Econometric Exploration of the Interaction between Disease and Physical Stature in Colonial Taiwan

OUTLINE PAPER AND SELECTED TABLES AND FIGURES

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Session 46: Diseases and Environmental Changes in Modern Asia

Abstract: Human welfare in Taiwan improved substantially under the Japanese between 1895 and 1945. The average stature of the ethnic Chinese born in Taiwan rose 1.12cm per decade from the late 1890s to c.1930, but more slowly during last 15 years of colonial rule (Morgan and Liu, 2003, forthcoming). The rise in the height of the population reflected significant returns to human welfare from the combination of economic growth and improved public health. Nevertheless, there was large year-on-year fluctuation, which seems to correlate with environmental events such as weather incidences (droughts and floods) and epidemiological incidences (epidemics). Short-term reversal in height trajectories is not uncommon, and these temporary shifts often can be explained by economic, medical or social disruptions (Floyd, 2002; Bielicki, 1986). The paper will examine the inter-relationship between average height and disease incidences that may have impacted on the available nutrition for human growth of children in affected years or the capacity of adult carers to provide for children under their care due to the effects of disease on their employment or other economic activity. The height data are drawn from the personnel health records of government employees born during the Japanese period and the colonial government’s statistical records for disease and weather incidences.

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DRAFT PAPER OUTLINE. Please do not cite without contacting the author for a revised and extended update of the paper.
Introduction

Human nutrition and the biological welfare of the ethnic Chinese in Taiwan improved substantially during the Japanese colonial occupation of the island from 1895 to 1945. Average physical stature, which is a sensitive indicator of net nutrition in a population, increased rapidly. The average height of the Taiwan Chinese rose 1.12cm per decade from the late 1890s to c.1930, but more slowly during the last 15 years of colonial rule from c.1930 to 1945 (Morgan and Liu, 2003, forthcoming). The rise in the average height of the population reflected significant returns to human welfare from the combination of economic growth and improved public health. During this period Taiwan was incorporated into the Japanese colonial empire, attracting investment in agriculture and infrastructure, which enabled it to become an important supplier of agricultural produce to Japan. On balance real incomes and the general level of prosperity of the Taiwan Chinese improved under the Japanese. Over the same period, Japanese public health initiatives were instrumental in reducing the death rate as well as the incidence of epidemic diseases and the severity of endemic diseases.

Despite the improved level of incomes and a healthier living environment, we find that the average level of attained stature fluctuated year-on-year. Some of these changes were quite large, and cannot easily be attributed simply to the adequacy of the height data we have collected. The fluctuations point to the impact of severe environment stress that had lasting effect on the population. In general, it would seem the fluctuations in height correlate with environmental events such as weather incidences (eg, droughts, floods, and increased typhoon activity) and epidemiological incidences (eg, epidemics). Short-term reversal in height trajectories is not uncommon, and these temporary shifts often can be explained by economic, medical or social disruptions (Floyd, 2002; Bielicki, 1986). However, commonly children experience catch up growth after these “insults” such that there is rarely lasting effects. By adulthood, the impact of severe food shortages or disease episodes has all but disappeared. For effects to remain in the stature record is to indicate a particular severity or combination of effects from which the children were unable to recover.

The aim of this paper is to examine briefly the inter-relationship between average height and disease incidences that may have impacted on the available nutrition for human growth of children in affected years or the capacity of adult carers to provide for children under their care due to the effects of disease on their employment or other economic activity. The height data are drawn from the personnel health records of government employees born during the Japanese occupation and the colonial period statistical records for disease and weather incidences.

Background

Taiwan became a colony of Japan as a consequence of China’s defeat in the first Sino-Japanese War of 1894. During the next five decades, Japan developed the island first as a producer of agricultural produce for the home islands, notably sugar and rice, and from the 1930s re-oriented the development strategy to position Taiwan as a base for projection of Japanese imperialist power into Southeast Asia. Early Japanese colonial policy was focused on the development of sugar, which called for sweeping reform of the land holding system, currency and banking, weights and measures, and other market enhancing factors. Large investment went into improving the infrastructure, in particular irrigation and transport (Chang and Myer, 1963; Chang 1983a; Ho, 1978).
Along with economic initiatives, Japanese public health programs reduced the incidence of plague and cholera, and the severity of endemic malaria, and the colonial authorities also introduced universal elementary education that raised the quality of human capital (Ho, 1978; Barclay, 1954). Life expectancy at birth for females rose from 29 years in 1906 to 45.8 years in 1936/40, while death rates declined from 33.4 per 1,000 to 18.5 per 1,000 over the same period (Barclay 1954, pp. 154, 146). While these colonial initiatives benefited the population, the policies were primarily intended to develop Taiwan as a supplier of food and raw materials for the home islands. In Samuel Ho’s apt description, Taiwan became “an agricultural appendage of Japan” (Ho, 1978: 29). In return, Japan sold manufactured goods to Taiwan.

Japanese colonization brought profound changes that transformed agriculture and built an infant industrial sector based on sugar processing. Despite broad agreement about trends in economic output and productivity, the income and welfare effects are disputed. Samuel Ho in his pioneer study of Taiwan’s economy conceded there was minor improvement in the standard of living (Ho, 1978). Earlier he had argued there was none (Ho, 1968). Hayami and Ruttan (1970) were similarly pessimistic. Other scholars have had more positive views of real wages and incomes (Mizoguchi, 1972; Chang, 1983b; Ho, 1971; Ka, 1995; Yeh, 1991). Recent anthropometric studies have found evidence for sustained improvements in the biological standard of living during the Japanese period (Morgan and Liu, 2003, forthcoming; Olds, 2003). The annual means estimated for height data fluctuated quite sharply at times. These fluctuations we hypothesize were markers of nutritional stress from change in the environment. Moreover, for the 15 years from about 1930 there was no practical increase in average height, which correlates with a shift in colonial policy and an increase in urbanization that may have change the health environment. Both aspects – the periodic fluctuations and the 1930-45 plateau – need further exploration, which is the purpose of the paper. The paper proceeds next with a brief discussion of the anthropometric approach to measuring the standard of living and the data we use, followed by consideration of the modeling issues involved in specifying the estimation of interaction between disease and height. These estimations will be presented at the conference, but meanwhile we present some of the underlying height and environmental data in the paper.

**Anthropometric method and data**

Stature is an indicator of the net nutrition of a population, and indirectly the impact of the socio-economic and epidemiological environment. Human biologists have long used stature to assess health, and economic historians have made use of height data to inquire into the “biological standard of living” (Komlos and Baten, 1998). Human growth, though, is a complex interaction of genetic and environmental factors, the product of which is uncertain (Eleveth and Tanner, 1990). While genetics determines the potential height an individual might attain, the realization of that potential is attributable to environmental factors from infancy to adulthood. Similarly, the average height of a population is attributable to the environmental conditions under which the population lives (Bogin, 1999; Schmitt and Harrison, 1988). Height is a function of net nutrition. Adult stature (or height of a child at a particular age) is a cumulative measure of the nutrition available for human growth over the growing period to adulthood (or the time of measurement), less the claims made on nutrient intake by the demands of body maintenance, physical exertion and combating disease. Final height reflects the environmental “insults” that occur during human growth. While
more-than-adequate nutrition after an insult may allow ‘catch up’ growth, with little lasting impact on a child, severe and prolonged malnutrition results in growth retardation, such as stunting (low height-for-age). The likelihood of any insult producing a lasting effect is a product of four factors: the severity of the insult, the age at which it occurs, its duration, and the post-insult environment (Eveleth and Tanner 1990: 194-195).

Height is closely correlated with income and the change in the distribution of income that determines access to resources, and therefore is a useful indicator of the standard of living, especially in the absence of conventional economic indicators such as real wage or income series (Steckel, 1995; Steckel and Floud, 1997). We can think of height as an output measure of the resources available for human growth and welfare, in contrast to income or wage information that measure the potential for well being. Height fluctuations can arise from any combination of factors that might affect the supply of nutrients to the growing child, from the amount and quality of food available for consumption to the environment in which consumption and sustenance is experienced. A child’s access to food nutrients is dependent on the adult providers, and as a consequence factors that affect the capacity or capability of the principal earners of income or producers of food will adversely affect nutrition. A drought or flood, for example, may impact on nutrition in a variety of ways. Most obviously, weather calamities can reduce the amount of food available, or disrupt the transport and marketing of food. These weather incidents will also raise the relative prices of food nutrients that reduce the capability of non-producers of food (urban and rural wage laborers) to purchase food nutrients, and their capabilities to make any purchase may be further reduced from weather-induced unemployment. Disease can similarly affect nutrient availability through several paths, from affecting the child’s ability to maximize available nutrition for growth through to incapacitating the productive adults to provide or care for the child. The difficulty that confronts us is how to measure the several and varying effects of the numerous constraints on the maximization of nutrient availability.

**Anthropometric, disease and weather data:** The primary height data are from the health examination records of individuals contained in the personnel files of Taiwan provincial government employees from the 1950s and 1960s, held at the provincial archive, Nantou. Only adult men are used for estimation of height trends. The other height data are from surveys, comprising colonial period anthropometric surveys for which Olds (2003) estimated mean heights and survey data from Taiwan (Taiwan, Executive Yuan, 1990). These height data are fully explained in Morgan and Liu (forthcoming). Disease and weather data are from the compendium of colonial statistics that the Kuomintang authorities compiled after China regained control of the island in 1945 (Taiwan, Department of Statistics, 1946).

**Modelling the impact of disease on height**

Our interest in this paper is the consideration of the effects of disease. Some diseases may affect children directly, while others mostly affect the adult carers of children. In this paper we will focus mostly on the diseases that directly affect children. We will

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1 Taiwan Provincial Archives (Taiwan wenxian guan, also known as Taiwan Historica), 252 Guangming 1st Rd., Zhongxing xincun, Nantou city. A list of the many disparate serial numbers of the holdings is available from the authors.
need to differentiate between two groups of children, infants up to one year whose nutrition and disease resistance is mostly related to the nutritional status of the breast-feeding mother, and secondly, those aged between one and four years who have been weaned and who consume their food nutrients directly.

From the above presentation of theory, final attained height is a function of net nutrition, which is gross nutrition less the deduction arising from environmental constraints, including body maintenance. We can express this most simply in equation (1) and equation (2).

\[ H_t = f \bullet ([\text{NuTot}] \text{less} [\text{Env. Constraints}]) \]  
(1)

\[ H_t = f \bullet \text{Net-nutrition} \]  
(2)

The variation in height over time is a product of the variation in the environmental factors from time to time that might influence height, of simply equation (3).

\[ \Delta H_t = f \bullet \Delta \text{Environ} \]  
(3)

Ideally, we would like to consider the separate impact on final attained height by the measurement of the separate impacts for each year from birth through to adulthood. For example, height at age four could be expressed as equation (4), where \( Y_4 \), height attained at age four, is the cumulative sum of separate environmental effects in the birth year \( X_1 \) to the fourth year \( X_4 \). However, the effect at any particular year is not the same. A severe insult between birth and two years of age will have a greater impact on the final attained adult height of a child than a nutritional deficit at a later period in the growth process.

\[ Y_4 = B_0 + B_1X_1 + B_2X_2 + B_3X_4 + B_4X_4 \]  
(4)

In addition, different types of environment insults interact differently. A shortage of food is a direct reduction in available nutrients for growth, whereas severe illness moderates the absorption of the available nutrients. In the latter we need to consider moderator and mediated models. In that sense, disease becomes a second order effect rather than a first order effect associated with direct nutrient acquisition. For the most part we are interested in the moderator effect: how a particular disease or environmental change might interact with other factors (income or food availability) to influence the net availability of nutrition for human growth.

THE REMAINDER OF THIS TEXT SUMMARIZES WHAT WE WILL DO FOR OUR PRESENTATION IN HELSINKI IN AUGUST. The final paper will report the results of our econometric testing of the height, disease and weather data.

The moving average for the mean height of the government personnel for whom we obtained medical records is shown in Fig 1. The regression estimates for the mean height, which controlled for occupation and location of residence, were joined with survey data (Olds, 2003; Taiwan, Executive Yuan, 1990) to create Fig 2. The straight line growth trend rates are overlaid on the period estimates shown in Fig 2, and the coefficients for the specific periods are reproduced in Table 1. These show that height rose at a rate of 1.1cm per decade from the 1880s to c.1930, more or less stagnated from 1930 to 1945, and again increased at a rate of 1.1cm per decade from the 1950s.
Fig 1: Change in the average height of Taiwan men, 1905-1945

Fig 2: The trend in average height of Taiwan men by sub-periods, 1881/83-1971/73

Table 1: Estimated trend in heights for selected three-year periods, 1881/83 to 1971/3

The estimates for the impact of disease and weather on the estimated average height shown in Fig 2 will be calculated using data from the compendium of colonial statistics (Taiwan, Department of Statistics, 1946). The underlying data are reproduced in the following figures.

Fig 3: Population death rates and disease-specific death rates, 1906-40

Fig 4: New estimates of infant deaths in Taiwan

Fig 5: Agricultural land affected by natural disasters

The crude death rate and the 1-4 years death rate show a downward trend from the early 20th century, though the trend was interrupted in 1910s by several severe epidemics, including influence and small pox. Fig 3 shows the trend in death rates along with disease-specific death rates for selected diseases. Fig 4 shows recent estimates of infant mortality calculated by Osamu Saito, which were kindly provided. Infant mortality trended down markedly from the late 1910s, which probably reflects not merely an improvement in sanitation but probably also an improvement in the health of lactating mothers and other carers of children. For the two decades 1920-40 between 10 and 20 percent of agricultural land was affected by some form of natural disaster which either reduced food available, raised food prices or otherwise impaired the purchasing power of consumers.

References:


JCRR (1966 – Chinese-American Joint Commission on Rural Reconstruction), Taiwan Agricultural Statistics 1901-1965, JCRR Economic Digest Series No. 18, Taipei: JCRR.


Taiwan, Executive Yuan (1990), Zhonghua minguo Taiwan diqu qingshao younian tongji minguo qishijiu nian (Statistics on Children and Youth in Taiwan Area of the Republic of China 1990), Taipei: Directorate-General of Budget, Accounting and Statistics.

Taiwan, Department of Statistics (1946), Taiwan sheng wushiyi nian lai tongji tiyao (Statistical Summary of Taiwan Province for the Past 51 Years), Taipei: Department of Statistics.

Table 1: Estimated trend in heights for selected three-year periods, 1881/83 to 1971/3

<table>
<thead>
<tr>
<th>Data series</th>
<th>Estimate period</th>
<th>Coefficient</th>
<th>Intercept (1881/83)</th>
<th>R-square</th>
<th>cm per decade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japanese survey</td>
<td>1881/83-1908/10</td>
<td>0.335</td>
<td>161.90</td>
<td>0.95</td>
<td>1.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(12.370)</td>
<td>(963.709)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 4 estimate</td>
<td>1905/07-1944/46</td>
<td>0.232</td>
<td>162.65</td>
<td>0.78</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6.518)</td>
<td>(285.751)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 4a estimate</td>
<td>1905/07-1926/28</td>
<td>0.345</td>
<td>161.28</td>
<td>0.70</td>
<td>1.15</td>
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<tr>
<td></td>
<td></td>
<td>(3.748)</td>
<td>(137.984)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 4b estimate</td>
<td>1926/28-1944/46</td>
<td>0.056</td>
<td>166.048</td>
<td>0.15</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.930)</td>
<td>(143.294)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surveys of Ministry of Education</td>
<td>1953/55-1971/73</td>
<td>0.335</td>
<td>160.15</td>
<td>0.98</td>
<td>1.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(14.927)</td>
<td>(254.479)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combined and interpolated series</td>
<td>1881/83-1971/73</td>
<td>0.255</td>
<td>162.24</td>
<td>0.98</td>
<td>0.85</td>
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<tr>
<td></td>
<td></td>
<td>(36.768)</td>
<td>(1278.977)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
The coefficient column reports the change in height for each three-year reporting period. To calculate the change in heights per decade, the coefficient is multiplied by 3.333 (the equivalent of dividing by three and multiplying 10).

The intercept is the estimated height of the projected straight line at the point it crosses the y-axis at the first period, 1881/83.

The t-statistic is in parentheses. All the reported coefficients and intercepts are statistically significant at the 1% level (p<0.01) except for the coefficient for Model 4b. The coefficient for Model 4b should not be statistically significant because average height stagnated, meaning there was not any significant difference from zero in the change in average height between 1930 and 1945. That is a practical significant result.

Sources:
Morgan and Liu, forthcoming; Olds, “The Biological Standard of Living”; Taiwan, Statistics on Children.
Fig 1 Change in the average height of Taiwan men, 1905-1945

Source: Morgan and Liu, forthcoming.
Fig 2: The trend in average height of Taiwan men by sub-periods, 1881/83-1971/73

Source: Morgan and Liu, forthcoming.
Fig 3: Population death rates and disease-specific death rates, 1906-40

Source: Taiwan, Executive Yuan, *Taiwan sheng wushiyi nian lai tongji tiyao* (*Statistical Summary of Taiwan Province for the Past 51 Years*), (Taipei: Provincial Bureau of Accounting and Statistics, 1946).
Fig 4. New estimates of infant deaths in Taiwan

Source: Osamu Saito

Fig 5. Agricultural land affected by natural disasters

Source: Taiwan 51 years statistic, T216-17

Fig 5. Agricultural land affected by natural disasters