



# Female productivity and mortality in early-20th-century Taiwan

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## Abstract

In late-Qing-dynasty Taiwan (1870–1895), female infanticide and general neglect killed over 15% of young girls. During the early years of Japanese rule (1895–1915), female infanticide was almost completely eliminated and the treatment of girls improved. This paper argues that the increase in the willingness to raise daughters was due to an increase in adult female productivity. Under Japanese rule, female seclusion decreased, female labor market participation greatly increased and the custom of foot-binding was ended. These changes increased the expected value of raising a daughter relative to raising a son.

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## 1. Introduction

A population's sex ratio is often a choice variable. In large populations, without sex-specific intervention, the ratio of male to female babies born is generally between 1.04 and 1.06. The ratio quickly declines since young boys have higher death rates than girls, particularly in the first few months of life, but usually the ratio remains greater than 1 throughout childhood. In many human populations, however, boys are preferred to girls and therefore the sex ratio increases above the natural ratio, as in China and India (Sen, 1989; Klasen, 2003). The most direct means of changing the sex ratio is through female infanticide, relative neglect of female

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children or, in modern times, sex-selective abortion.<sup>1</sup> Boys are sometimes allotted a greater portion of a family's food supply than girls, and families may be willing to sacrifice more to obtain high-quality health care for their sons. A relative lack of affection toward daughters may also affect their survival probability. Although lop-sided sex ratios among children are a phenomenon largely limited to Asia, more subtle differences in the sex ratio can be found in the West and may be attributed to these less direct forms of intervention (Klasen, 1998). Klasen and Wink (2002, p. 286) estimate that there were 65–110 million women “missing” in the world population circa 1995.<sup>2</sup> Ninety to 95% of the missing women were Asian.

Although culture is certainly a determinate factor in deciding the relative value of daughters, rational choice plays a role in determining the sex ratio. Skinner (1997, p. 23), for example, shows that in Japan the infanticide decision was affected by the sex of those children already born. Furthermore, the sex ratio within cultures can change rapidly when the cost structure in the society changes. Within a decade, the introduction of sex-selection abortion techniques noticeably increased the sex ratio among children in cultures that have historically favored boys (Coale and Banister, 1994, pp. 475–476). This is due to the fact that in most cultures the cost of abortion, psychic, legal and otherwise, is much lower than the cost of infanticide. Thus, the increase in the sex ratio was not due to a cultural shift in the subjective utility functions of the individuals in the population, but due to a technological change that shifted the costs these individuals faced.

The direct effect of economic conditions on the sex ratio is at present an important, but much more controversial topic. The sex ratio may be influenced by a wealth or income effect. Assuming there is a high psychological cost to infanticide or child neglect, one could reasonably hypothesize that an increase in a society's income or wealth would decrease the practice. An increase in income may lower the opportunity cost of raising a daughter, measured in utility forgone, while leaving unchanged the disutility involved in ending her life. Empirical support for this hypothesis, however, is weak. Chinese officials stated that the poor were driven to female infanticide by poverty, but the rich also practised female infanticide due to dowry concerns (Ho, 1959, p. 60). Lee et al. (1994) show that female infanticide was common among wealthy Qing nobles in the late-18th century, although they argue that it was even more common among the less wealthy nobility. Coale and Banister (1994) show that according to Chinese censuses, the greatest modern drop in the boy–girl sex ratio, rather puzzlingly, occurred among cohorts born in the 1940s, a war-torn era during which Chinese income was generally falling. In general, modern studies concerning “missing daughters” do not find that this phenomenon decreases with economic development (Croll, 2000, pp. 49–50).

This paper tests the hypothesis that the sex ratio is affected by the relative value of male and female labor. This hypothesis has been suggested by Lee (1981, p. 175) who notes that Topley (1975, p. 70) reports that female infanticide was uncommon in the silk-producing areas of Guangdong province where female labor was more highly valued. Lee also suggests that foot-binding lowered the value of girls since it limited their productivity. Using Indian data, Rosenzweig and Schultz (1982) found that the survival rate of boys and girls were conditioned on their earning potential and Murthi et al. (1995) found that while economic development

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<sup>1</sup> Sex-selection infanticides were done immediately after birth. One common method of infanticide practised in China was for the midwife to immediately drown the female baby in a bucket of water.

<sup>2</sup> Oster (forthcoming) argues that the dearth of women in many parts of the world may be due to the prevalence of hepatitis B among mothers. Yet, this was not a problem in Taiwan as can be seen by the relatively quick change in the sex ratio. Before the development of the hepatitis vaccination, it would have been impossible for hepatitis B infections to have decreased so drastically in such a short period of time.

generally has not decreased gender inequality in India, increasing female literacy and labor participation has had a positive effect. Qian (2005) shows that there are more girls now raised in areas of China in which female labor is in demand. Parents who practised female infanticide sometimes justified the practice by saying that females are just another mouth to feed and produce little (Pickering, 1898, pp. 60–61). As Croll (2000) makes clear, however, there are still many doubts as to whether a positive relationship exists between the proportion of daughters raised and female education or work opportunities.

This paper considers data from early-20th-century Taiwan. Japan ruled Taiwan as a colony from 1895 to 1945. After 1905, the Japanese authorities kept careful demographic records recording virtually all births and deaths. They also carried out censuses of the population. This material shows that there was a clear dearth of women in cohorts born before the Japanese takeover in 1895, but that the sex ratio changed quickly so that by 1911, the birth statistics no longer indicate widespread female infanticide and by 1918, death rates for female children had dropped below death rates for male children. Throughout the remaining years of Japanese rule the sex ratio remained low and it did not rise again until the post-World-War-II years under Chinese Kuomintang rule (Francis, 2005). The second section of this paper describes the early-20th-century decline in the sex ratio. The third section uses cross-sectional regressions to argue that a major reason for this change is that, under the Japanese, Taiwanese families no longer felt the need to keep women secluded. Women entered the labor market raising their productivity and the custom of foot-binding began to die out. Thus, daughters were no longer judged to be a burden to the family.

## 2. The change in Taiwan's sex ratio

Taiwan is a society populated largely by Chinese Hokkien and Hakka immigrants from the Asian mainland (Chuang, 1987; Shepherd, 1993). In the early years of settlement, during the 17th- and 18th-century, there was a large sex imbalance in the population since very few females immigrated. Intermarriage with aborigines was common. However, by the 19th century, the population was well established. Perhaps due to the early scarcity of women and the commonness of intermarriage, in some respects Taiwanese women had more rights and perhaps a higher social standing than women in many areas of China.

Population estimates for Taiwan were made before the Japanese took over in 1895 but none of these are accurate or informative enough to produce reliable information on Taiwan's sex ratio. Earlier conditions must be deduced from the first census of Taiwan done by the Japanese authorities in 1905 (Provisional Household Census Bureau, 1907a). This census reports the population by year of birth and sex. Due to the importance of astrology in traditional Chinese

Table 1  
The sex ratio among Taiwanese in 1905

Birth cohort	Actual sex ratio for Taiwanese in 1905
1901–1905	1.082
1896–1900	1.155
1891–1895	1.218
1886–1890	1.256
1881–1885	1.234
1876–1880	1.221

The sex ratio is defined as the number of males per females. Taiwanese data includes only native Taiwanese and is from Provisional Household Census Bureau (1907a) (i.e. the 1905 census).

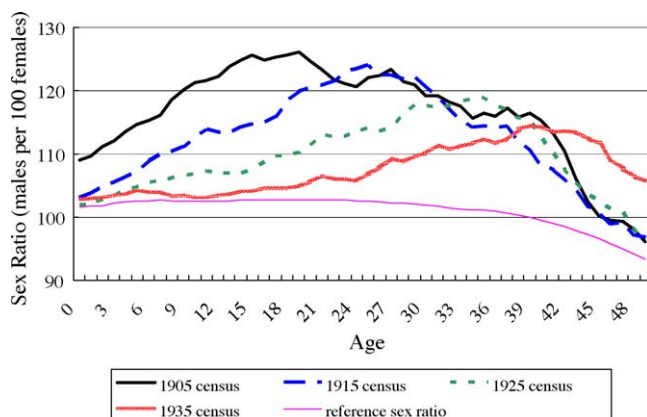


Fig. 1. Change in Taiwan's sex ratio over time (3-year-moving average). Data are from Provisional Household Census Bureau (1907a), Research Office (1917) and Provisional Domestic Census Bureau (1927, 1937).

society, the year of birth of almost all Taiwanese could be determined. Table 1, column 2, shows the sex ratio for 5-year age cohorts in Taiwan as of 1905. For those born during 1886–1890 the ratio of boys to girls was 1.256 declining to 1.082 for those born 1901–1905. The sex ratio in each birth cohort in 1905 was determined first by the sex ratio at birth and second by the death rate differential between the time of birth and 1905. Since, by nature, more males are born than females, with no intervention and equal treatment there will naturally be a small excess of males among young people. To estimate the magnitude of this natural excess, this paper uses the West tables from Coale and Demeny (1983).<sup>3</sup> The life expectancy at birth of Taiwanese males and females as of 1906 when complete vital statistics were first recorded was about 28 and 29 years, respectively (Barclay, 1954, p. 154). If one assumes that there was a maximum of 1.06 male children born per female child and life expectancy prior to 1906 did not exceed 30 years, then the West tables indicate that the ratio of males to females would not naturally have exceeded 1.02 in any of the 5-year cohorts. Thus, somewhat more than one in six females in pre-1895 cohorts were “missing” in 1905. The sex ratio falls quickly for cohorts born after 1895 and for cohorts born after 1900, only about  $(108.2 - 102.0) = 6.2\%$  of the girls are missing.

After 1905, the sex ratio continued to fall. Fig. 1 shows the sex ratio by age as reported in four censuses taken from 1905 to 1935. The sex ratio among children under the age of one continues to fall through 1915. After 1915, the sex ratio for these children is close to the natural level and little improvement is seen, but the total population continues to become increasingly feminine as the younger cohorts with a lower sex ratio grow older and the older cohorts with higher sex ratios die off. In 1905, the sex ratio for the total population was 111.5 and this fell to 103.4 in 1935. The 1905 census figures show an improvement in the sex ratio after the age of 19, but this is due to the relatively higher rates of mortality for adult men compared to adult females in early-20th-century Taiwan (Barclay, 1954, p. 156). This relatively high adult male mortality rate also accounts for the decline in the sex ratio for each adult birth cohort over time.

<sup>3</sup> These tables describe theoretical reference populations which have been derived from real data. The West tables were derived from a broad assortment of country data including that of Taiwan and other countries showing a broadly similar demographic pattern. They are commonly used as a reference when working with Chinese demographic data (Coale and Banister, 1994).

Table 2  
Relative rates of births and child mortality

Cohort	(A) Male births per 100 female births	(B) Percent of females who died before age 5	(C) Percent of males who died before age 5	(D) Female excess death rate (age 0–5 years) [(B) – (C)]	(E) Female excess death rate (age 0–5 years)
1906	109.1	30.5	28.5	2.0	4.1
1907	108.2	29.8	28.0	1.8	3.6
1908	107.3	29.8	29.8	0.0	1.9
1909	106.5	29.0	28.5	0.5	2.9
1910	106.3	28.1	27.6	0.5	3.1
1911	105.1	28.6	28.0	0.6	3.3
1912	104.9	29.2	28.1	1.1	3.5
1913	105.0	29.9	29.2	0.7	3.2
1914	106.0	31.5	31.1	0.4	3.0
1915	106.0	32.8	32.4	0.4	3.1
1916	105.0	31.4	31.1	0.3	3.3
1917	106.4	31.9	31.6	0.3	2.5
1918	106.0	32.0	32.4	–0.4	2.3
1919	105.9	29.7	30.7	–1.0	2.0
1920	106.0	26.9	27.8	–0.9	1.9
1921	105.4	26.8	26.0	–0.8	1.9

Total yearly births and deaths by sex, cohort and age used in this table are shown in [Provisional Household Census Bureau \(1907b\)](#), [Statistics Office \(1909–1919\)](#) and [Research Office \(1920–1923\)](#).

As a reference, [Fig. 1](#) also includes a curve representing the sex ratio that would be found in a hypothetical stable population in which 106 boys were born for every 100 girls and the age-specific death rate was the death rate Taiwan experienced in 1935 after the missing girls problem was largely eliminated.

The Japanese began keeping vital statistics early in their rule and by 1906 these statistics were virtually complete. All Taiwanese were registered and had identification papers. One had to have one's birth recorded to be registered. The only births that went unrecorded were some in which the child died almost immediately. Female babies who were to be killed at birth would presumably not have been reported as having been born ([Barclay, 1954, p. 159](#)). [Table 2](#) shows the reported sex ratio at birth from 1906, when complete statistics were first collected, to 1921. The 1906 figure of 109.1 is higher than the natural rate and shows female infanticide was still practised. By 1911, the statistics show female infanticide was rare.

The end of female infanticide could have been due to two types of factors: (1) it is possible that the cost of female infanticide was rising. [Barclay \(1954, pp. 159–160\)](#) notes that the Japanese authorities did not approve of female infanticide. [Saga \(1990, p. 28\)](#) quotes a man as stating that during this period infanticide was still being practised in some Japanese villages and that the number of live births each year was partly determined by how rigorously the Japanese constable enforced the laws against infanticide. Thus, parents may have refrained from infanticide because it entailed the added cost of possible criminal penalties. (2) It is also possible that the expected value of female children was rising. In economic terms, there was a shift in the demand for daughters so that parents would kill fewer daughters even if the cost of female infanticide had not changed. This would be the case if the burden of raising a daughter was decreasing, due to an increased demand for young female labor or an increase in female productivity.

The most common means of inferring the relative value of children is by observing the relative death rate ([Wolf and Huang, 1980](#); [Coale, 1991](#); [Muhuri and Preston, 1991](#)). It is considered

natural for young male children to die at a greater rate than young female children. However, [Barclay \(1954\)](#) found in 1906, Taiwanese female children died at a greater rate than male children and he attributed this to the relatively high value Chinese placed on male children. If female infanticide was decreasing in Taiwan because of pressure from the local police, then the number of unwanted girls in the population would increase. Since the police could not themselves redistribute a family's food, health care and affection among children, one would expect that the increase in unwanted girls would increase their relative death rate. If, however, female infanticide was decreasing primarily due to the fact that girls were becoming more highly valued, then not only would the rate of infanticide fall, but the care given to living female children would improve and their death rate should fall relative to that of the male children.

In fact, the death rate among female children was falling relative to the death rate of male children between 1906 and 1921 ([Table 2](#)). Therefore, we infer that the dominant cause of the decrease in the sex ratio and the elimination of female infanticide was a rise in the expected value of daughters. [Table 2](#) shows the proportion of children who died before the age of 5, and two measures of the relative death rate. There was no large change in the overall death rate during this period except for a temporary rise in the late 1910s due to a worldwide series of epidemics. Two relative death rates are reported: the column D, “female excess death rate”, shows the difference in the probability of a girl and a boy dying before reaching the age of 5. Column E, the “female excess death rate (1–5 years)”, reports the difference in the probability of a 1-year-old girl and boy dying before reaching the age of 5. This rate is calculated because it is possible that some female infanticides were reported to the Japanese authorities as children who were born and quickly died of natural causes.<sup>4</sup> Therefore, if the improvement in the relative death rate of daughters was due to a decline in reported deaths immediately after birth, the improvement could possibly be directly attributed to the fall in infanticide. As column E shows, such is not the case. The female excess death rate declined both between the 2nd and 5th year of life as well as in the full first 5 years of life. [Barclay \(1954\)](#) made similar calculations. He examined the relative probability of a male and female dying before age 10 and also found a decline in the relative death rate for girls in this period.

An alternative explanation for the relative fall in the death rate for young girls is a change in Taiwanese marriage customs during this period. Many girls, mainly in northern Taiwan, were adopted by prospective parents-in-law. This custom dated from at least the mid-19th century and did not die out until the 1930s. The average age of adoption in this period was 2, but some girls were adopted almost immediately after birth ([Wolf, 1995](#), pp. 170–174). [Wolf and Huang \(1980, pp. 236–241\)](#) show that adopted daughters-in-law had a higher death rate than daughters raised by their mothers. In the early 20th century, this custom was in decline. [Wolf \(1995, p. 225\)](#) suggests that the decline in adoptions caused the fall in the relative female death rate and that the decline in the custom of adopting prospective daughters-in-law was independent of the relative value placed on young girls. To test this, one can compare the fall in the relative female death rate for north and south Taiwan. While adoption was sometimes practised in the south, it was much less common than in the north ([Chuang and Wolf, 1995](#)). [Fig. 2](#) charts the relative decline in the death rate for girls under 5, north and south. The decline in the south, although less steady, was

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<sup>4</sup> In this second calculation, the male and female death rates to be compared are derived by dividing the number of deaths in each cohort that occurred between the first and fifth birthday by the total number of children in the cohort who lived until their first birthday. Then the male probability of death during this period is subtracted from the female probability of death.

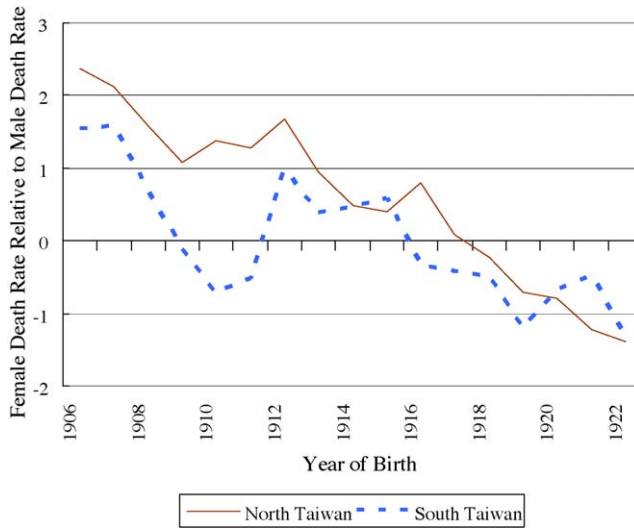


Fig. 2. Female excess death rates: 0–5 years of age.

comparable to that of the north indicating that the decline in adoptions was not the primary cause of the change in the female death rates.

When girls were adopted to be raised as daughter-in-laws, a bride price was often negotiated as a reimbursement to the parents for raising the girl. The bride price therefore depended on the age of the girl. The fact that a market for young girls existed must have alleviated the female infanticide problem. A mother who bore a girl who she could not afford to raise could seek out someone who did have the resources and motivation to raise the girl. Wolf (1980) shows that infanticide was rare in the Haishan, the area of northern Taiwan he studied intensively. He attributes the rarity of infanticide to the “hot market” for daughters-in-law in this area. Daughter-in-law adoptions were less common throughout most regions of the north, however, and the sex ratio throughout the north was much higher than in the Haishan area. Sa (1985, pp. 292–293) reports that in the Taipei area daughters-in-law under 2 years of age could be adopted for free or at a very nominal price. Given the low market value placed on these girls, it seems finding someone willing to raise a baby girl may not always have been easy or even possible.

### 3. Explaining the increase in the demand for daughters

The above section argues that in the two decades following the Japanese takeover of Taiwan, the perceived relative value of female children increased. This section argues that the reason for this change was an increase in the expected economic productivity of daughters. Under Qing rule, female human capital had been under-utilized due to the isolation of wives and daughters to preserve chastity.<sup>5</sup> Under the strict law-and-order regime imposed by the Japanese, the Taiwanese became convinced that females no longer needed to be secluded and female labor participation rates dramatically increased. Furthermore, the end to foot-binding (partly brought about by the increased opportunities for women outside of the home) also increased female productivity.

<sup>5</sup> Bray (1997, pp. 128–150, 271) describes female seclusion as it was generally practised in Qing China, although she argues that the seclusion might not have significantly affected female productivity.

The growing demand for daughters was probably not due to an increase in income or a shift in cultural values. During the early years of Japanese rule, the transportation system was greatly improved, property rights clarified and strengthened, and agriculture became more commercialized. But in this early period, it is unclear whether there was much increase in the average Taiwanese standard of living. Olds (2003) showed that there was an increase in net nutrition among the Taiwanese population, but most attempts to measure consumption per person in the first 25 years of Japanese rule do not show any significant increase (Mizoguchi and Umemura, 1988). There was some cultural change, but not to the degree that would later be experienced. During this period, for instance, few Taiwanese children yet attended the Japanese schools that would later become popular.<sup>6</sup> After 20 years of occupation, the 1915 census reports that less than 2% of the Taiwanese population could speak Japanese (Research Office, 1917).

A comparison of the 1905 and 1915 censuses does show two major changes within the Taiwanese population. Probably the greatest cultural change was the ending of the practice of foot-binding. Foot-binding may have raised the value of a woman in an aesthetic sense, but it decreased her ability to work. Women who were of Hokkien ethnic origin made up 84% of Taiwan's female population and Japanese statistics show that over 90% of Hokkien women born before 1880 had bound feet in 1905. Hakka women (13% of the female population) and aborigines women (3% of the female population) bound their feet only rarely. For cohorts born after 1880, there was a decline in foot-binding, but in 1905 about two-thirds of Hokkien girls were still subject to foot-binding. Partly due to Japanese pressure, foot-binding continued to decrease after 1905, and in 1915 the Japanese authorities outlawed the practice. The 1915 census was conducted 6 months after the practice was banned. This census, and the 1920 census shows that the custom of binding young girls' feet did end and many women unbound their feet. The unbinding of feet was most common for young women whose feet had not yet been completely deformed. In the 15–19 age group 80% of bound-footed women had released their bindings by October 1915. Although the Japanese originally pressed older women to unbind, this was generally found impractical. Of those bound-footed women over the age of 50, only 29% released their bindings.<sup>7</sup>

The second major change was in the female labor market. The two Japanese censuses recorded the number of people in each area who worked and broke the data into three types of categories. One categorization system was based on the industry in which one worked. A second categorization system divided labor into what could roughly be labeled “full-time” and “part-time” labor. “Part-time” labor could be labor done by someone the Japanese judged to not be fully employed or it could be moonlighting done by a laborer who was also categorized as having a full-time job. A third categorization system divided labor into four types based on the employment relation. These categories consisted of (1) the self-employed and employers, (2) unpaid family laborers, (3) wage laborers, and (4) government workers. In 1905 and 1915, few Taiwanese female laborers were in category (4). In Table 3, I add the few government

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<sup>6</sup> In 1910, only 761 Taiwanese girls, age 8–12, were attending Japanese schools. Their number increased greatly to 9627 in 1917, but this was still less than 5% of girls in this age group (Statistics Office, 1913; Academic Affairs Section, 1919).

<sup>7</sup> One problem with these census statistics is that they do not differentiate degrees of binding. These statistics show that in the late-19th-century Taiwan, binding feet was almost universal among Hokkien women, but many of the poorer women who had to work probably had lightly bound “cucumber feet”. Tightly bound “three-inch lily feet” were probably only found in upper-class households.



Table 3  
Labor participation rates

Labor category	(A) Full-time			(B) Part-time			=(A) + 0.5(B) equiv. labor		
	1905	1915	Annual change	1905	1915	Annual change	1905	1915	Annual change
Female labor (age 10 and over)									
Total	29.6	40.5	3.2%	25.6	17.6	−3.7%	42.4	49.3	1.5%
Employer and self-employed	2.0	2.8	3.4%	22.3	15.3	−3.7%	13.2	10.5	−2.3%
Unpaid family labor	18.9	21.5	1.3%	0.0	0.0	0.0%	18.9	21.5	1.3%
Wage labor, etc.	8.7	16.2	6.4%	3.3	2.2	−4.0%	10.4	17.3	5.2%
Male labor (age 10 and over)									
Total	89.1	87.2	−0.2%	12.6	5.1	−8.6%	95.4	89.8	−0.6%
Employer and self-employed	37.6	34.5	−0.9%	6.7	3.1	−7.4%	41.5	36.1	−1.4%
Unpaid family labor	6.4	9.4	3.9%	0.0	0.0	0.0%	6.4	9.4	3.9%
Wage labor, etc.	45.2	43.3	−0.4%	5.9	2.0	−10.3%	48.2	44.3	0.8%
Female labor (aged 15–24)									
Total	39.0	53.3	3.2%	18.9	11.4	−4.9%	48.5	59	2.0%
Employer and self-employed	0.7	1.5	7.9%	13.7	7.1	−6.4%	7.6	5.1	−3.9%
Unpaid family labor	27.3	28.2	0.3%	0.0	0.0	0.0%	27.3	28.2	0.3%
Wage labor, etc.	11.0	23.6	7.9%	5.2	4.3	−1.9%	13.6	25.2	6.4%
Male labor (aged 15–24)									
Total	94.1	93.0	−0.1%	9.5	2.6	−12.2%	98.9	94.3	−0.5%
Employer and self-employed	16.4	14.0	−1.6%	2.1	0.8	−9.1%	17.5	14.4	−1.9%
Unpaid family labor	7.9	12.5	4.7%	0.0	0.0	0.0%	7.9	12.5	4.7%
Wage labor, etc.	69.8	66.5	−0.5%	7.4	1.8	−13.2%	73.5	67.4	−0.9%

From *Provisional Household Census Bureau (1907a)* and *Research Office (1917)*, Tables 5 and 7. The number in parentheses is the percentage change per year, 1905–1915.

workers to the wage labor category. In my regressions, I combine categories (1), (3) and (4) into one “commercial labor” category.

*Takekoshi (1907)* argued that one of the problems hindering Taiwan’s economic development was the fact that women were kept at home and did little labor. Almost all Taiwanese women did work in the home. Textile production within the household was generally the most common occupation of bound-footed Chinese women. But the Japanese did not count this as labor and judging from a comparison of the daily wages a woman could earn weaving hats (a popular indoor occupation of bound-footed women in this period) and the wage for heavy female agricultural labor, heavy outdoor labor was probably twice as productive. *Gates (2001, 2004)* shows that while work by bound-footed women was certainly important to the Chinese economy, women with natural feet were never assigned jobs bound-footed women did. Women with natural feet invariably did heavy labor. In Taiwan, the women who did field work usually assisted their father or husband on the family farm. Important exceptions were the natural-footed Hakka women who were often hired out to do heavy labor, such as carrying heavy loads as a porter, and the women who picked tea leaves (*Campbell, 1915*, p. 249; *Takekoshi, 1907*, p. 202). Generally, the census only considers unpaid family labor to be *real* employment if it was done outside the house. Raising pigs and chickens was the most common form of part-time work. Full-time female laborers were usually field labor. During the first few violent years of Japanese rule the large majority of women probably remained at home, but by 1905 the census shows that women were working outside the house for wages and their numbers increased greatly over the next 10 years.

Table 3 shows how the male and female labor forces changed from 1905 to 1915. Most workers in all the categories shown were working in agriculture. There were no qualitative differences between the trends in the agricultural and non-agricultural labor force so I do not report separate results for these categories. Two sets of figures are presented for both males and females. First is the labor force participation rate for all people over 10 years of age. Second is the labor participation rate for young adult workers 15–24 years old. This includes the peak ages for female participation in the labor force. This age group was probably the one parents would most likely notice when evaluating the costs and benefits of raising a daughter.

Both sets of figures show that male labor force participation was actually declining and that men were increasingly likely to work at home as unpaid family labor rather than sell their labor on the market. Women, on the other hand, were entering the work force in greater numbers and this was driven primarily by increases in wage labor. The number of full-time female wage laborers (adjusted for population change) was increasing by 6.4% per year and for young adults the rate of increase was 7.9% per year. Adding part-time labor into the calculation, as done in the last two columns of the table, does little to change the results. By 1915, almost a quarter of the 15–24-year-old female population was doing full-time wage labor.

The large increase in the commercialization of the female labor force was important for two reasons. First, women who were inefficiently utilized at home could find employment elsewhere. Second, it shows that many families felt women were safe enough outside the home to enter employment relations. This being the case, women were also more likely to be doing other productive work outside the house. When considering female labor commercialization as a variable affecting the degree to which families were willing to expend resources to raise a girl, one should keep in mind that, to some degree, this variable is an instrumental variable measuring the degree to which women could participate in the economy generally.

The concurrent rise in commercial female labor and the willingness to raise daughters suggests the hypothesis that the movement of women out of seclusion into the labor market was noted by parents and this increased their expectations for their daughters as producers. This production would benefit the family directly as long as the daughter was unmarried and indirectly insofar as it would be cheaper to acquire an appropriate husband for the girl. The fact that parents were now under less pressure to bind their daughters' feet may have also contributed to an increase in the expected value of daughters. Baby girls were thus less likely to be viewed as a burden.

Two cross-sectional regressions were run in order to test this hypothesis. In the 1905 census report, the number of male and female children under 5, basic employment data and foot-binding data is given for each of Taiwan's 20 counties (*ting*). In the 1915 census report, this information is given for the 12 newly created counties into which the old 20 counties had been consolidated. In both censuses, figures are given for Japanese, Taiwanese and foreigners (mainly citizens of China). The regressions pertain only to the Taiwanese data.

For each census year, ordinary least-squares regressions are run on the county-level data. The descriptive statistics for these regressions are reported in Table 4. The dependent variable is the sex ratio of children under 5 years of age in the county. There are four independent variables: (1) the percentage of women doing full-time commercial labor, (2) the percentage of women doing unpaid family labor, (3) the proportion of 10–14-year-old girls who have bound their feet and (4) the percentage of full-time male laborers working as farmers. This last variable is used to control for possible differences between town and country. In fact, the regressions do not show any significant differences between these two types of areas. In one specification of the regressions (model 1), the labor force participation variables are left out since they are strongly correlated

Table 4  
Descriptive statistics for the county-level sex-ratio regressions

Variable	1905	1915
Sex ratio of children under 5	107.6 (97.9–116.7)	103.2 (98.2–106.3)
Female commercial labor force participation rate (%)	14.6 (2.5–52.8)	26.9 (6.7–71.2)
Female unpaid family labor participation rate (%)	19.7 (2.7–38.0)	19.7 (9.0–40.8)
Agriculture (%)	74.2 (59.3–90)	75.1 (57.5–89.8)
Girls with bound feet (%)	50.3 (0.4–95.2)	24.3 (0.1–90.0)

All numbers except the sex ratio are percentages. All data are derived from *Provisional Household Census Bureau (1907a)* and *Research Office (1917)* (the 1905 and 1915 censuses). The top figure is the mean value. The lower figures in parentheses show the range of values across counties.

with foot-binding. As for foot-binding, I focus on the 10–14-year-olds because what was happening to young females best reflects the expectation parents would have for their daughters under 5 years of age. There was one younger age group reported, the under-10-years-of-age category, but this contained many girls whose feet were to be bound, but the binding process had not yet begun. By 10 years of age, girls whose feet would have been bound had already begun the process. It would have been preferable to use labor participation data for only younger women, but this was not possible at the county level. When one runs similar regressions using only one variable for total female labor participation which combines family and commercial labor, the primary change in the results is that the *t*-statistic for labor participation in the 1905 regression is significant only at the 10% level. As argued above, unpaid family labor may make less efficient use of female human capital. The unpaid family labor data may also be unreliable. The difference between family workers and non-workers would often have been a matter of degree and may have been arbitrarily defined by the census workers.

The results of the regressions are shown in *Table 5*. The 1905 model 2 regression shows that commercial labor is a good predictor of the sex ratio. A 10% increase in female wage labor in an area would lead to a decrease of 1.5 boys per 100 girls. Areas in which binding young girls feet was less common also show a more balanced sex ratio; a 10% increase in female wage labor in an area would lead to a decrease of 0.9 boys per 100 girls. Less rural areas probably had lower sex ratios, however, the effect is not statistically significant.

By 1915 the effect of the “bound” variables is no longer statistically significant. This is, in fact, what the hypothesis would predict. By the early 1910s, it was becoming clear that the foot-binding practice would not be allowed to continue and thus the percentage of older girls who had undergone foot-binding was no longer important. People could be fairly certain that none of the girls now being born would have their feet bound in the future. Thus together the two regressions show that the strong positive coefficient for the foot-binding variable in 1905 does not just reflect unchanging cultural differences between the bound Hokkien, on the one hand, and natural-footed Hakkas and aborigines, on the other. Once the custom of foot-binding was ended, the behavior of the two groups converged.<sup>8</sup> The commercial labor participation

<sup>8</sup> Superficially, it may seem irrational that parents would bind the feet of their daughters although they were more willing to raise daughters with unbound feet. This behavior can be rationalized in an economic model if one assumes individuals are subject to social pressures to conform. The bound-foot equilibrium would be an inferior local equilibrium. Instead of using foot-binding as an independent variable, one can use the proportion of Hokkien in the population, but the multicollinearity is too strong to use both variables simultaneously. Using the Hokkien variable gives similar results to the regression shown: the Hokkien variable is important and statistically significant in 1905 and not so in 1915.

Table 5  
Predictors of the sex ratio of children under 5 (county-level)

Independent variables	1905		1915	
	Model 1	Model 2	Model 1	Model 2
Intercept	98.76**	92.61**	101.4**	96.14**
Female commercial labor participation rate		-0.15*		-0.09**
Female unpaid family labor participation rate		0.03		-0.06
Agriculture	0.06	0.16	0.01	0.13
Bound feet	0.09**	0.09**	0.05	0.03
Adj. <i>R</i> -squared	0.43	0.58	0.24	0.70
<i>F</i> value	8.19**	7.61**	2.61	6.76*
Dependent variable mean	107.61	107.61	103.17	103.17
Number of observations	20	20	11	11

All data is from Provisional Household Census Bureau (1907a) and Research Office (1917) (the 1905 and 1915 censuses). Values in parentheses are standard errors.

\* Indicates significance at the 5% level.

\*\* Indicates significance at the 1% level.

rate variable still remains statistically significant and important although its estimated effect has decreased. To put the commercial labor effect in proper perspective, consider that the percentage of females doing commercial labor in 1915 rose from about 10% on the northern tip of the island, in Taipei and Ilan, to about 70% in Hualien and Taidong in the eastern part of the island.<sup>9</sup> This variation in labor force participation rate would mean that model 2 would predict that the boy–girl sex ratio would be 5.4% lower in the east ( $60^* - 0.09 = -5.4$ ) and, in fact, a 4.8% difference was observed (a ratio of 105.1 boys per 100 girls in the north versus 100.3 boys per 100 girls in the east).<sup>10</sup>

<sup>9</sup> Many of the women in Hualien and Taidong were aborigines who were used as hired labor by Chinese and Japanese.

<sup>10</sup> Among the 20 old counties in 1905 and the 12 new counties in 1915, there was one unusual county – the Pescadore Islands – an archipelago lying in the Taiwan Straits whose population traditionally relied on fishing and raising peanuts and sweet potatoes. The women in these islands did much more labor outside the house than the average woman on the island of Taiwan. In 1905, slightly over 50% of Pescadore women worked doing commercial labor (compared with slightly less than 10% on Taiwan) and there were only 106.8 boys per 100 girls compared with 108.9 on Taiwan. The 1905 situation on the Pescadores thus fits the 1905 regression predictions reasonably well. However the Japanese linked the Pescadores to Taiwan by steamship and in 1908, the Japanese began enlarging what was to become Kaohsiung harbor relying heavily on migrant male laborers from the Pescadores (Yin, 1981, pp. 322–324). Pescadore male migrant labor also became important for large Japanese-owned sugar plantations (Ka, 1995, p. 103). In 1915 almost 25% of Pescadore men aged 18–40 were absent from the island when the census was taken. This caused a major change in the Pescadore economy. While on the main island of Taiwan, the new conditions imposed by the Japanese regime raised the value of female labor relative to male labor by encouraging the commercialization of female labor, in the Pescadores it was the value of male labor which increased relative to female labor. The result was that while the sex ratio for children was falling from 108.9 in 1905 to 103.6 in 1915 all across the island of Taiwan, in the Pescadores, the sex ratio jumped from 106.8 boys per 100 girls in 1905 to 110.8 boys per 100 girls in 1915. This increase in the sex ratio is further evidence confirming the hypothesis that the relative value of female labor has a strong effect on the sex ratio, but the increase in the value of male labor among the Pescadore population cannot be observed from the census figures, so the outlying Pescadore county observation was eliminated from the 1915 regression. If the observation is included with a dummy variable for the Pescadores, then the dummy variable for the model 2 regression would have a value of 10.5 and a *t*-statistic of 7.2. This means that there were roughly 10% fewer girls raised on the island than the census statistics would predict. If the observation is included without a dummy variable than nothing but the intercept term is statistically significant.

Table 6  
Predictors of the sex ratio of children under 5 (township-level, 1915)

Independent variables	Ratio of boys to 100 girls	
Intercept	57.63**	105.77**
Female labor participation rate	-0.05*	-0.08**
Agriculture	0.00	-0.01
Bound	0.02	0.00
County dummy variables	No	Yes
Adj. <i>R</i> -squared	0.06	0.07
<i>F</i> value	5.09**	2.14*
Number of observations	211	211

There are 211 observations since some of the 198 “townships” were divided between counties, and therefore were divided into two or three portions. All data are from [Research Office \(1917\)](#) (the 1915 census). Values in parentheses are standard errors. Among the county-level dummy variables in the second regression, Taipei County was the reference county. None of the *t* values of the 11 county-level dummy variables approached significance. To save space, they are not shown.

\* Significance at the 5% level.

\*\* Significance at the 1% level.

The tables compiled from the 1905 census do not include labor participation or foot-binding statistics at the “township” level (Taiwan’s 109 *bao*, 83 *li*, five *xiang* and one *shi* into which the counties were divided). However, the 1915 census data for the townships include figures which allow us to calculate (1) the sex ratio of children under 5 and the total number of children under 5, (2) the percentage of total female laborers among female inhabitants over 10 years of age (the overall female labor force participation rate), (3) the proportion of male full-time laborers in the primary agricultural sector, and (4) the proportion of women over 10 with bound or previously bound feet. A regression similar to the county-level regressions thus can be run. The only differences are that at the township-level, labor cannot be divided into unpaid family and commercial labor and foot-binding data is only available for women in general rather than by age group. The township-level regressions were originally run as OLS regressions but many of the 198 townships were quite small and, unlike the county-level regressions, a Goldfeld–Quandt tests showed significant heteroskedasticity conditioned on the number of children in each township.<sup>11</sup> Further testing showed that the variance was roughly proportional to the number of children in each township so this was used to weight the regressions. [Table 6](#) shows the results of the township-level regressions. The second regression in the table includes a set of dummy variables to control for county. Since none of these dummy variables approach statistical significance, they are not reported. The regression results show that the negative correlation between female labor force participation and the ratio of boys to girls is evident not only across counties but across townships within counties as well. The coefficients for the female labor force participation variable show that a township in which female labor participation was 10% higher than elsewhere would be predicted to have 0.5–0.8 fewer male children per 100 females.

From 1905 to 1915, the sex ratio for children under 5 fell from 108.2 boys per 100 girls to 103.8, a drop of a little over 4%. The cross-sectional coefficients generated by the regression on 1905 county-level data predict a decrease of roughly 3.5% ([Table 5](#)). The decline in foot-binding leads to a predicted 2.5% drop and the increase in commercial labor leads to a predicted 1.4% decline in the sex ratio.

<sup>11</sup> The GQ statistics are 10.57 and 10.25.

#### 4. Conclusion

Early-20th-century Taiwan is unique in that it is the only well-documented example of such a rapid change in the sex ratio of a society's children. Coale and Banister (1994) show that China went through a similarly rapid change in the 1940s, but there is little reliable demographic data for China during that period. The change in China can only be observed in the population figures of later censuses.<sup>12</sup>

This study argues that the Taiwanese data confirms that the unbalanced sex ratios typical of many traditional Chinese populations can be explained by parents' choice. In traditional Chinese society, the costs of female seclusion and foot-binding meant that raising daughters was a heavy burden for parents to bear. Once these customs were abandoned, parents quickly adapted to the new conditions and became more willing to raise daughters.<sup>13</sup>

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<sup>12</sup> Oster (forthcoming) suggests that the Chinese census data showing the rapid change in the sex ratio may not be reliable. But the rapid change in the sex ratio shown by the much higher-quality Taiwan data suggests that the Chinese data are credible. A rapid fall in the Chinese sex ratio would indicate that historically China's "missing girls" problem has not been due to hepatitis B (see endnote 2). The timing of the fall in the Chinese sex ratio is curious since the 1940s was a period of war, disorder and economic recession very different than the conditions under which the sex ratio declined in Taiwan. It may be that the relative expected value of female labor in China was rising during this period because of the wartime "tax" on males. In China, the breakdown in social order mainly threatened sons since they could be taken away by warlords and governments and turned into soldiers who often never returned home. This hypothesis is supported by the fact that after peace was restored in 1949, the sex ratio once again started to rise and only fell back again when the communists' collectivist policies again lowered the value of sons as producers for the family.

<sup>13</sup> Other cultures, most notably many Middle Eastern cultures, have secluded women to at least the same extent as the Chinese, and yet have not shown an unnatural dearth of females (Croll, 2000). Female labor productivity is not the only factor determining the relative value of sons and daughters. Since the number of females in a society is a constraint on the number of children that may be born, females should have a high value in a society where bearing children is highly valued. Early Taiwanese data does not offer any figures that would allow us to estimate the perceived marginal value of additional children. However, Lavelly and Wong (1998) and Lee and Feng (1999), show that in Qing-dynasty China, of which Taiwan was originally a part, Chinese generally tried to limit the number of children they had to raise. Therefore, the marginal value of additional children would not have been high and this would have also limited the reproductive value of females.

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