Was Japanese Colonialism Good for the Welfare of Taiwanese? Stature and the Standard of Living*

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ABSTRACT Japanese rule transformed Taiwan from 1895 to 1945, laying the foundations for the post-1950 "economic miracle," but there is little consensus about the impact on the welfare of Taiwan's ethnic Chinese. A difficulty with past studies is the adequacy of economic indicators to measure the standard of living. Instead of conventional economic data, we use average adult height, an indicator of nutritional status. The rise in the average height of the Chinese indicates welfare improved under colonialism, but the static average height from 1930 highlights the negative effect of the shift in economic policy during the late colonial period.

Japanese colonial rule is frequently if begrudgingly credited with laying the foundations for Taiwan's post-Second World War "miracle" economy. From 1895 to 1945, the colonial government invested in physical infrastructure, human capital and market enhancing factors. Under Japanese rule agricultural output and productivity rose; ports, railways and large irrigation systems were built; and some modern industry established. Investment in public health and education made the population healthier and better educated. Nevertheless, there is little agreement about whether the ethnic Chinese of Taiwan were better off. Some scholars have argued Japanese policies produced a modest improvement in human welfare. Others claim the extractive character of Japanese rule limited any benefit. Christopher Howe, in a recent survey in *The China Quarterly* of Taiwan's economic growth in the 20th century, tentatively sided with the pessimistic view, stating Japanese policies "may well have been regressive and severe" for income and income distribution.[1]

This article presents new evidence for sustained gains in the standard of living of Taiwanese under the Japanese. The most rapid improvement occurred in the earlier period of rule, rather than after the mid-1920s as is commonly argued.

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1 Christopher Howe, "Taiwan in the 20th century: model or victim? Development problems in a small Asian economy," in Richard Louis Edmonds and Steven M. Goldstein (eds.), *Taiwan in the Twentieth Century: A Retrospective View* (Cambridge: Cambridge University Press, 2001), p. 46.

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We also for the first time show the negative consequences for human welfare of the shift in colonial policy in the 1930s. Instead of conventional economic indicators such as per capita income or real wages, we use the secular trend in stature, the change in the average height of the adult male population. Height is a sensitive indicator of the standard of living or well-being of a population, "a mirror of the standard of living."[2] Change in the average height of a population captures the impact on the human organism of change in per capita income, access to health care, the incidence of disease and the intensity of work.[3] Economic historians over the past 25 years have used the secular change in anthropometric measures of human growth such as stature to shed new light on the processes of industrialization in Europe and North America.[4] Few scholars have used such an approach for Asia.[5] Economists have used height to analyse health and income inequality in developing countries or the interdependence between low income and low health status in developed economies.[6] In the early 19th century the public health pioneer Louis-René Villermé wrote that human height becomes greater the better fed, clothed and housed is the population.[7]

The approach in this article, novel as it might be for the historical study of human welfare in Taiwan, has produced new insights into modern development. It was applied in recent studies of Taiwan and China.[8] We begin with a review of the debate on economic growth and the standard of living in Taiwan. Next, we outline the anthropometric approach and data. Thirdly, we describe the trends

2 James M. Tanner, "Introduction: growth in height as a mirror of the standard of living," in John Komlos (ed.), *Stature, Living Standards, and Economic Development: Essays in Anthropometric History* (Chicago and London: The University of Chicago Press, 1994), pp. 1–6.

3 Overviews of the anthropometric approach include: Richard H. Steckel, "Stature and the standard of living," *Journal of Economic Literature*, Vol. 33, No. 4 (1995), pp. 1903–40; Richard H. Steckel and Roderick Floud, "Introduction," in Richard H. Steckel and Roderick Floud (eds.), *Health and Welfare during Industrialization* (Chicago: University of Chicago Press, 1997), pp. 1–16; Timothy Cuff, *The Hidden Cost of Economic Development: The Biological Standard of Living in Antebellum Pennsylvania* (Hampshire: Ashgate, 2005), pp. 10–44.

4 Komlos, *Stature, Living Standards*, and John Komlos and Joerg Baten (eds.), *Studies on the Biological Standard of Living in Comparative Perspective* (Stuttgart: Franz Steiner Verlag, 1998).

5 Lance Brennan, John MacDonald and Ralph Shlomowitz, "The heights and economic well-being of North Indians under British rule," *Social Science History*, Vol. 18, No. 2 (1994), pp. 271–307; Pierre van der Eng, "An inventory of secular changes in human growth in Indonesia," in John Komlos (ed.), *The Biological Standard of Living on Three Continents: Further Explorations in Anthropometric History* (Boulder: Westview Press, 1995), pp. 175–88; Gail Honda, "Differential structure, differential health: industrialization in Japan, 1868–1940," in Steckel and Floud, *Health and Welfare*, pp. 251–84; Carl Mosk, *Making Health Work: Human Growth in Modern Japan* (Berkeley: University of California Press, 1996); Stephen L. Morgan, "Biological indicators of change in the standard of living in China during the 20th century," in Komlos and Baten, *Studies*, pp. 7–34.

6 John Strauss and Duncan Thomas, "Health, nutrition, and economic development," *Journal of Economic Literature*, Vol. 36, No. 2 (1998), pp. 766–817; Anne Case, Darren Lubotsky and Christina Paxson, "Economic status and health in childhood: the origins of the gradient," *American Economic Review*, Vol. 92, No. 5 (2002), pp. 1308–34; Menno Pradhan, David E. Sahn and Stephen D. Younger, "Decomposing world health inequality," *Journal of Health Economics*, Vol. 22, No. 2 (2003), pp. 271–93.

7 Cited in Phyllis B. Eveleth and James M. Tanner, *Worldwide Variation in Human Growth*, 2nd ed. (Cambridge: Cambridge University Press, 1990), p. 191.

8 Kelly Olds, "The biological standard of living in Taiwan under Japanese occupation," *Economics and Human Biology*, Vol. 1, No. 2 (2003), pp. 187–206; Stephen L. Morgan, "Economic growth and the biological standard of living in China, 1880–1930," *Economics and Human Biology*, Vol. 2, No. 2 (2004), pp. 197–218.

in anthropometric indicators, and lastly we discuss the relationship between these trends in stature and other indicators of economic change in Taiwan.

Debates about Economic Growth and the Standard of Living

Taiwan was ceded to Japan after the 1894 Sino-Japanese War. The island Japan inherited is typically described as a subsistence agrarian economy, with little commercialization, and hardly amenable to modern economic development.[9] "Markets were small and fragmented because of poor transport and a confused currency system. Little of the economy was monetised or related to foreign trade. Sanitation, education, communications, unified weights and measures, and efficient money and financial institutions did not exist or were barely developed."[10]

Recent scholarship is more positive. Inclusion in the China Treaty Port system from the mid 19th century spurred on a small but vibrant export sector based on tea, rice, sugar and camphor such that by 1895 the economy was "far from the primitive, subsistence structure … as sometimes portrayed," though it lacked infrastructure for modernization.[11] Nevertheless, life was hard, often dangerous and short-lived, for the then 2.8 million Chinese. "Taiwan was renowned as an unhealthy place. … The semi-tropical climate of Taiwan favoured the spread of a multitude of disease-producing agents. … [As a result], the population harboured many body parasites and … many people passed their lives chronically enfeebled."[12] Epidemics of plague and cholera were frequent, endemic malaria in some years reached epidemic proportions, and enteric diseases, internal parasites and tuberculosis were common.[13]

The Japanese colonial authorities implemented a raft of measures to expand markets and economic opportunities, lower transport barriers that had fragmented local markets, and improve the health and social environment. Public health programmes reduced the incidence of epidemics and the severity of malaria, and the colonial authorities progressively extended education.[14] Life expectancy at birth for females rose from 29 years in 1906 to 45 in 1936/40, while death rates declined from 33.4 per 1,000 to 18.5 per 1,000 over the same period.[15]

9 Samuel P. S. Ho, *Economic Development of Taiwan, 1860–1970* (New Haven and London: Yale University Press, 1978), pp. 23–24; Shu–jen Yeh, "Economic growth and the farm economy in colonial Taiwan, 1895–1945," PhD diss., University of Pittsburgh, 1991, pp. 18–23.

10 Chang Han-Yu and Ramon H. Myers, "Japanese colonial development policy in Taiwan, 1895–1906: A case of bureaucratic entrepreneurship," *Journal of Asian Studies*, Vol. 22, No. 4 (1963), p. 434.

11 Howe, "Taiwan," p. 40.

12 George W. Barclay, *Colonial Development and Population in Taiwan* (Princeton: Princeton University Press, 1954), pp. 133–34;

13 *Ibid.* pp. 134–35.

14 Ho, *Economic Development*, pp. 33–35; Barclay, *Colonial Development*, pp. 136–72. Patricia Tsurumi, *Japanese Colonial Education in Taiwan, 1895–1945* (Cambridge, MA: Harvard University Press, 1977); Patricia Tsurumi, "Colonial education in Korea and Taiwan," in Ramon H. Myer and Mark R. Peattie (eds.), *The Japanese Colonial Empire, 1895–1945* (Princeton: Princeton University Press, 1984), pp. 275–311.

15 Barclay, *Colonial Development*, pp. 154, 146; Mohammad Mirzaee, "Trends and determinants of mortality in Taiwan, 1895–1975," PhD diss., University of Pennsylvania, 1979, pp. 47–50, 60, 63–64.

Selected social and economic indicators for colonial Taiwan are summarized in Table 1.

Colonial development was not for the benefit of the Taiwanese, but to develop Taiwan as a supplier of food and raw materials for Japan and a market for its manufactures. In Samuel Ho's apt description, Taiwan was "an agricultural appendage of Japan."[16] Sugar and rice were the key sectors, with the focus initially on sugar.[17] Sugar growing and processing was the basis of Taiwan's industrialization. Rice became an export crop from the mid-1920s after the acclimatization of the *ponlai* (蓬萊) rice variety.[18] About 45 per cent of the rice harvest was exported to Japan in the 1930s.[19] The 1920s was a technological watershed in Taiwan agriculture – growth rates accelerated and foreshadowed the post-war "green revolution."[20] Agriculture grew about 1.5 per cent a year in the first two decades, increasing to about 4 per cent from 1920 to 1940, though annual output varied wildly.[21] Agricultural output grew faster than the population through the colonial period.

Despite broad agreement about trends in economic output and productivity, scholars disagree about the welfare outcomes for the Taiwanese. After the well-known debate on the standard of living during the industrial revolution in England, we may distinguish between optimist and pessimist views. This distinction is not entirely appropriate for Taiwan as most authors acknowledge positive benefits. The disagreements in our view rest primarily on the extent to which the Taiwan Chinese shared in the economic growth, secondly on the timing of shifts in welfare effects and, thirdly, on the degree of harshness of Japanese extraction of the economic surplus. The main exponent of a pessimistic view is Tu Zhaoyan (涂照彦), a Japan-educated Taiwan scholar who argued Japanese monopolistic power impoverished the Taiwan peasantry and stymied the growth of Chinese capitalists.[22]

Samuel Ho, in his study of Taiwan's development, concluded "the average Taiwanese improved his general economic conditions moderately and in a few areas, such as education and health, significantly,"[23] underscored by "both the

16 Ho, *Economic Development*, p. 29.

17 Chang Han-Yu, "Development of irrigation infrastructure and management in Taiwan, 1900–1940," in Editing Committee for the Essays of Dr Chang Han-Yu (ed.), *Economic Development and Income Distribution in Taiwan: The Essays of Dr Chang Han-Yu*, Vol. 4 (Taipei: Sun Ming Books Co., 1983), p. 32.

18 Chang, "Development of irrigation"; p. 52; Howe, "Taiwan," p. 46.

19 Ho, *Economic Development*, p. 31.

20 Ramon H. Myers and Adrienne Ching, "Agricultural development in Taiwan under Japanese colonial rule," *Journal of Asian Studies*, Vol. 23, No. 4 (1964), p. 557; Ramon H. Myers, "Agrarian policy and agricultural transformation: mainland China and Taiwan, 1895–1945," *Journal of Chinese Studies of the Chinese University of Hong Kong*, Vol. 3, No. 2 (1970), pp. 521–42.

21 Yhi-min Ho, *Agricultural Development Taiwan 1903–1960* (Nashville: Vanderbilt University Press, 1966), p.31; S.C. Hsieh and T.H. Lee, *Agricultural Development and its Contribution to Economic Growth in Taiwan: Input-Output and Productivity Analysis of Taiwan Agricultural Development* (Taipei: Joint Commission on Rural Reconstruction, 1966), p. 14.

22 Tu Zhaoyan (To Shogen), *Riben diguozhuyi xia de Taiwan* (*Taiwan under Japanese Imperialism*), trans. Li Mingjun, (Taipei: Renjian, 1999). Original: *Nihon teikokushugika no Taiwan* (Tokyo: Tokyo University Press, 1975).

23 Ho, *Economic Development*, p. 91.

Table 1: **Selected Indicators of Modern Development during the Colonial Period**

	Population (millions)	Life expectancy at birth (years)[a]	Index of net domestic product (in 1937 prices, 1937 =100)	Index of agricultural production[b] (1935–37=100)	Index of industrial production[c] (1937=100)	Index of real per capita income[d] (1935–37=100)	Enrolment in primary school (% school-age population)
1905	3.0	28.3	n.a.	32	n.a.	48	n.a.
1910	3.3	33.9	37	41	24	58	5.8
1915	3.6	28.5	36	45	30	60	9.6
1920	3.8	27.2	40	51	30	75	25.1
1925	4.2	34.3	62	59	51	72	29.5
1930	4.7	41.6	79	73	70	79	33.1
1935	5.3	42.8	102	89	88	94	41.5
1940	6.1	43.8	93	102	123	99	57.6
1945	6.9	n.a.	n.a.	81	35	71	71.3[e]

Notes:

[a]Life expectancy is the average for male and female based on life table estimates. The 1905 estimate is for year 1906.

[b]The index numbers for agricultural output from Samuel Ho are the average of the previous five years.

[c]The 1910 index of industrial production is for 1912.

[d]The real per income index numbers are the average of the previous five years. The 1905 number is an average of 1905 and the previous two years. The index was calculated from the original estimates of Wu Tsong-min used in his 2001 article that he generously made available to the authors.

[e]The percentage of enrolment is from 1944.

n.a., data not available.

Sources:

Samuel P. S. Ho, *Economic Development of Taiwan, 1860–1970* (New Haven and London: Yale University Press, 1978), Tables 3.1, A33 and A49; Mohammad Mirzaee, ''Trends and determinants of mortality in Taiwan, 1895–1975,'' PhD diss., University of Pennsylvania, 1979, Tables AC-3 to AC-16 ; Patricia Tsurumi, *Japanese Colonial Education in Taiwan, 1895–1945* (Cambridge, MA: Harvard University Press, 1977), Table 13; Wu Tsong-min, ''Taiwan nongxuye zhi shengchan'e: 1902–1952'' (''Taiwan's agricultural production: 1902–1952''), *Jingji lunwen congkan*, Vol. 29, No. 2 (2001), pp. 303–38.

wage and per capita consumption data … at least until the late 1930s."[24] Wages and consumption were kept low to repatriate profits to Japan,[25] while rice exports reduced the per capita availability of rice and forced farmers to substitute sweat potatoes.[26] The effects of this change in consumption were uncertain, he acknowledged, as the diet mix may have improved.[27] Certainly, "there is no evidence that the Taiwanese population suffered from chronic hunger."[28] This view is at odds with an earlier conclusion that income and consumption rose slowly until the 1930s and thereafter declined, and per capita availability of food was 1,800–2,000 calories a day.[29]

Several studies have refined or questioned Samuel Ho's findings. Chang used Japanese survey data to estimate that adult male farmers consumed 3,600 calories in food and their incomes in the 1930s were higher than in the early 1950s.[30] Shu-jen Yeh estimated adult-equivalent per capita daily food availability rose to 2,500 calories and per capita consumption increased from 1904 to 1937, growing faster after 1925.[31] Real wage estimates by Toshiyuki Mizoguchi show a rapid rise from the 1920s. "We can safely say that Taiwanese workers obtained at least partially the fruits of the economic development of Taiwan under Japanese rule," Mizoguchi concluded.[32] Wu Tsong-min has revised earlier estimates of gross domestic product to construct a real income series for the 20th century that supports arguments for sustained higher growth into the 1930s, and others are producing new estimates of Taiwan GDP.[33]

Chih-Ming Ka found large gains in the standard of living after the mid-1920s from a shift in the linkage between the rice and cane sectors. A stagnant rice sector up to the 1920s, he argued, enabled Japanese sugar companies to contain costs through setting the contract price of cane in terms of the food grain Chinese growers needed. With the growth of rice exports the nexus was undone. Growers of *ponlai* marketed most of their grain and bought subsistence rice (*chailai* 在來) on the domestic market, which increased the demand for *chailai*

24 *Ibid.* p. 100.
25 *Ibid.* p. 32
26 *Ibid.* pp. 93–96
27 *Ibid.* pp. 96–98.
28 *Ibid.* p. 97.
29 Samuel P. S. Ho, "Agricultural transformation under colonialism: the case of Taiwan," *The Journal of Economic History*, Vol. 28, No. 3 (1968), pp. 313–40. Also the critique by Yhi-min Ho, "Taiwan's agricultural transformation under colonialism: a critique," *The Journal of Economic History*, Vol. 31, No. 3 (1971), pp. 672–81.
30 Chang Han-Yu, "A study of the living conditions of farmers in Taiwan, 1931–1950," in *Economic Development and Income Distribution*, pp. 77–78, shows farm income grew rapidly during the 1930s, and was still above that prevailing in 1950.
31 Yeh, "Economic growth," pp. 202, 234.
32 Mizoguchi, "Consumer prices and real wages," pp. 47–51; quotation p. 48.
33 Wu Tsong-min, "1910 nian zhi 1950 nian Taiwan diqu guonei shengchan mao'e zhi guji" ("Estimates of the gross domestic product of the Taiwan area 1910 to 1950"), *Jingji lunwen congkan* (*Taiwan Economic Review*), Vol. 19, No. 2 (1991), pp. 127–75; Wu Tsong-min, "Taiwan nongxuye zhi shengchan'e: 1902–1952" ("Taiwan's agricultural production: 1902–1952"), *Jingji lunwen congkan*, Vol. 29, No. 2 (2001), pp. 303–38. For comparison of his 1991 and 2001 figures, see Figure 9 in Wu Tsong-min, "Taiwan's agricultural production," p. 324. New GDP estimates are emerging from the Asian Historical Statistics Project at Hitotsubashi University. See http://www.ier.hit-u.ac.jp.

and raised prices as supply declined because of the conversion of *chailai* land to *ponlai* production. Some cane farmers switched to the *ponlai* export rice, raising the productivity of rice land, the standard of living of rice growers and rural incomes generally after 1925.[34] The "broadly based promotion of productivity" across all cropping produced "a substantial rise in peasant living standards."[35] Exports had delivered benefits: "… the gains from [rice] export production were relatively evenly distributed" among rice farmers, with a flow-on effect to others, compared with the surplus extracted earlier by the Japanese sugar capitalists.[36]

Nevertheless, the view persists that Japanese colonial policy squeezed rural incomes and constrained consumption such that the Taiwanese shared little of the fruits of economic growth. The problem, as Howe and others note, is we do not have adequate income data to estimate directly the effects of colonialism on individual welfare.[37] Cropping data suggest Taiwan's farmers were other than subsistence farmers by the 1920s and had embraced the commercial opportunities of the colony. Sugar was mostly grown by owner-cultivators.[38] The transportation network opened island-wide markets for farmers to expand into fibre crops, fruits and vegetables, and animal husbandry for sale rather than self-consumption.[39] Output of beans, vegetables and fruit tripled between 1916/20 and 1936/40, and meat production almost doubled.[40]

We argue that the pessimistic view of colonialism for human welfare is difficult to support in view of returns to health and nutrition, as proxied by average height. In the absence of personal and income data, average height enables us to gain a measure of aggregate welfare where none based on extant aggregate economic data exists.

Anthropometric Methodology

Human growth is a complex interaction of genetic and environmental factors, the product of which is uncertain.[41] While genetics determines the potential height an individual might attain, the realization of that potential depends on environmental influences from infancy to adulthood. Within a family, the genes of an individual determine the final height of each same-gender sibling. For a population, however, the average height is primarily attributable to the environmental conditions under which the population lives.[42] Taller populations

34 Chih-Ming Ka, *Japanese Colonialism in Taiwan. Land Tenure, Development, and Dependency, 1895–1945* (Taipei: SMC Publishing, 1995), pp. 133, 144.
35 *Ibid.* p. 177.
36 *Ibid.* pp 185, 187.
37 Howe, "Taiwan," p. 43. Ka, *Japanese Colonialism*, p. 139.
38 About 80% of sugar delivered to Japanese mills came from family farms, the mainstay of cane production. Ka, *Japanese Colonialism*, ch. 3.
39 Myers and Ching, "Agricultural development in Taiwan," p. 558.
40 Ho, *Economic Development*, pp. 341–42.
41 The classic study of human growth is Eveleth and Tanner, *Worldwide Variation*. For an excellent introduction, see Cuff, *The Hidden Cost*, pp. 10–44.
42 L. H. Schmitt and G. A. Harrison, "Patterns in within-population variability of stature and weight," *Annals of Human Biology*, Vol. 15, No. 5 (1988), pp. 353–64.

are likely to have enjoyed a better quality of life. The secular change in stature shows how well the human organism has survived its socio-economic and epidemiological environment. From the trend in average height of a population we can infer change in income and income distribution, assess access to nutrients as influenced by the relative prices of food, and obtain measures of gender, social and spatial differences in nutritional status.

Height is a function of net nutrition, not gross nutrition. In an economic sense, we can think of height as a net output measure of actual human growth, whereas income is an input measure of the potential for human growth.[43] Adult stature (or the 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 for body maintenance, physical exertion and combating disease. Final height reflects the environmental insults, the constraints on available net nutrition that occur during human growth. While more-than-adequate nutrition after an insult may allow "catch-up" growth to take place, with little lasting affect on a child, severe and prolonged malnutrition results in growth retardation, such as stunting (low height-for-age). The likelihood of any insult having 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.[44]

Stature therefore is a function of proximate determinants such as diet, disease, work intensity and the living environment. Ultimately, stature reflects income that allows access to resources for human growth,[45] especially in a low-income economy where a high share of the household budget is spent on food. Higher incomes allow families to purchase better diets for their children and individual heights will increase. As incomes rise individuals change their consumption patterns, obtain a more complete diet or better housing and health care. Once incomes are sufficient to satisfy nutrition needs, any further increase will not raise stature, and may even produce poor anthropometric outcomes.[46]

Stature and per capita income for the individual are correlated.[47] The relationship is not linear; the incremental increase in height decreases with rising income and in some historical instances trends in stature and income may diverge. At the aggregate level of national populations the relationship between height and income depends largely on the distribution of income.[48] Average height may differ for a given per capita income according to the proportion of

43 "Stature measures [economic] performance by heath history rather than inputs to health, which has the advantage of encompassing the supply of inputs to health as well as the demands on these inputs …" Steckel, "Stature," p. 1905.

44 Eveleth and Tanner, *Worldwide Variation*, pp. 194–95.

45 Steckel and Floud, "Introduction," p. 5.

46 For example, the increase in obesity: John Komlos and Marieluise Baur, "From the tallest to (one of) the fattest: the enigmatic fate of the American population in the 20th century," *Economics and Human Biology*, Vol. 2, No. 1 (2004), pp. 57–74.

47 Richard H. Steckel, "Height and per capita income," *Historical Methods*, Vol. 16, No. 1 (1983), pp. 1–7.

48 *Ibid.* p. 3; Steckel "Stature," pp. 1911–15.

the population able to purchase sufficient nutrition and medical care. The average height of a population could be expected to rise, for a given per capita income, with improved equality of income distribution. Similarly, average height might decline were there an increase in income inequality, deterioration in public health, or another social or economic effect that reduced the net nutrition available to the population. In addition, stature may be affected by consumer preference. People may choose to spend extra income on industrial goods or items that may detract rather than enhance health. The relationship between average height and economic change is far from simple, which makes interpretation of various influences on height difficult and sometimes controversial.[49]

Taiwan Stature Data

Our primary data are the health examination records of individuals from the personnel files of Taiwan provincial government employees in the 1950s and 1960s. These are held at the provincial archive, Nantou (南投).[50] Other height data are from surveys. The earliest anthropometric surveys were the Japanese health and sanitation surveys. We used the mean height of ethnic Chinese adult males aged 21–40 years from these surveys as estimated by Kelly Olds, corresponding to the birth years 1881–1910.[51] Recent surveys from Taiwan and mainland China are used to compare the average height in Taiwan and that in Fujian and Guangdong from where the pre-1945 Chinese in Taiwan originated.[52]

Height and other individual data were collected for 2,783 males and 95 females born before 1945, of which we use a subset that comprises 1,838 men and 94 women, shown in Table 2.[53] All subjects were ethnic Chinese born in Taiwan between 1899 and 1945, with about equal proportions from the north, central and south regions along the populous west coast of Taiwan and 3.2 per

49 The problem is not the identification of the influences on stature – the biomedical sciences provide the theoretical underpinnings – but measuring and accounting for the direct, the indirect and the interaction effects of separate factors.

50 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.

51 Olds, "The biological standard," pp. 189–91.

52 Taiwan, Executive Yuan, *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, 1990); People's Republic of China (PRC), Chinese Student Physique and Health Research Group (ed.), *Zhongguo xuesheng tizhi yu jiankang yanjiu* (*Research on the Constitution and Health of Chinese students*) (Beijing: Renmin jiaoyu, 1988). For discussion of the Taiwan surveys, Yi-Ching Huang and Robert M. Malina, "Secular changes in the stature and weight of Taiwanese children, 1964–1988," *American Journal of Human Biology*, Vol. 7, No. 4 (1995), pp. 485–96; and for China, Stephen L. Morgan, "Richer and taller – stature and the standard of living in China, 1979–1995," *The China Journal*, No. 44 (2000), pp. 1–39.

53 A regression analysis of height by age revealed Taiwan males reached final adult height at about 21 years old; therefore adult men were defined as aged 21–59. Women 18 years and older had reached final height.

Table 2: **Characteristics of the Adult Sample Population**[a]

		Males		Females	
		N	%	N	%
Period born	1896–1905	8	0.4	–	–
	1906–15	45	2.4	–	–
	1916–25	322	17.5	4	4.3
	1926–35	884	48.1	9	9.6
	1936–45	579	31.5	81	86.2
	Total	1,838	100.0	94	100.0
Age	18–20	0	0	26	27.7
	21–29	1,224	66.6	62	66.0
	30–39	487	26.5	5	5.3
	40–49	98	5.3	1	1.1
	50–59	29	1.6	–	–
	Total	1,838	100.0	94	100.0
Region	North	543	29.5	33	35.1
	Central	621	33.8	23	24.5
	South	612	33.3	32	34.0
	East	59	3.2	6	6.4
	Other Taiwan[b]	3	0.2	–	–
	Total	1,838	100.0	94	100.0
Occupation[c]	Unskilled	266	14.8	3	3.2
	Semi-skilled	456	25.3	45	47.9
	Skilled	377	20.9	15	16.0
	Semi-professional	613	34.0	30	31.9
	Professional	90	5.0	1	1.1
	Total	1,802	100.0	94	100.0
	(Not recorded)	(36)		–	–
Education	Illiterate	49	2.7	0	0
	Elementary or none	455	25.3	4	4.3
	Middle school	93	5.2	5	5.3
	Vocational middle school	424	23.6	32	34.0
	Senior high school	37	2.1	9	9.6
	Vocational high school	287	16.0	22	23.4
	Post secondary	453	25.2	22	23.4
	Total	1,798	100.0	94	100.0
	(Not recorded)	(40)			

Notes:
[a]Adult males are age 21–59 and adult females 18–50 – see text for details of definition.
[b]All subjects were Taiwan-born. The birth place was not specified for three subjects.
[c]Occupation skill levels were classified using a five-point scale based on job title.
Source:
Personnel Records, Taiwan Provincial Archives (*Taiwan wenxian guan*) Nantou, Taiwan.

cent from the east coast.[54] Two-thirds of the sample was aged 21–29 years at measurement and one-quarter was 30–39 years. Most subjects were born in the three decades 1916 to 1945. Only 2.5 per cent of the sample was born before

54 We follow conventional regional classification. The north comprises Taipei city, Taipei county, Keelung city, Ilan county, Taoyuan county, Hsinchu county and Miaoli county; central comprises Taichung city, Taichung county, Changhua county, Nantou county and Yunlin county; the south comprises Chiayi county, Tainan city, Tainan county, Kaohsiung city, Kaohsiung county, Penghu islands and Pingtung county; the east comprises Huanlien and Taitung counties.

1915. The sample size exceeds 20 subjects a year, for most years exceeding 50 subjects, except for those born in the early 1910s. Measurement took place between 1943 and 1968, with one-third measured between 1955 and 1956, soon after the reorganization of the Kuomintang and provincial government administration in the early 1950s.[55]

Nearly half the men had some secondary education, most in vocational streams.[56] About a quarter had elementary education and another quarter post-secondary education – only 49 subjects (2.7 per cent) for whom we have recorded education details were illiterate or without education. Our sample therefore was an educated elite compared with the Taiwan population of the 1950s and 1960s.[57] They were probably similar in social background to the 18 to 22-year-old college and university students in the Taiwan surveys that we use to benchmark contemporary anthropometric standards.

Occupations were classed into five grades: unskilled, semi-skilled, skilled, semi-professional and professional.[58] The relatively high education level is reflected partly in the occupation classifications, with a high proportion of white-collar occupations (semi-professional or professional). Only 14.8 per cent of men were classed as unskilled manual workers, while semi-skilled and skilled manual workers made up 46.2 per cent of the sample. The non-manual or white-collar grades accounted for 38.9 per cent, of whom most were semi-professionals and in the commercial classes.

The 94 adult women aged 18 or older were born between 1921 and 1945, with more than half born in the early 1940s. About equal proportions came from north Taiwan (35 per cent) and south Taiwan (34 per cent), with another 25.5 per cent from central Taiwan and 6.4 per cent from the east. They were measured between 1953 and 1968 – most were measured between 1965 and 1967 – and were mostly aged 20–23 years. They were better educated than the men: 72 per cent had secondary education and 23 per cent post-secondary education. One-third of them were employed in white-collar occupations.

Secular Change in Taiwan Stature

Analysis of historical change in stature arranges the height data according to the year or period of birth of the subjects, rather than the year of measurement. This

55 See Bruce J. Dickson, "The lessons of defeat: the reorganization of the Kuomintang on Taiwan, 1950–52," *The China Quarterly*, No. 133 (1993), pp. 56–84.

56 Most Taiwanese were excluded from post-elementary academic streams, despite policies for integration after 1919, with few alternatives other than the vocational schools. Tsurumi, *Japanese Colonial Education*, chs. 4 and 5.

57 When they were recruited to government service in the 1950–60s nearly 72% of the men had post-elementary education, compared with 15.3% in the 1956 census and 27% in the 1966 census. Census data are from Ho, *Economic Development*, p. 323.

58 The five-class scheme is an adaptation for China and Taiwan of the scheme in W.A. Armstrong, "The use of information about occupation," in Edward Anthony Wrigley (ed.), *Nineteenth-Century Society: Essays in the Use of Quantitative Methods for the Study of Social Data* (Cambridge: Cambridge University Press, 1972), pp. 191–310.

enables the computation of annual or periodic mean heights. The decal mean stature of men and women are summarized in Table 3. We only report the average height in 1916–45 for the women because the sample size was inadequate for further analysis. Their average height for the three decades was 156cm, which was 3.1cm shorter than women college students measured in 1989 who were born in 1968–71.[59] The remainder of our analysis is focused on men.

The simple average height of men rose 2.0cm from 165.7cm in 1906/15 to 167.7cm in 1936/45. Figure 1 shows the annual average height along with a double-centred three-year moving average.[60] Ordinary least-square (OLS) regression is used to obtain reliable estimates for the trend in height by controlling for within-period variation in the distribution of the age, region, education and occupation of the subjects.[61]

Five OLS regression models are reported for Taiwan men aged 21 to 59 born between 1905 and 1945. There were too few subjects born before 1905 for inclusion in the analysis. Exclusion of outliers, along with missing data for education and occupation for some subjects, reduced the number of subjects for each regression compared with the whole sample reported in Table 2. Models 1–3 examine the data in five-year intervals from 1905/09 to 1940/44 and models 4–5 used three-year intervals from 1905/07 to 1944/46. Every model estimated height coefficients controlling for the period and place of birth, education level and occupation skill. Model 1 excludes east Taiwan.[62]

Table 3: **Summary of Mean Height by Decades, 1896–1945**

	Males		Females	
	Mean	**S.D.**	**Mean**	**S.D.**
1896–1905	166.3	6.48	–	–
1906–15	165.7	4.05	–	–
1916–25	166.4	3.36	155.8	3.10
1926–35	167.3	3.71	156.0	4.22
1936–45	167.7	5.07	155.6	4.20

Notes:
The means are unadjusted for region or occupation biases. The female sample is too small for longitudinal analysis and is reproduced for comparison with females measured in later years.
Source:
See Table 2.

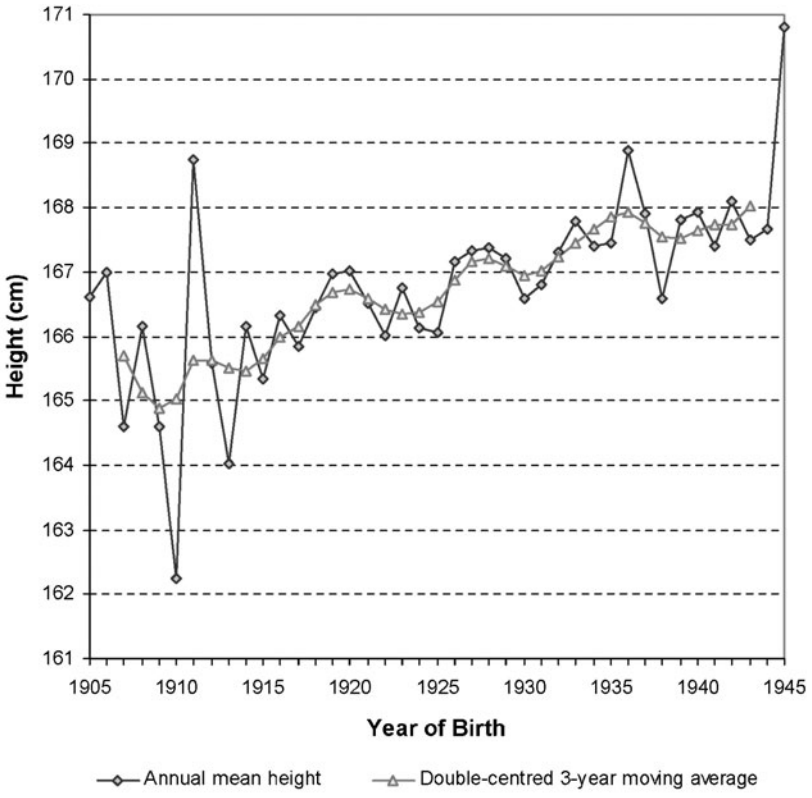
59 Taiwan, *Statistics on Children*, p. 17. The height of 159.1cm was the average for women aged 18–21 years in the period 1968–71.

60 A doubled-centred moving average takes the three-year moving average of a three-year moving average of the annual series. It has the same span as a five-year moving average, but tracks more closely the variations in the original series.

61 The OLS regression uses categorical variables to code for specific characteristics of the subjects. If there were, for example, more white-collar employees, who on average are taller than manual employees, in one period compared with another, the estimated height for the period with more white-collar employees would be biased upwards. We are not interested in any predicative capability of the regression and are not concerned with the statistic for "model fit" (the R-square statistic), which is typically low for these types of regressions.

62 There were few subjects from east Taiwan, but we retained the east because the model statistics were stronger.

Figure 1: **Change in the Average Height of Taiwan Men, 1905–1945**



Source:
See Table 2.

Two specifications are used for the education variable. Models 1, 2 and 4 classified the education levels of the subjects as elementary or none, which is the reference group, lower secondary, upper secondary and post-secondary. Models 3 and 5 reclassified the secondary level into academic (general high schools) and vocational (technical and commercial high schools).[63] Occupation skill level is classified into four groups. Three are manual occupations (unskilled, semi-skilled and skilled), and the fourth group labelled professional comprises the commercial classes (shop assistants, clerks and shop owners), semi-professionals (technicians, nurses and supervisors) and a handful of professionals (accountants, managers and engineers).

63 The vocational streams are described in Tsunami, *Japanese Colonial Education*, pp. 85–88, 110–22.

The estimates for models 1–3 in Table 4 reported a mean of 167.0cm for the reference group, subjects born in 1925–29 in central Taiwan who had an elementary education and unskilled employment. The secular trend in heights from 1905/09 to 1940/44 derived from the estimates in model 2 is plotted in Figure 2.[64] Heights fall from 165.4cm in 1905/09 to 164.9cm in 1910/14 before beginning a strong upward trend to 167.0cm in 1925/29. Stature dips below 167cm in the 1930/34 interval, rises to 167.3cm in 1935/39 and dips back to 167.2cm in 1940/44. Height increased at a rate of 1.1cm per decade for the period 1910/14–1925/29, but the trend is more or less flat for the period 1930/34–1940/44.

Regional differences in height are observed in height series, and reflect the variations in regional economies, climates and other factors that influence the net nutrition of a population.[65] Models 1–3 show that the north Taiwanese were 0.8 to 0.9cm shorter than the reference group from central Taiwan (the results were statistically significant at the 0.01 level), which is contrary to Olds' finding that northerners were taller.[66] South Taiwanese were 0.4cm shorter on average than those from central Taiwan (statistically significant at the 0.1 level) and those in the east were 0.7cm shorter, but the result was not significant. Explanations for the differences will be canvassed below, but econometric exploration of the factors behind these differences is beyond the scope of this article.

The education coefficients show the better educated were taller. Education (a) specification found the lower secondary educated were 0.8cm taller than the elementary-educated reference group (statistically significant at the 0.01 level), the upper secondary were 0.2cm taller (the difference was not statistically significant), and post-secondary were 0.8–0.9cm taller (significant at the 0.05 level). Similar results were obtained for the alternative specification Education (b), with the vocational group 0.8cm taller than the reference group and the post-secondary 0.9cm taller.

Occupational differences in height were evident.[67] Professional, skilled and semi-skilled employees were taller than unskilled employees, the control group, as expected, though the difference between groups was surprisingly small, less than 0.5cm, and none of the coefficients for skill was statistically significant. In addition, contrary to expectations, the professional group was slightly shorter than the skilled workers whereas in most height studies the professionals would be significantly taller.

64 Calculation of the actual heights from the regression results is the addition of the coefficient for any period and the reference mean height. For example, in model 2, the coefficient for the period 1915–19 is –1.2, which added to the mean 167.0cm produces a height estimate for the reference group of 165.8cm for this period.

65 Steckel, "Stature," pp. 1921–22.

66 Olds, "The biological standard," pp. 196, 201.

67 Differences in average height by social class or occupation indicate the degree of inequality in the biological standard of living between social classes, and in the past could be as great as 8.0cm. Steckel, "Stature," pp. 1922–23.

Table 4: **Regression Estimates for Factors Affecting Change in Heights, Model 1 to Model 3**

	Model 1			Model 2			Model 3		
	estimate	**t-statistic**		**estimate**	**t-statistic**		**estimate**	**t-statistic**	
(Constant)	167.0	570.046	***	167.0	570.213	***	167.0	571.170	***
Period of birth									
1905–09	−1.6	−1.318		−1.6	−1.319		−1.6	−1.336	
1910–14	−1.9	−2.203	**	−2.1	−2.530	**	−2.1	−2.530	**
1915–19	−1.3	−2.499	**	−1.2	−2.468	**	−1.3	−2.521	**
1920–24	−0.6	−1.885	*	−0.7	−2.067	*	−0.7	−2.130	*
1925–29		reference							
1930–34	−0.1	−0.449		−0.1	−0.482		−0.2	−0.617	
1935–39	0.1	0.403		0.3	0.822		0.2	0.536	
1940–44	0.2	0.499		0.2	0.610		0.1	0.285	
Region of birth									
North	−0.9	−3.524	***	−0.9	−3.536	***	−0.8	−3.421	***
Central		reference							
South	−0.4	−1.823	*	−0.4	−1.814	*	−0.4	−1.782	*
East		excluded		−0.7	−1.221		−0.7	−1.198	
Education (a) [a]									
Elementary									
Lower secondary	0.8	2.682	***	0.8	2.618	***			
Upper secondary	0.2	1.496		0.2	1.472				
Post-secondary	0.9	2.550	**	0.8	2.349	**			
Education (b) [b]									
Elementary								reference	
Secondary general							0.2	0.513	
Secondary vocational							0.8	2.821	***
Post-secondary							0.9	2.558	*

Table 4: **Continued**

	Model 1		Model 2		Model 3	
	estimate	**t-statistic**	**estimate**	**t-statistic**	**estimate**	**t-statistic**
Occupation skill [c]						
Unskilled		reference				
Semiskilled	0.2	0.395	0.1	0.328	0.1	0.243
Skilled	0.5	1.177	0.5	1.166	0.4	1.128
Professional	0.2	0.697	0.3	0.783	0.3	0.762
N	1688		1746		1746	
R^2	0.033		0.034		0.035	
Adjusted R^2	0.025		0.025		0.026	
DW	2021		2018		2.019	

Notes:

[a]Education (a) classified the population according to broad general classes of educational level, elementary or primary schooling being 3–6 years school, lower secondary is middle school or junior high school, upper secondary is senior high school, and post-secondary includes colleges, technical institutes and universities.

[b]Education (b) reclassified the secondary levels into academic or general stream and a vocational stream, where the high school is specifically identified as a technical or commercial high school.

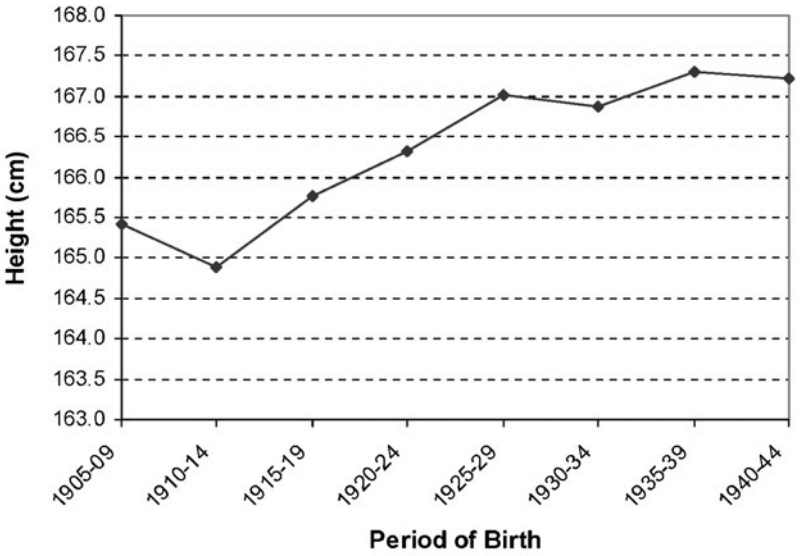
[c]Occupation skill used job-identified skill level to classify the population into three manual groups of unskilled, semiskilled and skilled workers, for example, from labourers through to skilled mechanics. The fourth group labelled professionals covered white collar or non-manual groups, and comprised commercial groups, semi-professional and higher professionals.

Statistical significance of the coefficients are indicated by * < 0.1, ** < 0.05, *** < 0.01; no asterisk means the results were not significant in terms of formal statistical tests.

Source:

See Table 2.

Figure 2: **Estimated Average Height of Taiwan Men, Five-Year Intervals, 1905/09–1940/44**



Source:
Table 4, Model 2.

Regression models 4 and 5 (Table 5) use three-year intervals, from 1905/07 to 1944/46 (reference group 1926–28). The other variables and reference groups are the same as for models 1–3. The mean for the reference group is 167.2cm. The estimated coefficients for region, education and occupation were similar to those obtained for models 1–3, the differences being no more than 0.1cm and with the same level of statistical significance. A major difference is that the three-year interval estimates were more volatile than the five-year models, and approximate the pattern for the moving average. The estimated height trend based on model 4 is plotted in Fig 3.

The estimates for models 2 and 4 are similar, after we exclude data points before 1910, and show height rising rapidly until the late 1920s and then shifting to a flatter trajectory from about 1930 to 1945. The differences in estimates between models are an artefact mostly of within period sample size and the distribution of minimum and maximum heights for start or end years of any period.

To conclude our reporting of height trends, we use survey data to push the series backward into the late Qing and forward to the period after 1950, and add the mean for urban males from Guangdong and Fujian provinces. Figure 3 shows the four series ordered into three-year birth intervals. We can observe an

Table 5: **Regression Estimates for Model 4 and Model 5**

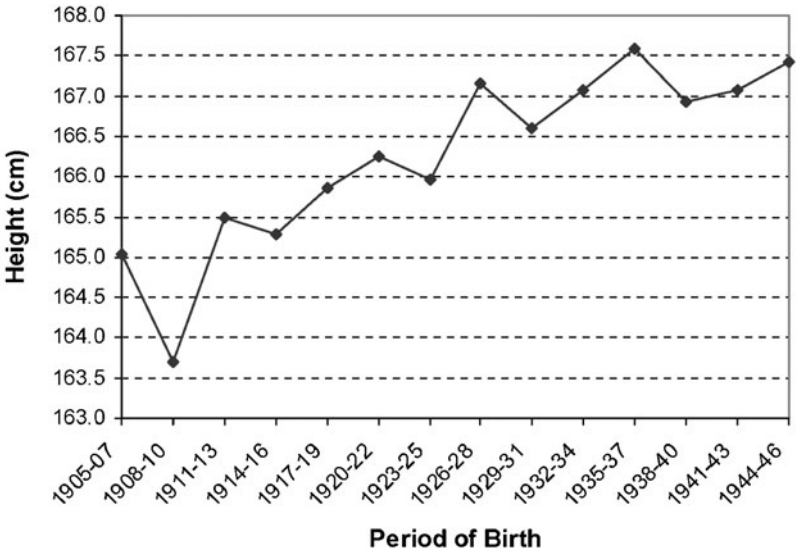
	Model 4			Model 5		
	estimate	**t-statistic**		**estimate**	**t-statistic**	
(Constant)	167.2	551.777	***	167.2	552.326	***
Period of birth						
1905–07	−2.1	−1.300		−2.1	−1.295	
1908–10	−3.5	−2.607	***	−3.5	−2.618	***
1911–13	−1.7	−1.697	*	−1.6	−1.664	*
1914–16	−1.9	−2.185	**	−1.9	−2.177	**
1917–19	−1.3	−2.180	**	−1.3	−2.235	**
1920–22	−0.9	−2.019	**	−0.9	−2.053	**
1923–25	−1.2	−3.024	***	−1.2	−2.959	***
1926–29		reference				
1929–31	−0.6	−1.615		−0.6	−1.664	*
1932–34	−0.1	−0.230		−0.1	−0.315	
1935–37	0.4	1.003		0.3	0.814	
1938–40	−0.2	−0.543		−0.3	−0.801	
1941–43	−0.1	−0.195		−0.2	−0.468	
1944–46	0.3	0.392		0.1	0.218	
Region of birth						
North	−0.9	−3.577	***	−0.8	−3.443	***
Central		reference				
South	−0.4	−1.707	*	−0.4	−1.680	*
East	−0.7	−1.183		−0.6	−1.149	
Education (a)						
Elementary		reference				
Lower secondary	0.8	2.712	***			
Upper secondary	0.2	1.365				
Post-secondary	0.7	2.150	**			
Education (b)						
Elementary					reference	
Secondary general				0.2	0.550	
Secondary vocational				0.8	2.824	***
Post-secondary				0.8	2.369	**
Occupation skill						
Unskilled		reference				
Semi-skilled	0.3	0.691		0.2	0.586	
Skilled	0.6	1.442		0.5	1.389	
Professional	0.4	1.058		0.4	1.006	
N	1751			1751		
R^2	0.041			0.042		
Adjusted R^2	0.029			0.029		
DW	2.015			2.015		

Note:
Statistical significance level * < 0.1 ** < 0.05 *** < 0.01

Source:
See Table 2.

upward trend in heights from the 1880s, through the Japanese colonial period, and into the post-war years up to the 1970s. The average height of Taiwan men rose from 162.2cm for those born in 1881/83 to 170.5cm for the 1971/73 cohort,

Figure 3: **Estimated Average Height of Taiwan Men, Three-Year Intervals, 1905/07–1944/46**



Source:
Table 5, Model 4.

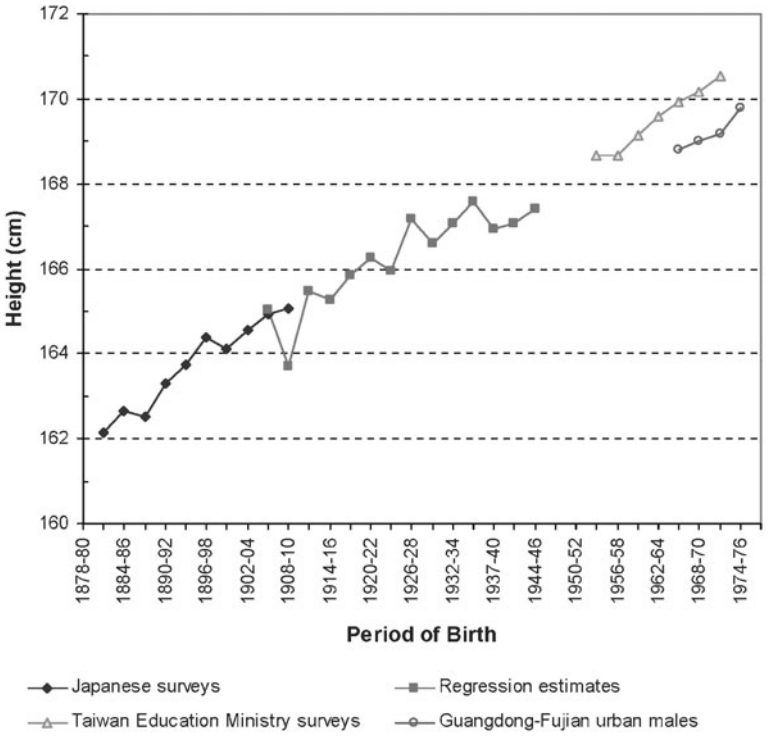
an increase in average height of 8.4cm over nine decades. Taiwan young men born in the 1960s and 1970s were on average 1.1cm taller in than their mainland counterparts. Differences in the tempo or rate of increase in height over time are evident in Figure 4.

We next analyse the inter-temporal rates of growth, reported in Table 6 and Figure 5. The three Taiwan height series are combined and the data gap between the 1944/46 and 1953/55 intervals were filled using linear interpolation.[68] Clearly evident in Figure 5, even without the trend lines, is the sideways shift in the upward trend, a flattening of the growth trajectory, that coincides with the switch in Japanese colonial policy that took place around 1930. Table 6 reports the regression estimates for the trend within sub-periods between 1881/83 and 1971/73. The overall trend for change in height from 1881/83 to 1971/73 was 0.85cm per decade.

From the late Qing into the early colonial period, about 1908/10, the average height of men rose 1.12cm per decade. Our estimates for 1905/07 to 1944/46 (model 4) show a slower rise of 0.77cm per decade. However, a straight line fit is inappropriate for the entire period as both the five-year and three-year interval

68 The combined series joined the Japanese survey series for 1881/83 to 1908/10, the model 4 estimates for 1911/14 to 1944/46, and the Ministry of Education surveys series for 1953/55 to 1971/73.

Figure 4: **Long Run Change in Average Height of Men in Taiwan, Guangdong and Fujian**



Sources:
Table 5, Model 4; Olds, "The biological standard of living"; Taiwan, *Statistics on Children*; People's Republic of China (PRC), Chinese Student Physique and Health Research Group (ed.), *Zhongguo xuesheng tizhi yu jiankang yanjiu* (*Research on the Constitution and Health of Chinese students*) (Beijing: Renmin jiaoyu, 1988).

models indicate a shift in the height trajectory between the late 1920s and early 1930s. Between the 1905/07 and 1926/28 intervals, the average height increased at 1.15cm per decade (model 4a), but thereafter slowed to 0.19cm a decade from 1929/30 to 1944/46 (model 4b). The regression coefficient for model 4b was not statistically significant, which means that the rise in height from 1929/30 to 1944/46 was not different from zero, and thus confirms the stagnation in average height. The Ministry of Education data from the 1980s and 1990s show the mean height for those born between 1953/55 and 1971/73 increased 1.12cm per decade, the same rate of increase as found for the late Qing and early colonial period.

In summary, these estimates show progressive improvement in the average height of Taiwan men born during the colonial period. The secular upward trend from the 1880s to the 1970s is almost monotonic, punctuated by short-term

Table 6: **Estimated Trend in Heights for Selected Three-Year Periods, 1881/83 to 1971/73**

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

Notes:

The coefficient column reports the change in height for each three-year reporting period. To calculate the cm change in heights per decade, the coefficient is multiplied by 3.333. The intercept is the estimated height of the projected straight line at the point it crosses the y-axis at time 1881/83. The t-statistic is in parentheses, and is statistically significant at the 0.01 level for all coefficients except for Model 4b (see text for discussion), which shows that the change in height for period 1926/28–1944/46 is not different from no change at all.

Sources:

Table 5, model 4; Kelly Olds, "The biological standard of living in Taiwan under Japanese occupation," *Economics and Human Biology*, Vol. 1, No. 2 (2003), pp. 187–206; Taiwan, Executive Yuan, *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, 1990).

reversals; the exception was the almost stagnate growth in the late colonial period, 1930–40s. Over the nine decades average height increased 0.85cm a decade, which was slightly less than in Europe where the increase in average height was about 1.0cm per decade from the mid 19th to mid 20th centuries.[69] For the colonial period to about 1930 the rate of increase was 1.12 cm a decade, which was faster than the 0.91cm per decade reported for Japanese military recruits from 1892 to 1937.[70] The statistical evidence for the flat trajectory in height during the 1930s–40s is striking confirmation of the adverse impact on the Taiwanese of the shift in colonial policy in the early 1930s, as Japan increasingly militarized and reoriented development in its colonies to support projection of imperial power.

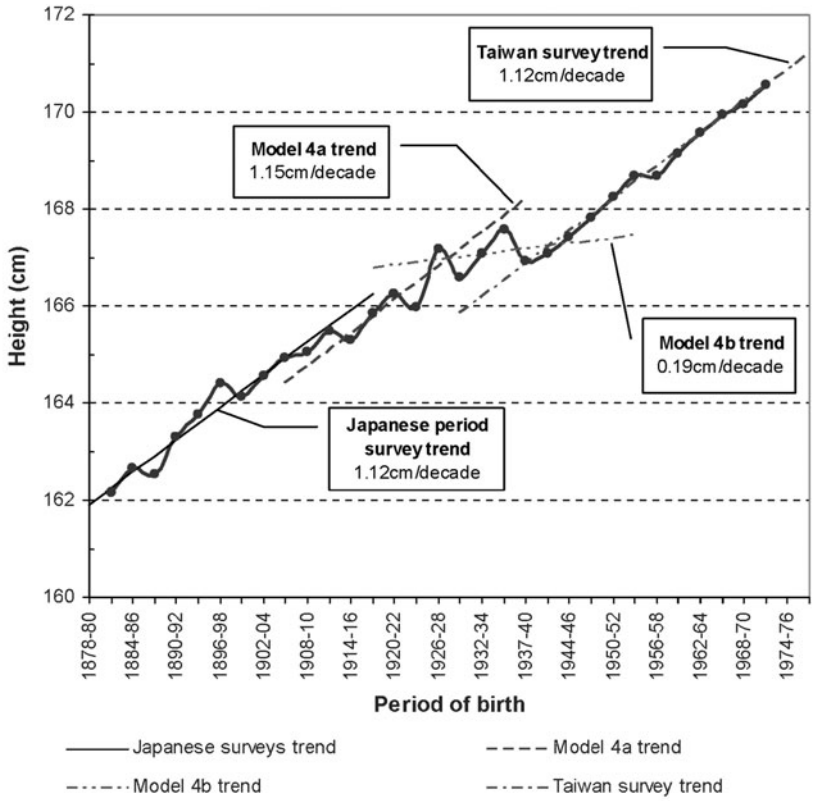
Discussion of Explanatory Factors

Height is an indicator of nutrition and welfare, which captures an important aspect of the human condition, but is not entirely a substitute for other measures of the standard of living. Economic, epidemiological and socio-political factors combine in varying ways to influence the magnitude, fluctuations and tempo of change in heights. The interaction is complex, and often the explanation

69 Roderick Floud, "The heights of Europeans since 1750: a new source for European economic history," in Komlos, *Stature, Living Standards*, pp. 9–24.

70 Ted Shay, "The level of living in Japan, 1885–1938: new evidence," in Komlos, *Stature, Living Standards*, p. 183. The 20-year-old Japanese military recruits were very short compared with Europeans or Chinese, measuring only 160.3cm in 1937.

Figure 5: **The Trend in Average Height of Taiwan Men by Sub-Periods, 1881/83–1971/73**



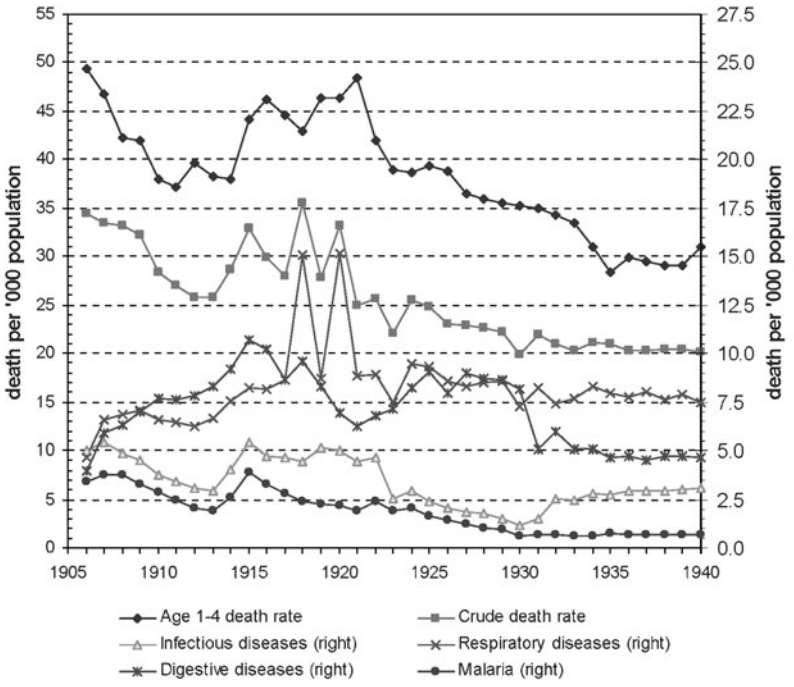
Source:
Figure 4; Table 6.

controversial. Even for the United States, the many available sets of data have not produced a consensus about the "antebellum puzzle," the reversal in heights in the mid 19th century despite rising real wages.[71] In this final section we put forward several scenarios to explain the trend our data report: the investment in public health, the benefits of economic growth and the impact of economic policy.

71 The "antebellum puzzle" literature is large. John Komlos, "Shrinking in a growing economy? The mystery of physical stature during the industrial revolution," *Journal of Economic History*, Vol. 58, No. 3 (1998), pp. 779–802; Michael R. Haines, Lee A. Craig and Thomas Weiss, "The short and the dead: nutrition, mortality, and the 'antebellum puzzle' in the United States," *Journal of Economic History*, Vol. 63, No. 2 (2003), pp. 382–413.

At the simplest level the trend in stature is broadly about improved public health combined with higher income with which to purchase nutrition inputs. By the start of the 1930s, the Taiwanese were healthier and enjoyed higher per capita incomes than in the past. Japanese investment in public health was "an impressive success," reducing mortality and morbidity.[72] Child mortality (1–4 years) declined from about 50 per thousand around 1900 to below 30 per thousand in the 1930s, and the crude death rate declined from nearly 40 per thousand to about 20 per thousand (Figure 6). Severe mortality and morbidity episodes still occurred: the epidemics of the 1910s temporarily reversed the downward trend that had begun in the first decade. However, reduced deaths from infectious diseases indicate positive control measures and less severe

Figure 6: **Population Death Rates and Disease-Specific Death Rates, 1906–1940**



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).

72 Barclay, *Colonial Development*, p. 238; pp. 133–72 passim.

morbidity for those afflicted. Lower mortality was reflected in increased life expectancy at birth of ten years to 43.8 years between 1910 and 1940 (Table 1).

Past studies have shown conclusively that increased height is correlated positively with lower mortality.[73] A recent study found the average height of men in eight countries increased 0.33cm for every additional year of life expectancy at birth, or a 3.3cm rise for each decade of extra longevity.[74] In Taiwan between 1910 and 1940, the average height of men increased about 2.4cm. Although the increase is less than the 3.3cm we might expect from a ten-year extension in life expectancy, the epidemics of the 1910s might well account for this.[75]

Another effect of reduced morbidity is that healthier adults are more productive, and better able to provide and care for their children. The decline in the incidence of malaria, for example, would improve adult productivity and in turn childhood health through better care and a more adequate diet.[76] Benefits of improved nutrition from disease control were not confined to colonial times, but would reached into the post-1950 economic "miracle" in improved capabilities of the measured subjects analysed in this article.[77]

Economic data reveal that there was strong growth throughout the colonial period until the late 1930s. Per capita real income more than doubled from the first decade to the fourth decade of the 20th century, as shown in Figure 7.[78] The mean index of per capita income increased from 48 for 1903/05 to 99 for 1936/40 (1935–37=100).[79] While colonial gross domestic income peaked in the later 1930s, the growth of per capita income was almost flat from 1932 to 1940, which coincides with the flat trajectory for the average height of men for 1930–45.

73 H.T. Waaler, "Height, weight and mortality: the Norwegian experience," *Acta Medica Scandinavica*, Supplementum 679 (1984), pp. 1–65; Robert W. Fogel, "New sources and new techniques for the study of secular trends in nutritional status, health, mortality, and the process of aging," *Historical Methods*, Vol. 26, No. 1 (1993), pp. 5–43.

74 Richard H. Steckel, "Health and nutrition in the pre-industrial era: insights from a millennium of average heights in northern Europe," in Robert C. Allen, Tommy Bengtsson and Martin Dribe (eds.), *Living Standards in the Past: New Perspectives on Well-Being in Asia and Europe* (New York: Oxford University Press, 2005), pp. 227–54.

75 The relationship between height and life expectancy for the Chinese may diverge from Steckel's estimates. The only Asian population in the study was Japan and the relationship was lower than for those whose population was of European ancestry.

76 Malaria's impact on productivity and income can be grasped from a missionary's observation. "Malarial fever," he wrote, is "man's deadliest foe" on Taiwan, and "seldom do three months elapse without one or more members of every household laid low." Further: "It is not uncommon in Formosa to find half of the inhabitants of a town prostrated by malarial fever at once. I have seen households of twenty to thirty with not one able to do work." George Leslie Mackay, *From Far Formosa: The Island, Its People and Missions* (Edinburgh and London: Oliphant Anderson & Ferrier, 1900), pp. 43, 314.

77 Robert W. Fogel discussed the ties between stature, productivity and mortality in his 1993 Nobel Prize acceptance speech, "Economic growth, population theory, and physiology: the bearing of long-term processes on the making of economic policy," *The American Economic Review*, Vol. 84, No. 3. (1994), pp. 369–95.

78 Estimates of national income include the widely cited T. H. Lee estimates used in Table 1 from Ho, *Economic Development*, pp. 284–85, and Wu Tsong-min, "Estimates 1910 to 1950"; Wu Tsong-min, "Taiwan's agricultural production." Revised estimates are coming out of the Asian Historical Statistics Project at Hitotsubashi University. See http://www.ier.hit-u.ac.jp.

79 The underlying series from which the index was computed, kindly supplied by Wu Tsong-min to the authors, was in 1990 dollars.

Figure 7: **Index of Real Per Capita Income (1935–37=100)**

Note:
The underlying per capita real income was based in 1990 dollars and converted to an index using the three-year average per capital income for 1935–37 fixed at 100.

Source:
Wu Tsong-min, "Taiwan's agricultural production," original data kindly supplied.

These trends are plausibly related. We know income is an important determinant of diet, more so for the poor, and as a consequence average height is sensitive to increased income at low income levels. Steckel's early estimate of the relationship between height and income found a doubling of income at low income levels (less than $4,000 in 1970 US dollars) raised the average height of men about 2.4cm for a population of European ancestry, holding other factors constant, such as income distribution.[80]

While we should be cautious about using average height to infer per capita income, warns Steckel,[81] the 2.4cm increase in the average height of Taiwan men

80 Steckel, "Height," pp. 2–4, 6. The estimates in 1985 dollars in Steckel, "Stature," p. 1915 show a doubling of income raised average height 2.8 cm for a European population.

81 Steckel, "Height," pp. 2–4, 6; Steckel, "Stature," pp. 1916–17. The height–income relation will shift over time due to change in the socio-economic structure.

between 1910 and 1940 suggests per capita incomes doubled. The actual increase in income was 1.7 times, from an index mean of 58 for 1906/10 to 99 for 1936/40. Leaving aside any differences in the height–income relationship between Taiwan and Europeans, the taller than expected average height in Taiwan suggests that the income share of the poor may have improved. Such a distributional shift will raise average height as the incremental gain in height is largest among the lower income groups.[82] Others have argued that income distribution in Taiwan became more equal during the 1920s.[83] The height data support this argument. Research is needed to explore the dynamics of income growth and income distribution as a result of the increased commercialization of agriculture after the mid-1920s. Commercialization seemingly was not bad for Taiwan farmers as their higher incomes enabled them to purchase foods and non-food goods that enhanced net nutrition.[84]

Our third story is the shift in Japanese colonial development policy in the 1930s. The main elements of the shift include greater self-sufficiency, a build-up of industry tied to militarist plans for southern expansion, and reduced support for export rice production to lessen rural distress in Japan from cheap imports.[85] In Taiwan, the impact of the policies on the growth and composition of industry was slight – the food sector increased its share of total output.[86] Rice output and exports continued to rise, while government subsidies to convert rice land to other crops were unattractive to farmers.[87] Rising real farm incomes in the 1930s was a disincentive for all but the poorest to migrate to urban areas and restricted the supply of labour for industry.[88]

We are on uncertain ground in discussing the impact of these developments. The new policies did not reduce rural consumption or real wages, according to current knowledge, yet the upward trend for average heights and the index of per capita income flattened while the downward trend in mortality rates stalled. What might have caused such effects? Rapid change in industrialization and urbanization levels in other societies have produced sharp deterioration in the biological standard of living, measured by height, despite economic growth and rising real wages.[89] More industrialization – even the tiny expansion in Taiwan – and more city residents without more investment in public health would worsen the urban health environment. The increase in infectious disease and a bottoming of the trend in mortality rates lend support to such a thesis. Deterioration in the access to nutrients and the quality of the living environment

82 Steckel, "Stature," p. 1916.
83 Shu-jen Yeh and Chih-ming Ka found that land distribution became more equal in the late colonial period (land was used as a proxy for income in the absence of personal income data). Yeh, "Economic growth," pp. 208–12; Ka, *Japanese Colonialism*, pp. 146–50.
84 Yeh, "Economic growth," pp. 201–04; Ka, *Japanese Colonialism*, pp. 158–59, 161, 177–78.
85 Samuel Pao-San Ho, "Colonialism and development: Korea, Taiwan, and Kwantung," in Myer and Peattie, *The Japanese Colonial Empire*, pp. 363–64; Ka, *Japanese Colonialism*, pp. 150, 160, 170–71.
86 Ho, "Colonialism and development," pp. 367, 394–95.
87 Ka, *Japanese Colonialism*, pp. 160–61.
88 *Ibid.* p. 169
89 The classic example is the "antebellum puzzle." Komlos, "Shrinking."

of the children of rural labourers who had taken urban employment would combine to reduce their final adult stature. The disease indicators suggest that the public health system was not coping with the changes – deaths from infectious diseases even increased in the 1930s (Figure 6). Farmers' incomes and consumption may also have changed in ways yet unknown with adverse effects, but we lack specific evidence. Did they spend their increased earnings on consumer goods that detracted from health? In summary, the welfare consequence of the shift in colonial policy during the 1930s is an under-researched topic that requires more investigation.

Conclusion

Over nearly a century the average stature of Taiwan Chinese men increased from about 162cm, for those born in the 1880s, to nearly 171cm for those born in the 1970s. Mean height increased at a rate of 0.85cm per decade. The rate of increase was fastest, 1.1cm a decade, during the first phase of the colonial policy from the 1890s to approximately 1930 and from the 1950s to the 1970s (Table 6). Taiwan men were also taller than their counterparts in Fujian and Guangdong provinces, the ancestral home of many (Figure 4).

In summary, the sustained rise in average heights indicate considerable health and welfare returns to the Taiwanese from colonial economic development. This finding supports those earlier scholars who have argued that Japanese colonial economic policy delivered broad economic benefits, despite the political and economic power the Japanese possessed to extract the economic surplus produced by Taiwan farmers. The gain in average height for most of the colonial period challenges the pessimists who argue the colonizers' grip on the economy denied the Taiwan Chinese benefit in real terms from the rise in economic output and productivity, and the change in markets, infrastructure and public goods. Colonialism did more than simply lay the foundations for Taiwan's post-war economic miracle. The stature data indicate the Taiwan Chinese on balance were better off however repugnant the economic, political and social discrimination inherent in colonialism: they were taller, healthier and lived longer lives.

Our finding of stagnation in the upward trend in average height in the 1930s is striking evidence of the negative impact of the late phase of Japanese colonialism. The rate of increase in average height was only 0.19cm per decade between 1930 and 1945. Other human welfare indicators also stagnated. The change in height, mortality and morbidity from the 1930s is consistent with the observed negative effects of early industrialization and urbanization reported for the United States, England and other countries in the anthropometric literature, though admittedly most Taiwanese were still rural dwellers. These findings call for further study of the interactions between the economic and the biological standard of living of the Taiwan Chinese, especially for the 1930–45 years.

We also need to develop explanatory models for the short-term fluctuations that characterize the mean heights from 1910 to 1945. Height cycles similar to

business cycles have been reported.[90] Short-term economic downturns do affect the height of children who live through such episodes, as Bruce Floyd has shown for Taiwan in the 1970s,[91] but the long-term effects are largely eliminated by catch-up growth once the good times return, provided the available nutrition is adequate to support it. Extreme weather effects such as typhoons and floods that occur in Taiwan, which reduce income and food availability, might be a source of some fluctuation.

These research issues and limitations can be addressed using anthropometric techniques, but we need to gather more individual health and related data. There are quantities of personnel health data from the 1950 and 1960s and the colonial periods that can be tapped. These include records of military service personnel since the 1950s, the forces raised by the Japanese military in the 1940s, the Chinese patrolmen in the colonial police force, and the employees of the Taiwan Sugar Company, Taiwan Electric Company and Taiwan Development Company.[92] Additional data would allow us to explore in more depth than we have the interactions between health, welfare, public policy and economic growth in Taiwan during the 20th century.

90 Marco Sunder and Ulrich Woitek, "Boom, bust, and the human body: further evidence on the relationship between height and business cycles," *Economics and Human Biology*, Vol. 3, No. 3 (2005), pp. 450–66.

91 Bruce Floyd, "Evidence of age-related response to short-term environmental variation: time series analysis of cross sectional data from Taiwan, 1969 to 1990," *American Journal of Human Biology*, Vol. 14, No. 1 (2002), pp. 61–73; on temporary reversals in the height of children during the wars, see Tadeusz Bielicki, "Physical growth as a measure of the economic well-being of populations: the twentieth century," in Frank Falkner and James M. Tanner (eds.), *Human Growth: A Comprehensive Treatise*, Vol. 3 (New York: Plenum Press, c1986), pp. 296–98.

92 The authors examined some service records at the military archives in Taipei, but our request for further access was turned down. We have seen evidence of personnel records with height for the other organization, but we have not found any holdings.