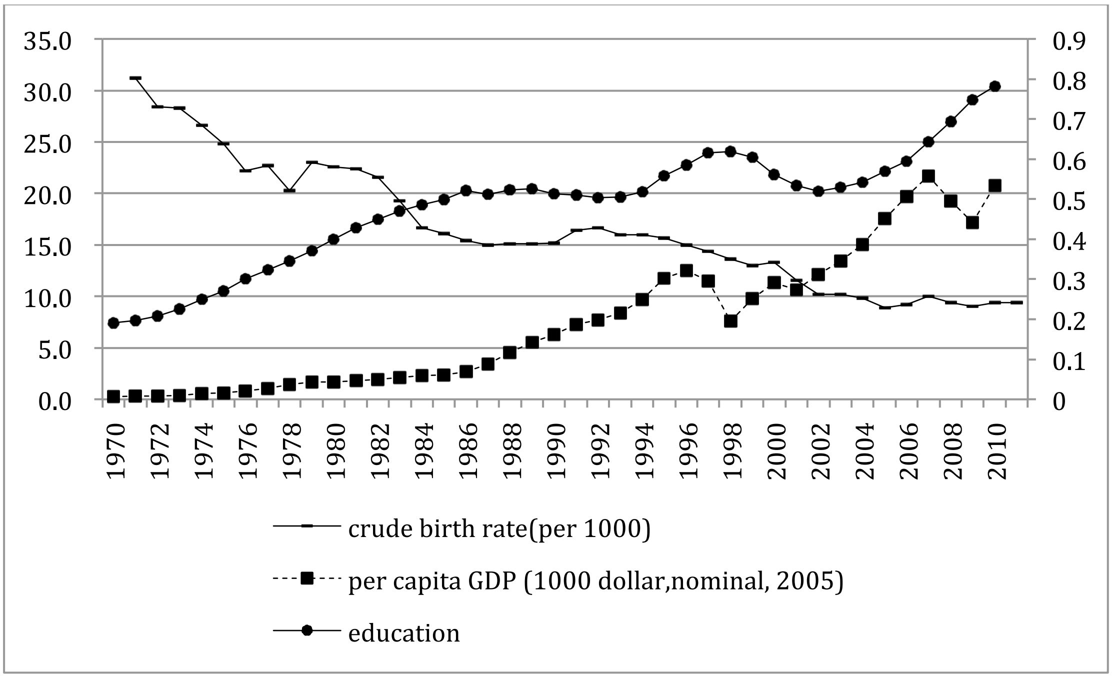

Figure 1 The trend of Education, CBR and GDP per capita

Source: Korean Population and Housing Census and Education Statistics

Recent research established the importance of the quantity-quality trade-off in the transition from stagnation to growth across a wide range of European societies in the nineteenth century using a variety of identification strategies. In particular, it was found to be present 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 covering 11 regions and 10 time points, reflecting 5-year time internal over the period 1970-2010. I use the high school enrollment rate, defined as the number of high school students per person aged 15–19, to reflect children's education, and the Crude Birth Rate (CBR), which is the number of births per 1,000 people per year, to measure parent's fertility. As will become apparent, although the Korean government's fertility control policy commenced in 1961 contributed to the decline in fertility over this period, regional variations allow us to capture the relationship between fertility and education.

The empirical analysis in this paper is performed using a first-order differencing model. I control for unobserved factors at the regional level that may affect both fertility and education. The panel data also allow us to control for regional and national time trends. The empirical results, consistent with UGT, show a significant negative relationship between children's education and parent's fertility, implying that there was a quantity-quality trade-off in Korean development. These results are robust to using alternative measures of fertility and lagged variables.

The remainder of this paper proceeds as follows. Section 2 presents the theoretical background and related literature. Section 3 shows the empirical analysis and the results. Finally, section 4 gives concluding remarks.

2. Theoretical background and related literature

A demographic transition, accompanied by decreasing fertility and a decreasing population growth rate, is crucial for escaping the Malthusian trap and entering a modern growth regime. If this demographic transition did not occur, the increasing output resulting from technological progress would be canceled out by an increasing population, and GDP per capita would remain stagnant. The first demographic transition occurred in Western Europe in the late nineteenth century and created sustained economic benefits from the Industrial Revolution, which began in the late eighteenth century.

The 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 caused decreasing fertility because of the opportunity cost of raising children. Child quality has a higher income elasticity than does child quantity, creating the quantity-quality trade-off. This argument, however, cannot explain the historical fact that the demographic transition occurred simultaneously in the most of Western Europe despite an income gap between the countries. Moreover, to make this argument, they postulate that all individuals have the same preferences over the quality and quantity of their children, 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, because parents care about their number of surviving children, lower infant and child mortality implies that more children survive, and thus, parents give birth to fewer children. Doepke (2005), however, shows empirically that an additional factor besides the change in infant and child mortality is necessary to explain the change in the net reproduction rate. Murphy (2010) also shows that decreasing infant mortality has no effect on decreasing fertility through empirical research on French data.

As another alternative, Caldwell (1976) and Morand (1999) construct a different household utility function based on the old-age-support model and try to explain the demographic transition using this utility function rather than one based on 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. Their argument, however, is not logical considering the fact that the young of all natural species seldom care for their parents. Furthermore, financial institutions that provide insurance for old age existed before the timing of the demographic transition, which does not support their argument (Hindle, 2004; Pelling and Smith, 1994). Moreover, although the rich have more 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, driving parents to decrease their fertility and increase their children's level of education. That is, they made the 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 the quality and quantity of children. Second, increasing technology led parents to reallocate their budget toward investments in their children's quality rather than their quantity. This process created a virtuous cycle in that 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, the economy was released from the Malthusian trap and achieved modern growth.

Empirical evidence for the quality-quantity trade-off continues to accumulate. Klemp and Weisdorf (2011) show that there was a quantity-quality trade-off during the Industrial Revolution in England by using data from Anglican parish registers over c. 1700–1830. Murphy (2010) also gives evidence for a quantity-quality trade-off in France by 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, implying that the quantity-quality trade-off along with cultural factors 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, by using inequality in landownership and the distance to Wittenberg, where Luther delivered a sermon that every Christian should able to read the Bible, as instrumental variables. They find that education preferences have a significant relationship with fertility. Fernihough (2011) compares two Irish cities, Belfast and Dublin, by using a data set of Irish families 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 parent's fertility using Spanish provincial level data in 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 have also played an important role in the development paths of twentieth century Asian countries. This question is important because if these countries, which achieved industrialization later, followed a growth path similar to that of western countries, which were leaders in terms of economic development, we could give a meaningful blueprint for economic growth to countries still caught in the Malthusian trap.

Bloom and Williamson (1997) have previously mentioned that the demographic transition and its cohort effect are major factors in the Asian economic miracle, including Korean economic achievement. 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 of children and the increasing quality. Doepke (2004) also describes the fertility transition in the middle of the twentieth century in Korea, analyzing the effect of human capital policies. He shows that education reform and child labor regulation played an important role in the demographic transition and in Korea's growth because these policies lowered 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, have 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 exists.

To do so, I use 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, the number of (surviving) children, n, and the human capital of each child, h.

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

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 their 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.

$$yn(\tau^q + \tau^e e) + c \le y \tag{2}$$

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 slow. Therefore, a child's level of human capital, h, is a function of his education and the technological environment.

$$h = h(e, g) \quad (3)$$

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, I can determine the optimal quantity and quality of children by adding some assumptions on h to ensure an interior solution.

$$n = \gamma / (\tau^q + \tau^e e) \quad (4)$$

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

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.

$$e = e(g, \beta, \tau^e, \tau^q) \quad (6)$$

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

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.

3. Empirical Analysis

1) Data Description

For the analysis, I use data from the Korean Population and Housing Census of 1966–2010. The Census has collected demographic, educational, and economic information for every Korean person every 5 years since 1925. I also use data from Education Statistics, which has collected information about every educational institution, including preschools, elementary schools, middle schools, every kind of high school, and colleges, graduate schools, and other advanced education institutions every year since 1963. From these data sets, I create a panel covering 11 regions and 10 time points (1970–2010, every 5 years).

Fertility, $Fertility_{i,t}$, is measured as the crude birth rate (CBR), which is the number of births per 1,000 people per year, in province i in period t.

The level of education, $Education_{i,t}$, is measured as the high school student ratio, defined as the number of high school students divided by the number of people aged 15–19 who are eligible for high school in province i in period t. The actual rate may be higher than the computed rate because the population aged 15–19 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. 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 entering college is extremely high.

The control variables in the model are the share of married women, defined as the number of married women aged 15–44 divided by the total number of women aged 15–44 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 1 provides the summary statistics of the variables.

(Insert Table 1 here)

2) Empirical Specification: First-Differencing Model

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

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

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 across the provinces in fertility, η_i , where,

$$\upsilon_{i,t} = \eta_i + e_{i,t} \tag{9}$$

The choice between a fixed effects model and a first differencing model depends on the assumptions about the idiosyncratic error, $e_{i,t}$. If there is autocorrelation in $e_{i,t}$ and no serial correlation in $\Delta e_{i,t}$, the estimator from the first differencing model will be more efficient. To test the autocorrelation in $e_{i,t}$, I perform the Wooldridge test for autocorrelation with a null hypothesis of no first-order autocorrelation and obtain 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 differencing model is appropriate in this context. Therefore, I examine the first difference of equation (8) and estimate the effect of changes in education on changes in fertility.

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 mean that I am assuming that there is no correlation between changes in the explanatory variables and those in the error term, whereas the levels of the explanatory variables could be correlated with the error term.

If there are no time constant explanatory variables, then I can estimate the partial effects 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 are time-constant variables such as the geographical characteristics of each province. Therefore, I can capture the partial effect of education on fertility when controlling for regional fixed effects even if there are omitted variables.

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

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

Then, the first differencing 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 every five-year interval between 1970 and 2010. The lag operator, Δ, is applied to the other variables in vector X . Given this changed empirical specification, I have 88 observations across 11 provinces.

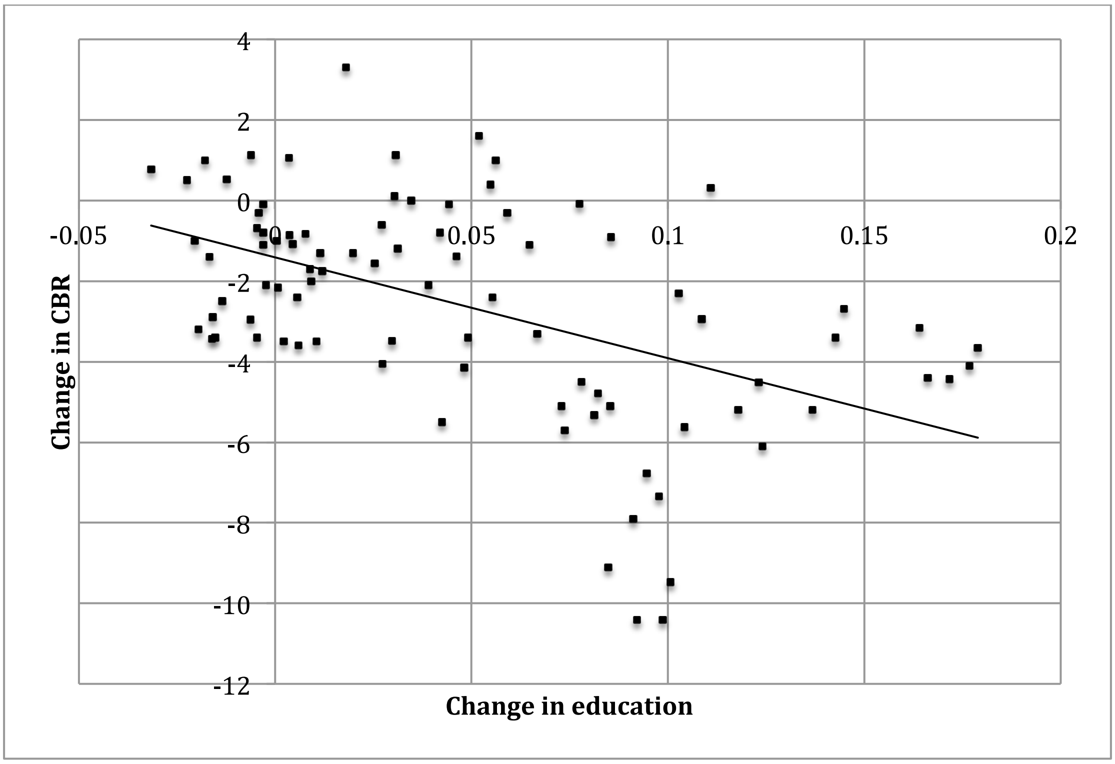

Figure 2 Change in CBR and change in the education

Source: Korean Population and Housing Census and Education Statistics

The negative correlation between the change in the CBR and the change in education is apparent in Figure 2 and is shown in the fitted values plotted from an OLS regression.

(Insert Table 2 here)

Table 2 depicts the results of these estimates from 1970 to 2010 in columns (1)-(11). The change in education has a negative and highly significant effect on the change in the CBR when controlling for regional fixed effects only (column (1)), controlling for regional fixed effects and national time trends (column (2)), and controlling for regional fixed effects and regional time trends (column (7)). Moreover, when controlling for the change in married woman, the change in share of agriculture, and the change in share of urban, the highly significant effect of the change in education on the change in the CBR holds. As one would expect, columns (3) and (8) present a positive effect of the change in married woman on the change in the CBR and a negative and highly significant effect of the change in education on the change in the CBR.

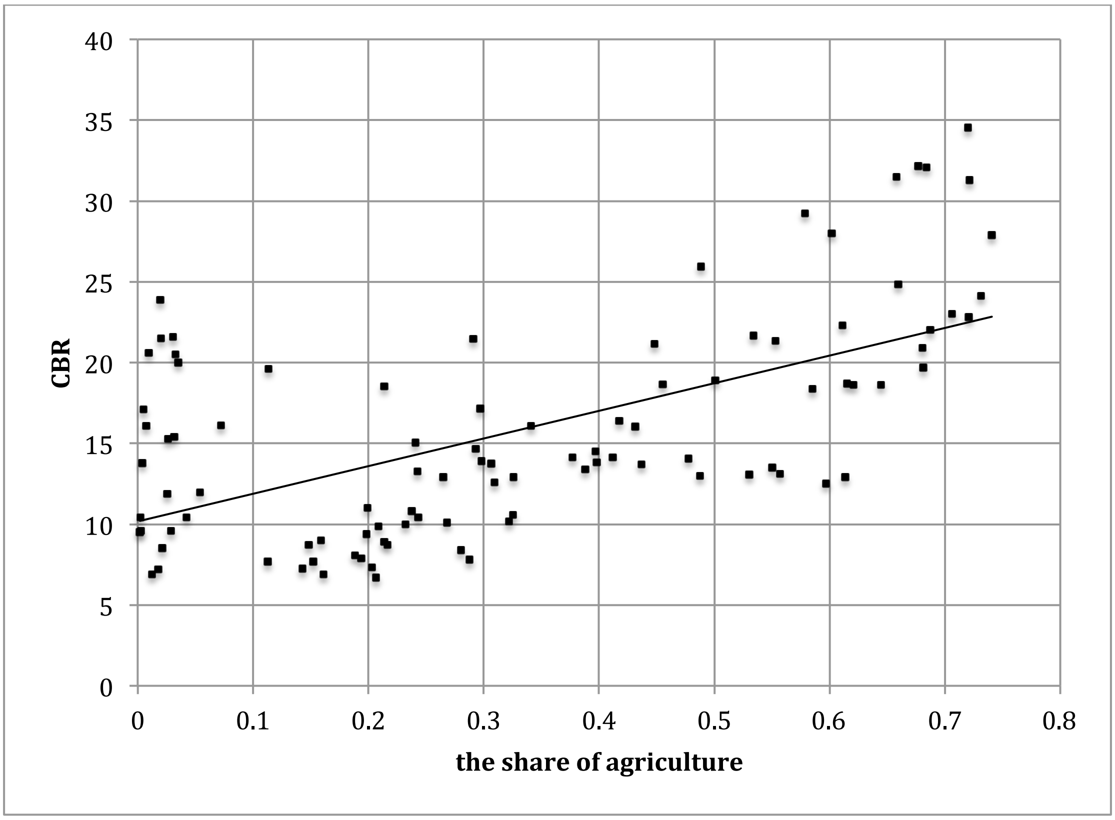

Figure 3 The share of agriculture and CBR
Source: Korean Population and Housing Census

Contrary to my expectation, columns (4) and (9) present a negative but insignificant effect of the change in the share of agriculture on the change in the CBR. As depicted in Figure 3, the relationship between the share of agriculture and the CBR is apparently positive, but when controlling for regional fixed effects, a national time trend, and regional linear time trends, the causal effect disappears. In columns (5) and (10), I observe the negative and significant effect of the change in the share of urban on the change in the CBR. These results are reasonable because the share of urban, which measures the share of human-capital-demanding occupations, should encourage decreasing fertility. However, the significant effect disappears when controlling for the regional time trend.

(Insert Table 3 here)
(Insert Table 4 here)

Table 3 depicts the effect of the change in education on the change in the CBR for 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, the Korean economy transitioned from a Malthusian agricultural economy 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 human capital accumulation, which is one of the driving forces of modern growth. Singh et al. (1996) also shows that the driving force of growth transitioned 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. Because the quantity-quality trade-off is particularly important in the transition, to test whether it existed during the transition period, I examine just the period from 1970-1990 and find that the highly significant effect of the change in education on the change in the CBR holds in every case, as in Table 2.

Table 4 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 education on the change in the CBR decreases as compared to the results for 1970–1990. Moreover, the significance disappears when controlling for the regional time trend. This means that the quantity-quality trade-off observed in the transition from a Malthusian regime to a modern growth regime occurred in Korea from 1970 to 1990.

(Insert Table 5)

To check the robustness of the above results, I measure fertility as the child-woman ratio, defined as the number of children aged 0–4 per each woman of child bearing age (15–44), which is used in Becker et al. (2010), as depicted in Table 5. The highly significant effect of the change in education on the change in fertility holds.

I further test robustness 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 five 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 differencing model is:

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

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 every five-year interval between 1970 and 2010

The negative correlation between the change in the CBR and the lagged change in education is apparent in Figure 4 and is shown in the fitted values plotted from an OLS regression.

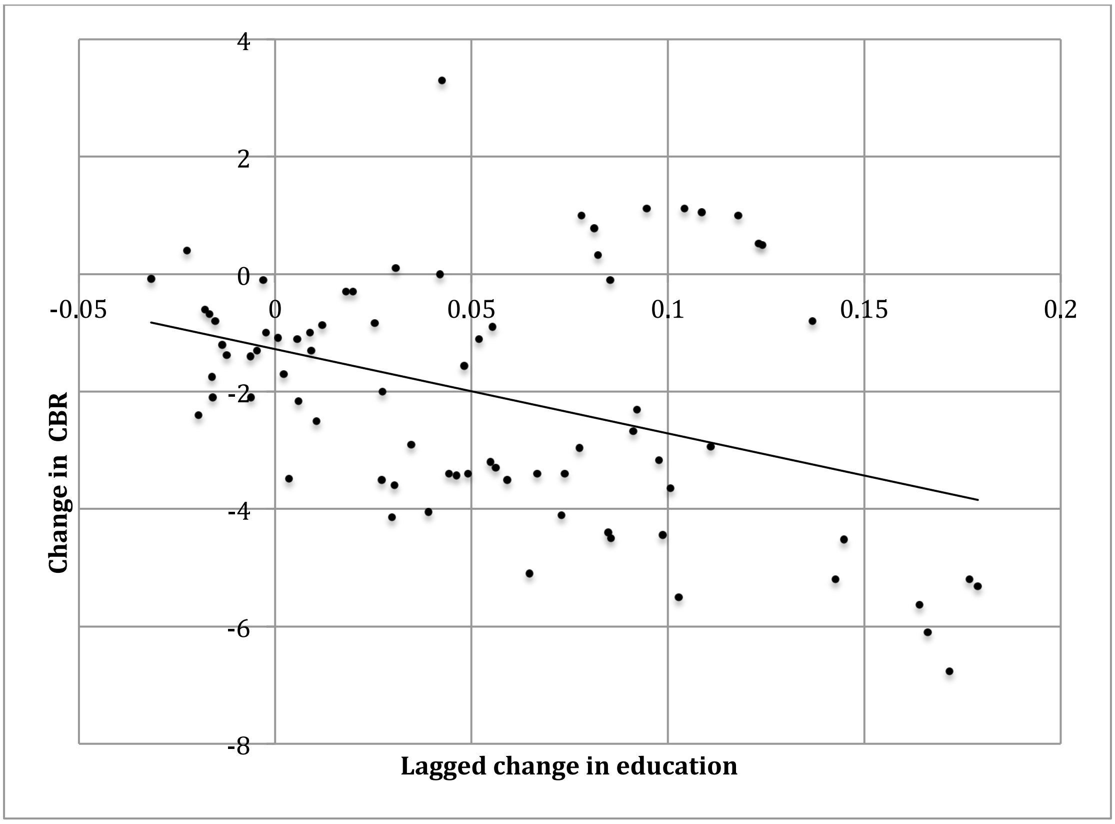

Figure 4 Change in CBR and lagged change in the education
Source: Korean Population and Housing Census and Education Statistics

(Insert Table 6 here)
(Insert Table 7 here)

Tables 6 and 7 depict the effects of the lagged change in education on the change in the CBR for 1970–2010 and 1970–1990, respectively. The highly significant effect of the lagged change in education on the change in the CBR holds in every case in both tables, that is, Tables 2 and 3.

(Insert Table 8 here)

As Table 8 presents, measuring fertility using the child-woman ratio instead of the CBR also indicates that the change in education has a highly significant effect on the change in fertility.

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 the rise in the demand for human capital in the course of industrialization and its adverse effect on fertility rates, which make increasing income per capita become possible (Galor, 2011, Galor and Weil, 2000, Galor and Moav, 2002).

Consistent with previous empirical finding primarily from the European continent, this paper establishes the existence of a quantity-quality trade-off in Korea. It finds that regions with higher levels of education have lower fertility. Using panel data spanning 11 provinces and the years 1970 to 2010, and controlled for unobserved heterogeneity, using a first-differencing model, the study finds that the quantity-quality trade off exists and plays a crucial role in Korea's increasing income per capita and economic development.

Future research could further explore the relationship between demand for human capital and the level of Korean technological progress. This analysis could establish the virtuous cycle in Korean development path, where technological progress increased the demand for human capital and generated a soaring level of education and a demographic transition. Furthermore, I hope that the unveiled Korean development path will present important policy implications for underdeveloped countries still trapped in a Malthusian economy.

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Table 1 Summary statistics

	Mean	Std.dev.	Min	Max
Crude Birth Rate	15.7564	6.7014	6.7	34.55
Child-woman ratio	0.3766	0.1704	0.1558	0.8585
Education	0.4636	0.1390	0.1505	0.6079
Share of married woman	0.5681	0.0584	0.3819	0.7014
Share of agriculture	0.3264	0.2352	0.0020	0.7406
Share of Urban	0.0775	0.0448	0.0229	0.2078

Crude Birth Rate is the number of births per 1,000 people per year. Child-woman ratio is defined as the number of children aged 0-4 per woman of childbearing age (15-44). Education is measured as the high school student ratio, defined as the number of high school student per the people in high school age (15-19). The share of married woman is defined as the number of married woman in age 15-44 per the number of woman in age 15-44, the share of agriculture is the number of people making their living of agriculture, forestry and fisheries per number of people employed, and the share of urban measured in the number of people employed in service sector per population.

Source: Korean Population and Housing Census and Education Statistics

Table 2 The Relationship between education and fertility over 1970-2010 (First-differencing Model)

Explanatory variables	Dependent variable: change in cbr										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Change in education	**-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
Change in married 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
Change in share of agriculture				**-2.8670**		**0.8033**			**-15.3305**		**-18.4484**
				2.3644		3.4311			9.5728		8.2869
Change in share of urban					**-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
R2	0.5325	0.7918	0.8286	0.8302	0.8387	0.8387	0.6224	0.6433	0.6916	0.6433	0.7014
observation	88	88	88	88	88	88	88	88	88	88	88

Table 3 The Relationship between education and fertility over 1970-1990 (First-differencing Model)

Explanatory variables	Dependent variable: change in cbr										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Change in education	**-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
Change in married 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
Change in share of agriculture				**-6.3647**		**-6.8495**			**-58.2885*** **		**-59.562*** **
				7.5044		7.6879			7.7523		8.3144
Change in share of urban					**-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
R2	0.6317	0.8046	0.8577	0.8602	0.8598	0.8627	0.6794	0.7456	0.8958	0.7559	0.8964
observation	44	44	44	44	44	44	44	44	44	44	44

Table 4 The Relationship between education and fertility over 1990-2010 (First-differencing Model)

Explanatory variables	Dependent variable: change in cbr										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Change in education	**-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
Change in married 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
Change in share of agriculture				**-1.7092**		**-0.2185**			**-40.9974****		**-41.1822****
				4.5191		4.2982			16.6275		15.9681
Change in share of urban					**-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
R2	0.1020	0.8577	0.8598	0.8601	0.8630	0.8630	0.6451	0.6543	0.7135	0.6630	0.7227
observation	44	44	44	44	44	44	44	44	44	44	44

Table 5 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: change in child-woman ratio										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Change in education	**-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
Change in married 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
Change in share of agriculture				**0.1322**		**0.1280**			**0.1436**		**0.1498**
				0.0817		0.0906			0.1348		0.1351
Change in share of urban					-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
R2	0.5806	0.8180	0.9181	0.9207	0.9213	0.9238	0.7117	0.7721	0.7755	0.7743	0.7780
observation	88	88	88	88	88	88	88	88	88	88	88

Table 6 The Relationship between education and fertility over 1970-2010 (First-differencing Model with 5-years lag)

Explanatory variables	Dependent variable: change in cbr										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Change in education	**-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
Change in married 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
Change in share of agriculture				**-10.1399*** **		**-10.1664*** **			**-7.2759**		**-7.1253**
				3.2766		3.2993			6.7697		6.7555
Change in share of urban					**-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
R2	0.4788	0.8897	0.8899	0.9035	0.8900	0.9037	0.5712	0.5773	0.5848	0.5860	0.5931
observation	77	77	77	77	77	77	77	77	77	77	77

Table 7 The Relationship between education and fertility over 1970-1990 (First-differencing Model with 5-years lag)

Explanatory variables	Dependent variable: change in cbr										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Change in education	**-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
Change in married 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
Change in share of agriculture				**-21.4251*** **		**-21.4782*** **			**-0.1962**		**-2.2330**
				4.3941		4.5154			16.8533		17.9307
Change in share of urban					**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
R2	0.5416	0.9124	0.9181	0.9557	0.9186	0.9557	0.5884	0.6808	0.6808	0.6833	0.6835
observation	33	33	33	33	33	33	33	33	33	33	33

Table 8 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: change in child-woman ratio										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Change in education	**-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
Change in married 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
Change in share of agriculture				**0.0114**		**0.0065**			**-0.6418*** **		**-0.6409*** **
				0.1219		0.1204			0.1098		0.1105
Change in share of urban					**-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
R2	0.5962	0.7572	0.7916	0.7916	0.7999	0.7999	0.6843	0.7387	0.8297	0.7394	0.8301
observation	77	77	77	77	77	77	77	77	77	77	77