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INDUSTRIAL REVOLUTION, DEMOGRAPHIC TRANSITION, AND
HUMAN CAPITAL ACCUMULATION IN KOREA, 1916-38

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ABSTRACT

This article analyzes a panel dataset to explore how industrial revolution, demographic transition, and human capital accumulation interacted in Korea from 1916-38. Income growth and public investment in health caused mortality to fall, which suppressed fertility and promoted education. Industrialization, skill premium, and closing gender wage gap further induced parents to opt for child quality. Expanding demand for education was accommodated by an active public school building program. The interwar agricultural depression aggravated traditional income inequality, raising fertility and impeding the spread of mass schooling. Landlordism collapsed in the wake of de-colonization, and the consequent reduction in inequality accelerated human and physical capital accumulation, hence growth in South Korea.

JEL Classification: I20, J13, N35, O53

Imperialism has attracted growth economists' attention as natural experiments, which led them to identify key causes of economic growth such as institutional change (see Acemoglu, Johnson and Robinson (2001), Engerman and Sokoloff (1997), and Hall and Jones (1999) among others). Japan imposed *de facto* rule over Korea in 1905 and formally integrated the country five years later as a part of its colonial empire, which collapsed with the end of the Second World War. Japanese rulers replaced the feeble but predatory government of dynastic Korea with an efficient and market-friendly one, reversing the pre-colonial stagnation into modern economic growth. As the architect of the industrial revolution, the colonial government made detailed observations on the transition, making the industrial revolution in colonial Korea one of unusually well-recorded industrial revolutions.

Estimate of aggregate input and output derived from the statistical legacy of the colonial rule indicated that the industrial revolution was driven more by accumulation of physical capital than by productivity advance (Cha and Kim (2006)). Prominently neglected in this type of calculation is human capital accumulation -- particularly in the form of healthier and longer life and spread of schooling -- highlighted in recent models explaining the transition from Malthusian stagnation to modern economic growth (Galor (2004)). Out of a variety of documents left by the colonial government, this article constructs a panel dataset comprising thirteen provinces from 1916-36, which is used to isolate causes of demographic transition and human capital accumulation and to investigate the ways the two developments interacted with each other and with the industrial revolution. The dataset permits measuring the role of different factors featuring in different types of "unified" growth models through econometric estimation, rather than calibration, of structural equations.

The first section describes major trends in key indicators of economic performance in the thirteen provinces of colonial Korea to motivate the analysis in the following section. The second section uses the panel dataset to estimate fertility, mortality and schooling equations. Causes of demographic and educational modernization in colonial Korea as revealed by the estimated equations provide important clues for understanding the growth miracle in South Korea, as the discussion in the third section shows. The final section summarizes and concludes.

Industrial Revolution in Colonial Korea

Different estimates of the population and aggregate output of colonial Korea agree in showing that an industrial revolution swept the country. As the more recent and refined set of estimates indicate, population grew 1.33%, and per capita output increased 2.37% per year from 1911-40 – a growth performance surpassing that observed in many other parts of the interwar world.¹ In the course of the economic growth, agricultural output as a share of GDP fell from more than two thirds to less than half from 1911 to 1940 (Figure 1). Regional population and output figures show that while living standards converged among the thirteen provinces of colonial Korea, they became increasingly dissimilar in terms of economic structure.² In particular, five

¹ Cha and Kim(2006). Earlier estimates of the aggregate output include Suh(1978) and Mizoguchi and Umemura(1988). Maddison (2001, 265)'s estimate of the world's per capita output growth is 0.91% per year from 1913-50.

² Data appendix explains the procedure used to estimate regional product and population. Estimated speed of absolute convergence is 0.0535, which is faster than those estimated for twentieth century U.S and Japan. See Barro and Sala-i-Martin (2004, chapter 11). Coefficient of variation for the share of manufacturing rose from

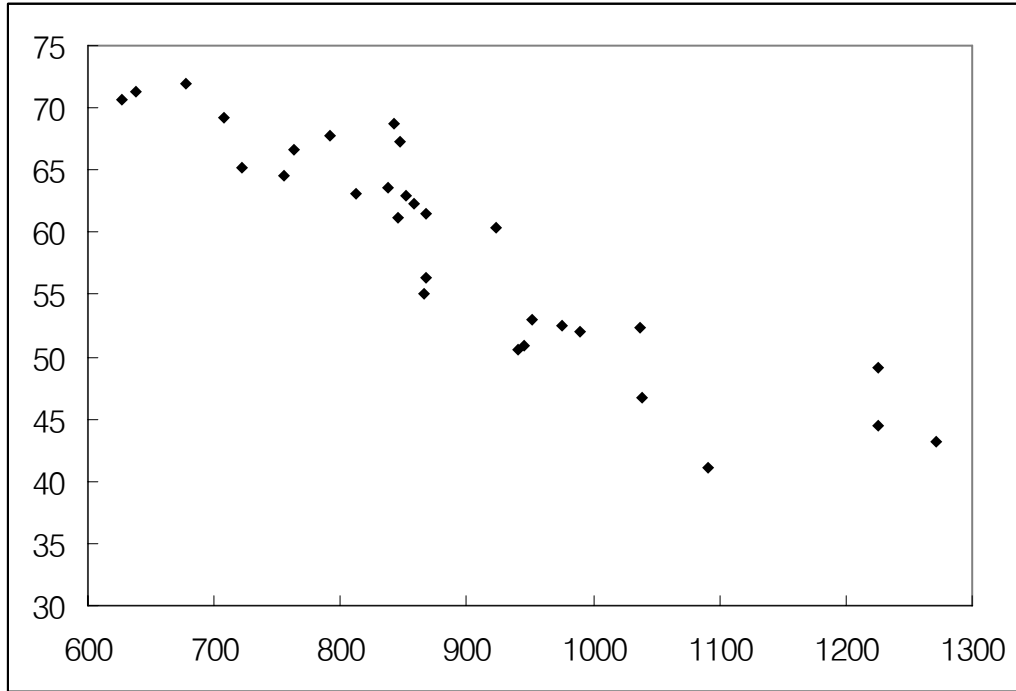
northern provinces witnessed faster income growth and industrialization to surpass eight southern provinces, which were initially both richer and less agrarian at the beginning of the colonial rule.³ The per capita output growth in the context of rapidly expanding population stands in stark contrast to worsening living standards and slow demographic expansion during the last century of pre-colonial Korea.⁴

Figure 1 Income Per Capita and Agricultural Output as a Share of GDP

0.49 to 0.75 from 1916-38.

³ The eight southern and five northern provinces correspond roughly with the territories of today's South and North Korea. Per capita output in the southern and northern provinces rose from 70 yen to 110 yen and from 65 yen to 121 yen in 1935 prices, respectively, from 1916-38. Manufacturing output as a share of GDP in southern and northern Korea was 6% and 5%, respectively in 1916, which rose to 10% and 23% in 1938, respectively. Reasons for the northern half forging ahead of the southern half included ready availability of minerals and water power and the imperial policy to set up war industries for invasion into China.

⁴ Cha (2007)'s estimate of the annual rate of population growth in 18th and 19th century Korea is 0.62% per year. Different studies, including Kim (1997) and Lee (2000), showed both rental and wage income fell as matter of trend in the nineteenth century.



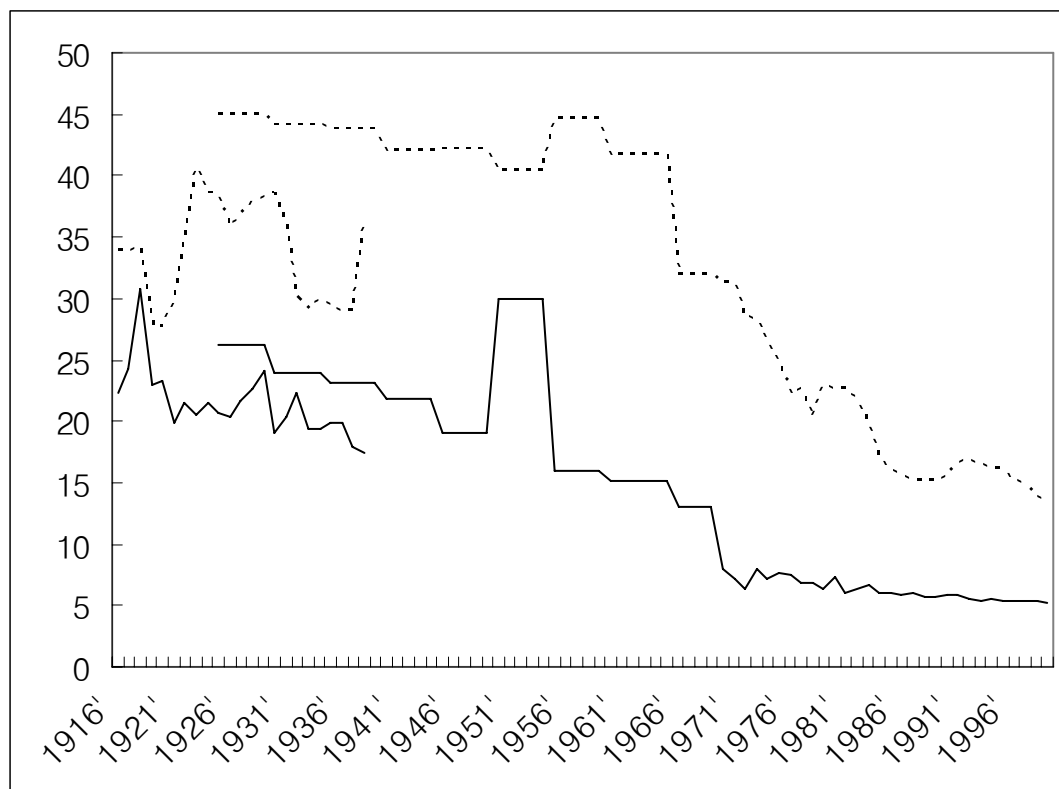
Notes: horizontal axis – income per capita in 1990 US dollars; vertical axis -- share of agriculture, fishery, and forestry in GDP in percent.

Source: Cha and Kim (2006)

As living standards improved, mortality fell in colonial Korea (Figure 2). The mortality transition is likely to have been driven by public investment in health as well, which resulted in proliferation of hospitals and physicians. While crude death rate fell with medical personnel per thousand persons rising over time in the thirteen provinces, correlation between panel observations on the two variables is positive. This reflects cross-sectional association, which appears to suggest that the colonial government followed a rule to put greater efforts to reduce mortality in provinces with higher mortality. The correlation may also indicate greater likelihood for physicians in the private sector to set up hospitals in areas with higher mortality, hence greater demand for medical service. Coefficient of variation for medical personnel per thousand

persons fell as a matter of trend, which together with convergence in per capita income would have resulted in narrowing interregional mortality gap. Mortality differential as measured by coefficient of variation for provincial crude death rate followed neither a falling nor a rising trend, however. One plausible justification may be that mortality also depended on industrial structure, in terms of which the thirteen provinces of colonial Korea were becoming increasingly different.

Figure 2 Crude Birth and Death Rates in Colonial and South Korea



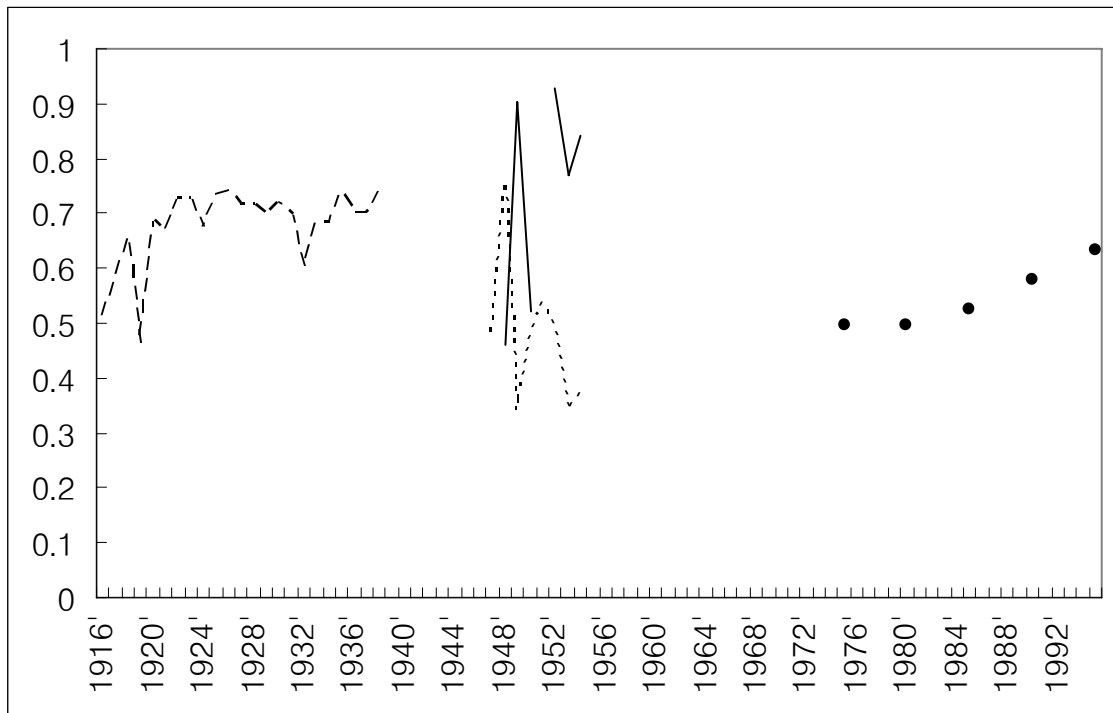
Notes: solid and dotted lines represent crude birth and death rates, respectively. Crude birth and death rates from 1916-38 were obtained by dividing the number of births and deaths, respectively, with the number of residents as counted by police authorities and published in *Chōsen sōtokufu tōkei nenpō*, while crude rates beginning from 1925 on are estimates based upon census reports.

Source: *Chōsen sōtokufu tōkei nenpō*, Kwon (1977), www.nso.go.kr.

Fertility as measured by crude birth rate gives impression of rising in the first half of the colonial period and falling in the second half, indicating that different shocks affected fertility with different intensity in different years of the colonial period (Figure 2). Models of fertility decision suggest three possible factors discouraging fertility in colonial Korea: mortality transition, industrialization, and contracting gender wage gap. Child mortality fell in the course of the mortality transition, reducing the number of births required to replace dying children (Kwon (1977); Doepke (2005)). As the economy industrialized, shift from “family production” to “production within firms” occurred, reducing demand for children as labor force (Lord and Rangazas (2006)). Figure 3 shows that gender wage gap contracted as a matter of trend (Panel A), which in Galor and Weil (1996)’s model reduces fertility by increasing women’s labor force participation. During Korea’s transition to modern economic growth, skill premium fluctuated widely without displaying either a downward or upward trend (Panel B).

Figure 3 Gender Wage Gap and Skill Premium in Colonial and South Korea

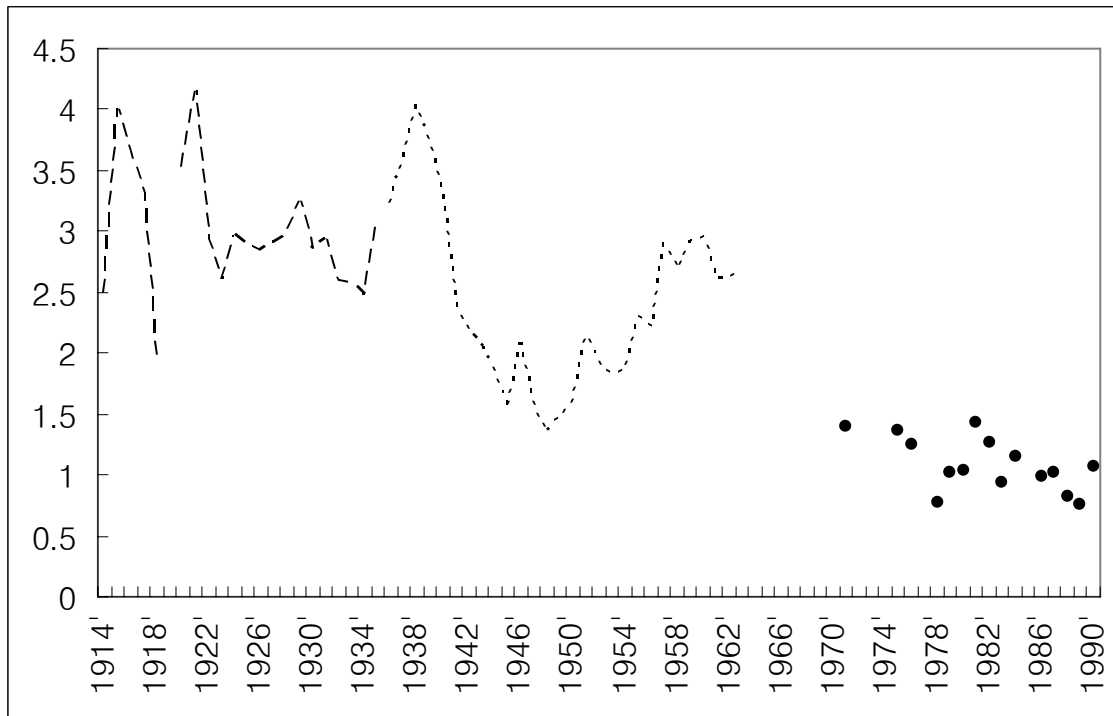
A. Gender Wage Gap



Notes: broken line – ratio of male to female servants wage; solid and dotted line – ratio of male to females workers wage in soap and confectionary industry, respectively; circles – ratio of male to female workers wage in production, transport, and equipment sectors.

Sources: *Chōsen sōtokufu tōkei nenpō*, Ministry of Labor, various years, and Kim and Park (2007).

B. Skill Premium



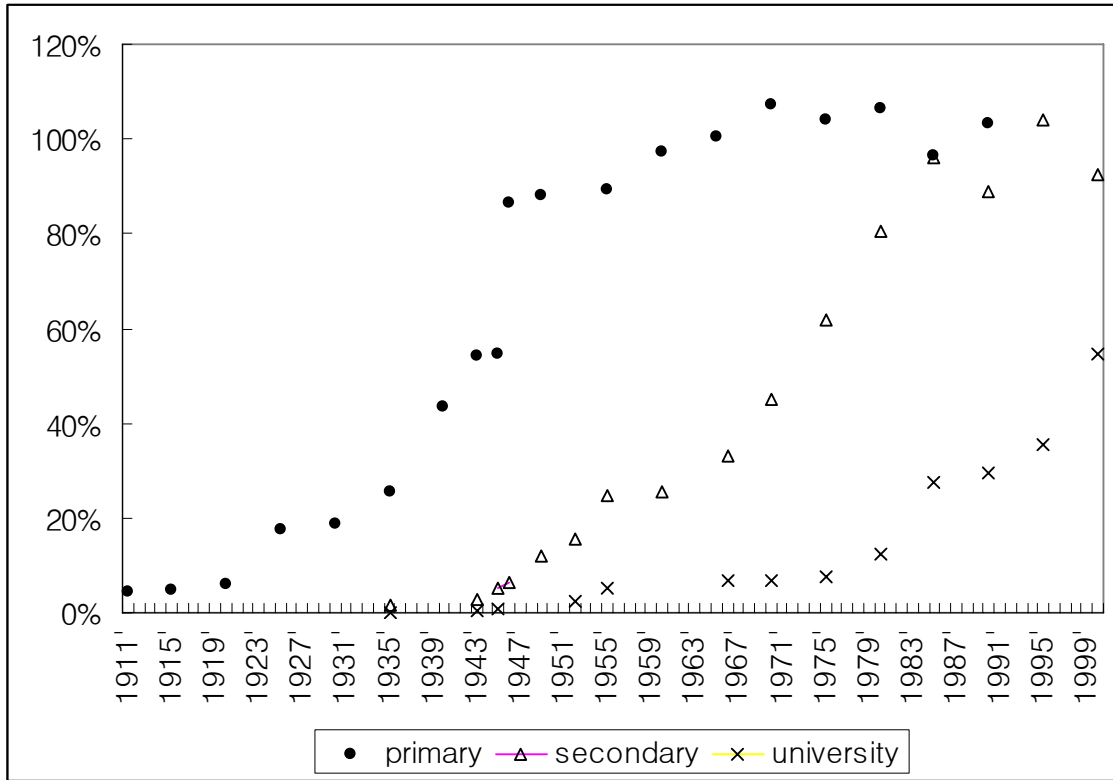
Notes: broken line – ratio of bricklayers to agricultural workers wage; dotted line and circles – ratio of bricklayers to coolies wage.

Sources: *Chōsen sōtokufu tōkei nenpō*, Ministry of Labor, various years, and Kim and Park (2007).

These fertility-suppressing developments were offset by rising income and worsening income inequality. Rising per capita output implies easing budget constraints for parents, which allowed them not only to consume more but also to raise a greater number of offspring. In colonial Korea, income and wealth were being distributed in an increasingly unequal way, which would have stimulated fertility, if time cost of child-rearing was higher for richer parents as in the model of De la Croix and Doepke (2003).⁵

⁵ Evidence of worsening inequality includes rising Gini coefficient and increasing share

Figure 4 School Enrollment Rates in Colonial and South Korea



Source: see Data Appendix

Note: Pre-1945 and post-1944 figures refer to colonial and South Korea, respectively. Primary school enrollment rates before 1946 includes children attending traditional schools run by village communities (*sōdang*). Enrollment rate may exceed unity, when students include individuals under or over school age.

Primary school enrollment rate rose consistently from 4% in 1911 to 55% in 1945 (Figure 4) as the colonial government made efforts to spread mass schooling by building primary schools. On the demand side, income growth permitted parents to raise better educated children as well as to grow more children and to consume more of acreage under tenancy contract. See Cha and Kim (2006).

Given budget constraint, the trade-off between quantity and quality of children implies that the shocks reducing (increasing) fertility would have helped advance (impede) schooling. They could have affected schooling directly, as well as via fertility. For one thing, falling mortality may have raised enrollment rate by reducing risk of investment in human capital and the number of dying schoolchildren. For another, as gender wage gap narrowed in colonial Korea, primary school enrollment rate rose faster for girls than boys, suggesting that gender wage gap affected overall enrollment rate by shifting gender-specific enrollment rates to different degrees. Finally, it is possible that rising inequality stood in the way of the advance of primary education, not only by raising fertility, but also by making it difficult to invest in human capital in the presence of capital market imperfections (Aghion and Williamson (1998)). Also as in the early twentieth century American South, Korean landlords, fearing that education would increase labor mobility, could have prevented the spread of schooling through budget process, (Gerber (1991, 314, 315)).

Industrial Revolution, Demographic Transition, and Primary Schooling

This section explores the interaction among industrial revolution, demographic transition, and human capital accumulation by estimating mortality, fertility and schooling equations. The estimation analyzes a panel dataset for the thirteen provinces of colonial Korea from 1916-38, which was constructed using the sources and procedures as described in data appendix. I begin with a general form of mortality equation – general in the sense that it includes all explanatory variables as available and as deemed relevant on the right hand side:

$$cdr_{it} = \alpha_0 + \alpha_1 \log(\text{income}_{it-1}) + \alpha_2 \text{mshare}_{it} + \alpha_3 \text{tenancy}_{it} + \alpha_4 \text{school}_{it-1} + \alpha_5 \text{doctors}_{it} + \alpha_6 \text{temperature}_{it-1} + u_{it} \quad (1).$$

Crude death rate (cdr_{it}) depends among others on living standards, which I measured by income per capita lagged by one year (income_{it-1}), because consumption in year t was determined to a considerable extent by the amount of rice harvested in the fall of year $t-1$. Manufacturing's share in the aggregate output (mshare_{it}) and land tenancy ratio (tenancy_{it}) capture differential mortality, i.e. different levels of risk of dying as represented by different types of economic activity and different income groups. Health education in primary schools may have improved sanitation practices, which would be reflected in a positive coefficient associated with primary school enrollment rate (school_{it-1}). Number of medical doctors per thousand persons (doctors_{it}) measures accessibility to medical institutions. Miyajima (2001) identified a seasonal pattern in mortality in pre-colonial and colonial Korea, staying low in warm months and rising as temperature falls, which leads one to expect α_6 to have a negative value.

The positive correlation between cdr_{it} and doctors_{it} as noted in the preceding section suggests that the latter is likely to be endogenous. Hence, equation (1) was estimated by two-stage least squares method, using population density in year $t-1$ and doctors_{it-1} as instruments for doctors_{it} . As unit root tests indicated that only crude death rate and temperature are stationary series, first differences of the remaining five variables were used.

Table 1 2SLS Results. Dependent Variable: Crude Death Rate.

Coefficient Estimate

	No cross-section effects	Cross-section random effects
$\log(\text{income}_{it-1})$	-0.0144** (0.0060)	-0.0121*** (0.0039)
$mshare_{it}$	0.0648* (0.0366)	0.0469** (0.0235)
$temperature_{it-1}$	-0.0001** (0.00007)	
$doctors_{it}$	-0.7014** (0.2992)	-0.5883*** (0.1966)
$school_{it-1}$		-0.0279 (0.0179)
<i>constant</i>	0.0257*** (0.0014)	0.0240*** (0.0010)
Observations	247	247
Durbin-Watson	1.29	1.77

Notes: standard errors in parentheses; *, **, and *** indicate significance at 10%, 5%, and 1% levels.

Table 1 presents the coefficients of mortality equation as estimated both with and without cross-section effects. It reports the coefficients of mortality equation estimated with cross-section *random* effects, the null hypothesis of absence of correlation between random effects and explanatory variables not having been refuted by Hausman test. Initial estimation of the two specifications indicated that income, degree of industrialization and the number of doctors as a share of population affected mortality at conventional levels of significance, while land tenancy ratio was not significant. In the equation without cross-section effects temperature also emerged as significant, while the coefficient associated with $school_{it-1}$ was not. Hence, dropping $tenancy_{it}$ and $school_{it-1}$ and re-estimating the mortality equation without cross-section yielded the results as reported in the left column of Table 1. On the other hand,

estimation with cross-section random effects indicated that the coefficient of $temperature_{it-1}$ was not significantly different from zero, while $school_{it-1}$ turned out as influencing mortality at 15% significance level. Therefore, the mortality equation with cross-section random effect was re-estimated after excluding $tenancy_{it}$ and $temperature_{it-1}$ to obtain the result shown in rightmost column of Table 1. The failure for $temperature_{it-1}$ to remain as an explanatory variable in the presence of cross-section random effects indicates regional temperature to be a key part of cross-section random effects. The cross-section random effects specification produced a Durbin-Watson statistic (1.77) larger than that obtained from no cross-section effects specification (1.27) and large enough to reject the presence of autocorrelation at 1% level, which suggests the presence of important province-specific effects other than temperature. Once unobserved heterogeneities are controlled for by adopting cross-section random effect specification, schooling emerged as a cause lowering mortality at 12% level of significance. Coefficient variance estimator robust to serial correlation and heteroskedasticity in the disturbances yielded standard errors somewhat different from those reported in Table 1; the difference was not sufficiently large as to shift the significance levels at which the coefficients are different from zero however.

Fertility and schooling decisions are made jointly subject to a budget constraint:

$$z_{t-1} = \alpha_0 + \alpha_1 x_t + \alpha_2 y_t \quad (2),$$

where z_{t-1} , x_t and y_t represent per capita GDP in year $t-1$, level of fertility and amount of schooling realized in year t . Income is lagged by one year, because spending in year t was determined to a considerable extent by the amount of rice harvested in the fall of

year $t-1$. There is a set of variables, m , affecting both demand for child and schooling, while schooling is constrained by additional set of variables, n , which describe schooling supply conditions:

$$x_t = \beta_0 + \beta_1 z_{t-1} + \sum_{i=2}^k \beta_i m_{t-1}^i + v_t \quad (3),$$

$$y_t = \gamma_0 + \gamma_1 z_{t-1} + \sum_{i=2}^k \gamma_i m_t^i + \sum_{j=k+1}^l \gamma_j n_t^{j-k} + w_t \quad (4).$$

Fertility (x_t) and schooling (y_t) are measured in terms of crude birth rate and primary schooling enrollment rate, respectively. The discussion in the preceding section suggests that the variable set m includes skill premium, gender wage gap, degree of industrialization, land tenancy ratio and crude death rate. I augmented m with the number of protestant missionaries, Catholic priests and Buddhist monks per thousand persons to see whether different religions influenced decisions on fertility and education.⁶ In equation (3) m_{t-1}^i indicates that variables in m are lagged by one year, since fertility observed in year t is an outcome of decision made in year $t-1$ using relevant information available in that year. Equation (4) shows that the state of variables in m in year t influences schooling realized in the year.

In colonial Korea, there existed two different types of primary schools: modern primary schools mostly established and run by the government and the other traditional schools run by village communities, known as *sōdang*. The set of supply-side variables n

⁶ Evidence of religion affecting fertility or education include Goldin (1998), Gruber(2005), Tortella (1994), and Weber (1905/2002). Admittedly, a more accurate index would be the number of believers as standardized by population, which unfortunately is not available.

includes $mschool_t$ and $tschool_t$ representing the number of modern and traditional schools per square kilometer, respectively. In pre-colonial Korea, Confucian classics were taught in *sōdang* to train children of privileged status (known as *yangban*) for state examination selecting civil servants. Although after 1910 *sōdang* education evolved to look increasingly like that provided by modern schools, modern schools proliferated at the expense of traditional schools (Furukawa (1996)). To capture the impact of the institutional shift in education sector, $inter_t (= mschool_t * tschool_t)$ was added to the set n . Finally, the set n also has population density ($density_{it}$) as another factor influencing the accessibility to schools.

Substituting equation (2) into (3) yields an expression of x_t in terms of y_t and m_{t-1} :

$$x_t = \delta_0 + \delta_1 y_t + \delta_2 \sum_{i=2}^k \beta_i m_{t-1}^i + v_t \quad (5),$$

where $\delta_2 = 1/(1 - \alpha_1 \beta_1)$, $\delta_1 = \alpha_2 \beta_1 \delta_2$, and $\delta_0 = (\beta_0 + \alpha_0 \beta_1) \delta_2$. Equations (5) and (4) were estimated, respectively, by generalized least squares method (allowing for cross section heteroskedasticity) and by two stage least squares method, using in m_t^i and n_t^i as instruments for the endogenous y_t .⁷ Hausman test having rejected the null hypothesis

⁷ Furukawa (1996: 166, 167) asserted that expanding demand for education pressurized the colonial government into building more schools, which raises questions about the adequacy of the use of $mschool_t$ (in n_t) as an instrument. To see if this claim is valid, I estimated a policy function by regressing $mschool_{it}$ on $income_{it}$ and $mshare_{it}$. Province i 's deviation from the national average number of modern and traditional schools per square kilometer in year $t-1$ was also included as a right-hand side variable, since Kimura (1990: 339) claimed that the colonial government's schooling building program followed "one school per three villages" principle. The only coefficient significantly

of absence of correlation between random effects and explanatory variables in fertility equation only, fixed effect specification was adopted for schooling equation. As unit root tests indicated that only crude birth and death rate are stationary series, remaining variable were first differenced. Initial estimation results included several coefficient estimates insignificantly different from zero at conventional levels of significance. Fertility and enrollment equations were re-estimated dropping variables associated with such coefficients to obtain the results as presented the left columns of Tables 2 and 3. In the right columns of the tables are shown the coefficient estimates obtained from simultaneous estimation of fertility and enrollment equations by generalized method of moments (GMM), using heteroskedasticity and autocorrelation consistent (HAC) covariance matrix and using z_{t-1} , and elements of m_t and n_t as instruments.

Table 2 2SLS and GMM Results. Dependent Variable: Crude Birth Rate.

	Coefficient estimate	
	2SLS	GMM
<i>enroll_{it}</i>	-0.1008*** (0.0313)	-0.1077*** (0.0230)
<i>skill_{it-1}</i>	-0.0005* (0.00003)	-0.0005** (0.0002)
<i>mshare_{it-1}</i>	-0.0376*** (0.0171)	-0.0332** (0.0151)
<i>cdr_{it-1}</i>	0.4993*** (0.0669)	0.4277*** (0.0974)
<i>tenancy_{it-1}</i>	0.0264* (0.0137)	0.0211** (0.0106)
<i>constant</i>	0.0246*** (0.0016)	0.0259*** (0.0021)
Observations	273	273

different from zero at 5% level was that associated with the deviation variable.

Durbin-Watson	0.76	0.74
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Notes: standard errors in parentheses; *, **, and *** denote significance at 10%, 5%, and 1% level, respectively.

As seen in Table 2, coefficients of fertility equation estimated using two stage least squares method (2SLS) and generalized method of moments (GMM) differ little.⁸ The negative value of δ_1 associated with schooling ($enroll_t$) indicates that budget constraints dictated parents to raise a smaller number of children, if they wanted to educate them better, and vice versa. Estimated coefficients of the variables in $m - \delta_2\beta_1$'s -- have expected signs, which indicates that $\delta_2 (=1/(1-\alpha_1\beta_1))$ is positive. Skill premium ($skill_{t-1}$) was found to reduce fertility, while on the first round of estimation gender wage gap emerged associated with a coefficient insignificantly different from zero, hence was subsequently dropped. Industrialization ($mshare_{t-1}$) also turned out to be a cause discouraging fertility, which validates Lord and Rangazas (2006)'s claim on the positive effect of family production sector on child demand. Estimated coefficient for crude death rate (cdr_{t-1}) is positive and significantly different from zero, confirming that parents made fertility choices sequentially. It is smaller than unity, which suggests that replacement of dying children was less than complete. Less than full replacement implies that although *gross* fertility falls in the course of mortality transition, *net* fertility rises (Doepke (2005)): indeed Kwon (1977: 248)'s estimate of net reproduction rate

⁸ Although standard errors based on White coefficient variance estimator robust to serial correlation and heteroskedasticity in the disturbances are different from those reported in the left column of Table 2, the coefficients remained significantly different from zero at the same levels of significance.

from census result increased from 1.68 in 1925/30 to 1.93 in 1940/45.⁹ Finally, income and wealth inequality as measured by land tenancy ratio ($tenancy_{t-1}$) was found to affect fertility positively. This not only validates De la Croix and Doepke (2003)'s assumption of differential time cost of child-rearing among different income groups, but also is consistent with Cha (2007)'s finding that *yangban* parents remained considerably less fertile than the rest of the population in colonial Korea. Finally, negative δ_1 ($= \alpha_2\beta_1\delta_2$) and positive δ_2 imply a negative value for $\alpha_2\beta_1$, which in turn indicates that β_1 -- measuring income effect on fertility -- is negative, for α_2 is positive.¹⁰

Table 3 GLS and GMM Results. Dependent Variable: Primary School Enrollment Rate.

	Coefficient estimate	
	GLS	GMM
$\log(income_{it-1})$	0.0179** (0.0075)	0.0156*** (0.0056)
$gender_{it}$	-0.0058*** (0.0017)	-0.0051*** (0.0010)
cdr_{it}	-1.9554*** (0.2319)	-1.0114*** (0.1598)
$tenancy_{it}$	-0.0757** (0.0351)	-0.0939** (0.0408)
$mschool_{it}$	3.5306* (0.1598)	5.6612*** (0.1598)

⁹ This contradicts Kalemli-Ozcan (2003)'s claim that mortality decline leads to falling net fertility by reducing precautionary demand for children. Full replacement of dying children is unlikely, because a fraction of parents grow out of their fertile periods all the time.

¹⁰ In the presence of factors affecting fertility other than living standards, the sign of simple correlation between fertility and income would vary depending upon places and periods as noted by Clark and Hamilton (2006)'s survey.

	(1.9634)	(2.0044)
<i>tschool_{it}</i>	0.4543***	0.5616***
	(0.0804)	(0.0855)
<i>density_{it}</i>	-0.0033***	-0.0028***
	(0.0004)	(0.0006)
<i>constant</i>	0.0569***	0.0350***
	(0.0055)	(0.0044)
Observations	273	273
Durbin-Watson	1.48	1.57

Notes: standard errors in parentheses; *, **, and *** denote significance at 10%, 5%, and 1% level, respectively.

Coefficients of enrollment equation obtained using generalized least squares and generalized method of moment (Table 3) are broadly comparable. Income effect on schooling is positive, which together with negative income effect on fertility confirm that income elasticity is greater with respect to child quality than quantity.¹¹ Skill premium and the degree of industrialization in year t ($skill_t$ and $mshare_t$) emerged on the first round of estimation associated with coefficients insignificantly different from zero: their impact on education is felt only indirectly, i.e. through their influence on fertility decision made in year $t-1$. Gender wage gap ($gender_t$) lowered enrollment rate directly, probably because increase in gender gap encouraged male schooling less than it discouraged female schooling, and vice versa. Crude death rate in year t had adverse

¹¹ Becker and Lewis (1973). Equation (2) may be inserted into (4) to derive a schooling equation having crude birth rate and variables in set m and n on the right-hand side. Estimating this equation simultaneously with fertility equation (3) generated a negative coefficient for income in the fertility equation and a negative coefficient for crude birth rate in the schooling equation, which were not significantly different from zero.

effect on school enrollment rate in year t , because higher mortality implies both a larger number of dying schoolchildren and higher risk of investment in human capital. Negative impact of land tenancy ratio ($tenancy_t$) on education suggests the presence of capital market imperfections or landlords' influence on education policy or both. Finally, availability of schools (as measure by $mschool_t$ and $tschool_t$) promoted primary schooling, although the interaction term proved to be insignificant. Population density ($density_t$), another indicator of accessibility to education, affected enrollment rate adversely.¹²

To summarize and integrate the results obtained so far, the industrial revolution triggered by inflow of modern production technology and foreign (largely Japanese) savings had mixed effects on mortality: income growth lowered mortality, which was partially cancelled out by the detrimental impact of industrialization. The industrial revolution was accompanied by introduction of modern medicine, which further drove down mortality. The mortality decline promoted primary schooling by lowering risk of investment in education on the one hand and by reducing replacement demand for children on the other. Income growth lowered fertility and raised schooling, a shift towards child quality which was reinforced by the industrialization reducing demand for children as workforce in family production sector. Skill premium affected fertility negatively, while closing gender wage gap promoted education. In the absence of the ambitious school building program implemented by the colonial government, primary school enrollment rate would have risen at a significantly slower pace than it actually did. Finally, income inequality worsened, which in the presence of capital market

¹² Goldin (1998, 368) observed that sparsely settled states tended to lead secondary schooling in the United States.

imperfections and difference in time cost of child-rearing among different income groups encouraged fertility and retarded educational progress.

Post-colonial Leap Forward in Historical Perspective

Political shocks with powerful economic consequences separate colonial and post-colonial periods. In 1945, Korea was liberated from Japanese rule, which was immediately followed by division of the Korean peninsula, cutting South Korea off from manufacturing base concentrated in the northern provinces of the peninsula. The Korean War from 1950-53 destroyed a substantial portion of both human and physical capital accumulated during the colonial period. From 1953-90, per capita output grew in South Korea two-and-half times as fast as in colonial Korea, i.e. 6.12% vs. 2.37% per year. Occurring in the aftermath of fundamental regime shifts, both the colonial and South Korean growth are best viewed as transition paths to steady states: the faster growth of per capita output in South Korea suggests that the gap between actual and steady state values of per capita output was greater at the beginning of the post-colonial than at the beginning of the colonial growth.

The level of per capita output in 1953 was about one and half times as high as that in 1911, although the post-colonial turmoil reduced it to a level about one quarter lower than that reached in 1940 (Cha and Kim (2006)). Average per capita output from 1953-90 was about three-and-half times as high as that from 1911-40. Therefore, the larger gap between actual and steady state values in South Korea reflected higher level of steady state value of per capita output.

Jones (2002: 129)'s model of growth and development relates steady state level of per capita output to population growth, savings rate, amount of time individuals spend

accumulating skill, policies affecting the rate of technological diffusion, and world technology frontier. Of the five variables, population growth accelerated from 1.33% per year from 1911-40 to 1.88% per year from 1953-90, lowering the level of steady state in South Korea. Shifts in policy regime appeared to have a similar effect, albeit modestly: Cha and Kim (2006)'s comparison indicated that economic policies implemented by colonial and South Korean authorities resulted in economies similar in term of the degree of openness, while tax rates rose after 1945 undermining incentives for entrepreneurs to import and adapt technologies from leader countries

The remaining three variables shifted after 1945 to raise the steady state value of per capita output. As people learn by doing, world technology frontier in the second half of the twentieth centuries would have moved ahead of that in the first half. Nevertheless, considering the vastness of human knowledge accumulated from the ancient past up to the beginning of the twentieth century, the amount of the world technology stock in the first and second half of the twentieth century would appear more comparable than dissimilar. On the other hand, human and physical capital accumulation accelerated substantially after 1945 to account for the major part of the postcolonial surge in the steady state value of per capita output: savings rate quadrupled from 4.04% from 1911-40 to 16.40% from 1953-90, while primary school enrollment rate rose from 22% from 1911-45 to 99% from 1949-90.¹³ Kang (1994) attributed the rise in the South Korean savings rate primarily to falling dependency ratio, which resulted essentially from declining proportion of persons younger than 15 occurring in the course of fertility transition (Cho, Byun, and Park (2004, 125)). The fertility

¹³ These are averages of figures presented in Figure 4, which also shows that after the end of the colonial rule secondary school enrollment rate started to rise consistently.

decline and post-colonial advance in schooling having been concurrent developments representing shift from quantity to quality of children, explaining the growth acceleration after 1945 boils down to identifying the causes of the shift.

Kimura (1990: 346) conjectured that primary schooling made a great leap forward with the end of colonial rule (Figure 4), because the rate of return to education rose as Japanese returned home leaving a large number of vacant skilled positions. The claim is inconsistent with Figure 3, which shows no sign of rising skill premium in post-colonial years, hence suggests that demand for skill contracted as well at the same time skill supply did. Demand for skill fell in South Korea, probably because the country was both considerably poorer and less industrialized than colonial Korea: recall that faster growth and industrialization occurred in northern provinces had made North Korea both richer and less agrarian than South Korea by the end of the colonial rule. To make matters worse, the conclusion of colonial rule disrupted economic linkage not only among different regions of Korea, but also between Korea and Japan. As a consequence, real wage indices for manufacturing and construction workers in Seoul more than halved from 1944-48 to recover the level at the end of the colonial period only by the early 1950s (Kim and Park (2007)). Under such circumstances, gender wage gap stopped narrowing (Figure 3). Deterioration in living standards and de-industrialization together with stagnant skill premium and gender wage gap imply that schooling demand would have contracted with the end of colonial rule.

Supply conditions did not improve with de-colonization either. People fled from the communist North and returned from outside Korea into South, raising population density from 153 in 1944 to 179 persons per square kilometer in 1946 in the eight

southern provinces.¹⁴ With the end of the colonial rule, Japanese teachers (accounting for 40% of total primary school teachers at the end of the colonial rule) were repatriated, while the U.S. occupation forces occupied many of school buildings as their garrisons. While efforts were made to counter the negative supply shocks by increasing the operating rate of existing education facilities by adopting two-shift school system, it seems difficult to believe that the makeshift measures were sufficient to push the supply schedule to its initial position.¹⁵

There remain two variables, which changed to help advance schooling after 1945: mortality and income and land distribution. As seen in Figure 2, mortality fell to a lower level in the emergent South Korea, which, according to the mortality equation estimated in the preceding section, was attributable to warmer climate, the larger role played by agriculture, and the greater availability of medical personnel in South Korea.¹⁶ Second, traditional landlordism collapsed, and land tenancy ratio fell virtually to zero in the aftermath of de-colonization. As the colonial period came to an end, Japanese landlords fled Korea, leaving a huge amount of unclaimed acreage, while Korean landlords, who had collaborated with the colonial regime during the Second World War, found their traditional dominance over village communities significantly weakened. In this political vacuum, “people’s committees” cropped up everywhere,

¹⁴ Population density in 1944 for the whole Korea was 114 persons per square kilometer.

¹⁵ Lee (2003) provides a detailed account of primary education under the U.S. military government. Such shifts occurring on the supply side imply that quality of education deteriorated, and that the increase in enrollment rate from 1945-46 is likely to overstate the actual pace of the spread of primary education.

¹⁶ Number of doctors per million people rose from 123 in 1938 to 217 in 1949. Kwon (1977, p.61).

demanding landlords to lower rental rates, and, in some counties, going so far as to dispossess landlords. Transactions and law enforcement costs rose, inducing landlords to dispose of their holdings (Cumings (1981, chapters 3 and 8); Shin (1994); Jeon and Kim (2000, p. 257)). At least equally important was the land reform carried out in March 1946 in Soviet-controlled northern Korea, exerting further pressure on the southern regime to abolish colonial landlordism. Risks of land confiscation increased, which in combination with the increased transaction costs led landlords with larger properties to sell off around one third of their holdings during the first year of the post-colonial period. As a consequence, land prices as standardized by grain prices fell by two thirds, and prevailing rental rates fell from over one half to one third of gross output during the first six months after liberation from colonial rule in August 1945. When the South Korean land reform law was put into effect in June 1949, two thirds of land held by wealthier landowners had already been disposed of (Hong (2001, pp. 196, 197), Shin (1998, p.1336)).

The collapse of landlordism mattered far more than the reduction in mortality in spreading primary schooling in post-colonial Korea: calculations using the schooling equation estimated in the preceding section indicates that the increment in enrollment rate attributable to land reform (5.5% points) far outweighed that due to mortality transition (0.3% point). In sum, growth acceleration in South Korea was driven by faster accumulation of physical and human capital, which occurred as parents shifted away from quantity towards quality of children. The post-colonial rush to schools was prompted primarily by the collapse of traditional landlordism, which reduced income and wealth inequality significantly.

Conclusions

This article analyzed a panel dataset to trace the origins of demographic transition and human capital accumulation in colonial Korea to diffusion of medical and production technology, capital inflows, and policies to improve health and to promote education. Korea was first exposed to these shocks, when the country made an enforced transition from autarky to an open economy in 1876. During the four decades from the port-opening to integration into the Japanese empire, living standards hardly improved, however. Apparently, health and productivity shocks offset each other, and technological learning was not fast enough to counter mounting population pressure.¹⁷

One important reason for the persistence of Malthusian stagnation was to be found in the fact that education continued to exist after 1876 for a small minority, *yangban*, who were supposed not to work, but to rule, hence enjoyed privilege to sit for state examination selecting civil servants. Public service in dynastic Korea offered enough opportunities of rent-seeking to induce *yangban* parents to invest in examination training for their offspring, reducing their fertility to a level lower than that for the rest of population (Cha (2007)). Extra-legal taxation and confiscation of property not only drained resources and talents away from productive uses, but also retarded saving and physical capital accumulation (Chung (2006, chapter 1)).

Replacing the corrupt government with an efficient bureaucracy and implementing an

¹⁷ Genealogical evidence indicates that mortality started to fall with the opening of Korea in 1876 to international trade, most likely as a consequence of the diffusion of modern medical technology and public efforts to improve public hygiene (Cha (2007), Shin (1996, chapters 3 and 4)). O (1995: 337-38) provides evidence of new rice seed varieties from Japan being used in southern Korea in as early as 1894-95. Kim (2001, 200) shows widening trade deficits in the decades following 1876.

ambitious schooling building program, Japanese rulers could put an end to Malthusian stagnation. They also carried out a land survey, which acknowledged and legalized traditional rights to land, with a view to securing allegiance of *yangban* landowners (Gragert (1994)). As a consequence, traditional landlordism and inequality continued to prevail, standing in the way of educational improvement, hence impeding technological learning and economic growth. Post-colonial land redistribution taking place in South Korea under the influence of the North Korean land reform dealt a blow to the landlordism reigning over Korea from ancient past. The consequent reduction in inequality gave boost not only to human, but also to physical capital accumulation after 1945, allowing per capita output in South Korea to grow two and half times as fast as in colonial Korea.

Data Appendix

Output: gross domestic product by sector is from Cha and Kim (2006). Real gross regional product from agriculture, fishery and forestry was obtained by multiplying real gross domestic product from agriculture, fishery and forestry by provincial share in total value of thirteen major agricultural commodities, which was compiled from *Nōgyō tōkeihyō* and kindly made available by Sub Park. Real gross regional product from manufacturing and mining was obtained by multiplying real gross regional product from manufacturing and mining by provincial share in total value of gross manufacturing output, which was taken from *Chōsen sōtokufu tōkei nenpō* and generously made available by Kijoo Park. Real gross regional service output was derived by multiplying real gross domestic service output with provincial share in total population.

Demographic variables: population total and its age structure are from Cha (2006). To

derive population by province the population total was multiplied by provincial population, which was estimated using end-of-year counts of residents as available from *Chōsen sōtokufu tōkei nenpō*. As the source does not provide end-of-year count for 1928, average of figures for the two adjacent years was used. Crude birth and death rates were by dividing number of births and death by the end-of-year count of residents.

Number of schools and enrolled students: *Chōsen sōtokufu tōkei nenpō*.

Land tenancy ratio: calculated using acreage cultivated by owner operators and sharecroppers published in *Chōsen sōtokufu tōkei nenpō*. Acreage by province being unavailable for 1924, average of acreage for the two adjacent years was substituted.

Temperature: *Chōsen kishō nenpō*

Number of medical doctors: *Chōsen sōtokufu tōkei nenpō*.

Skill premium and gender wage gap: calculated using nominal wage observed in major cities and published in *Chōsen sōtokufu tōkei nenpō*.

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