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Nora Cheng
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Nora Cheng
National Taiwan University

Tsong-Min Wu
National Taiwan University

Elliott Fan
National Taiwan University and IZA

ABSTRACT

Sweet Unbinding: Sugarcane Cultivation and the Demise of Foot-Binding[*]

This study investigates the sudden disappearance of foot-binding, a costly custom practiced for centuries in China and Taiwan prior to its demise. We estimate the numbers of women who unbound their feet in response to the rapid growth of the sugarcane cultivation in Taiwan in the early 20th century, growth which boosted the demand for female labor relative to male labor. Cross-township variations based upon multiple history datasets indicate that cane cultivation had a strong and robust effect on unbinding. The IV estimations utilizing cane railroads – lines built exclusively for cane transportation – support a causal interpretation of the estimated effect. This finding implies that a change in gender-specific labor productivity can help eliminate costly norms against women, and it also provides additional support for the argument that foot-binding was incentivized by economic motives. We also present evidence lending credit for the conventional hypothesis of foot-binding as a form of marriage competition.

JEL Classification:	J16, N35, Z13
Keywords:	foot-binding, social norms, gender roles, sugarcane

Corresponding author:
Elliott Fan
Department of Economics
National Taiwan University
No.1 Roosevelt Road
Section 4, Taipei 10617
Taiwan
E-mail: elliottfan@ntu.edu.tw

1. Introduction

People's interactions with others around them, as well as their decisions on education, employment, marriage and fertility, are guided by social norms. Several studies have found that for women, some gender norms are so deep-rooted in society that even females studying in top-notch US universities (Bursztyn, Fujiwara and Pallais 2017), those who are medical doctors in the US (Sarsons 2019) and those who live in societies with leading levels of gender equality (Kleven, Landais and Søgaard 2019) are not exempt from their influence.[1] These findings suggest that our behaviors may be governed by gender-specific beliefs and values in much more profound ways than generally perceived, which therefore calls for further research to advance our understanding.

An important area in which progress has been made by researchers over recent years is the research undertaken into the origins of gender norms, where a number of studies have focused on various factors, such as traditional forms of farming or husbandry (Hansen, Jensen and Skovsgaard 2015; Becker 2020), politico-economic regimes (Campa and Serafinelli 2019; Booth, Fan, Meng and Zhang 2019), the pre-industrial variations in gender-specific productivity (Alesina, Giuliano, and Nunn

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[1] Based upon field experiments on students in an MBA program in the US, Bursztyn et al. (2017) found that single female students reported lower desired salaries and a willingness to travel and work for long hours when it was expected that their male classmates would see their preferences, whereas there were no such concessions in the responses of male or married female students. Sarsons (2019) found that when referring a patient to a surgeon, physicians in the US evaluated the performance of a surgeon differently depending largely on the gender of the surgeon; the death of a patient led to physicians being more pessimistic about the ability of a female surgeon as compared to that of a male surgeon, leading to fewer referrals to female surgeons. Using Danish data, Kleven et al. (2019) found that after their first birth, mothers tended to experience reductions of around 20 percent in their participation rate, wage rate and the number of hours worked, whilst such 'child penalties' were not experienced by fathers.

2013; BenYishay, Grosjean, and Vecci 2017; Brown and Satterthwaite-Phillips 2018), and historical events leading to substantial changes in local gender ratios (Fernández, Fogli, and Olivetti 2004; Grosjean and Khattar 2019; Teso 2019). A common feature of the gender norms identified in these studies is that once formed, a norm tends to persist, even after the original conditions giving rise to it have changed. Such strong persistence helps explain why some ancient norms have survived major industrial and social changes and remained popular in modern societies. This also raises questions relating to the ways in which existing gender norms may undergo substantial change in the near future, and in particular, when certain harmful norms, such as the practice of 'female genital mutilation' (FGM) could be brought to an end.

Our primary aim in this study is to contribute causal evidence to the extant literature by examining the demise of a prominent gender-specific norm behavior, the practice of foot-binding, an ancient custom carried out in China and Taiwan which involved the tight wrapping of girls' feet at a very young age to permanently modify their shape and size. The disappearance of the practice of foot-binding in Taiwan provides a particularly interesting setting for the goals of this study for the following two reasons. Firstly, foot-binding was widely practiced in both China and Taiwan for centuries prior to its demise; however, in contrast to China, the practice disappeared quite suddenly in Taiwan. Over a period of just 15 years, from 1905 to 1920, the proportion of adult females with bound feet in Taiwan declined from around 68

percent to just 11 percent.[2] The experience of such an abrupt ending to the practice of foot-binding in Taiwan may serve as a valuable template for the elimination of other harmful gender norms, such as FGM. Secondly, the decade from 1905 to 1915 also witnessed a booming sugar industry in Taiwan, providing a unique opportunity to estimate the extent to which women stopped binding their feet in response to the surge in the demand for female labor brought about by cane cultivation. The estimated effect may help to shed some light on the role played by economic incentives in bringing a harmful norm to an end.

Our investigation begins with the analysis of historical administrative records to document the demise of foot-binding in Taiwan. From the start of the Japanese occupation of Taiwan in 1895, given that they considered foot-binding to be a corrupt custom, the colonial government launched a series of public campaigns and sponsored the social movements led by local elites in the hope of eradicating it without having to rely on edicts banning the practice. However, prior to 1905, whilst this bottom-up approach had been quite effective in discouraging parents from binding the feet of their young girls, it had failed to encourage bound women to unbind their feet, a process which would involve the removal of the foot wrapping followed by a period of rehabilitation. Although most women were able to partially restore their mobility and physical strength after unbinding, they had to endure significant pain during the process. For individuals acting rationally, unbinding would be undertaken if and only if the disutility of the procedure was outweighed

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[2] Although the demise of foot-binding started earlier in China, it took a much longer period of time to complete (see Section 2.1 for details).

by the benefit. It was not until 1905-1915, a period which coincided with the timing of the sugar boom in Taiwan, that a large wave of unbinding occurred.

We therefore go on to develop a research design that will enable us to estimate the effects of cane cultivation on this wave of unbinding. The development of the sugar industry and cane farming was engineered and sponsored by the Japanese colonial government which ruled Taiwan from 1895 to 1945. As compared to rice farming, cane cultivation brought about a much greater demand for female workers, and as a result, the sugar boom led to a greater proportion of female labor being induced into agricultural production. This raised the opportunity cost of practicing foot-binding since it impeded the physical strength and mobility.

Our analysis in this study estimates the extent to which females in townships which experienced higher growth in cane cultivation between 1905 and 1915 were more likely to unbind their feet over the same period. Given that farmers adopted cane cultivation voluntarily, using the OLS method to estimate the effect of cane cultivation on unbinding raises a concern about selection. To address the concern, we instrument cane cultivation using a special type of railroad – cane railroad – as the instrumental variable (IV). Unlike ordinary railroads which transported passengers and various types of freight, the privately-owned cane railroads, built by the sugar corporations, were used exclusively for the transportation of cane. Since the cane railroads were unrelated to the transportation of passengers or other types of freight, this implies that foot-binding would only have been affected by the rise in cane cultivation. This feature lends support to the cane railroad as a valid IV, highlighting its advantage over ordinary railroads that have been shown to have

increased real income (Keller and Shiue 2008; Donaldson and Hornbeck 2016; Donaldson 2018) and enhanced factors mobility (Sequeira, Nunn, and Qian 2020; Banerjee, Duflo, and Qian 2020) in various countries. Both are alternative channels that may had direct impacts on unbinding, thereby violating the exclusion restriction requirement. Using cane railroads as the IV alleviates this threat.

We find strong and robust effects of cane cultivation, with a one standard deviation increase in the proportion of land used for cane cultivation leading to: (i) a significant increase of 18.9 percentage points in unbound women; and (ii) a significant decrease of 12.8 percentage points in women remaining bound in 1915, controlling for their initial foot-binding status in 1905. These substantial estimates confirm the importance of economic incentives in ending norms harmful for women.

To further explore the motives behind foot-binding, we also evaluate the conventional hypothesis which posits that foot-binding was a means of marriage competition: given that men in the marriage market had a preference for women with bound feet, foot-binding was considered to be a form of investment made by parents to enhance the marital prospects of their daughters.[3] In order to test this hypothesis, we examine the pattern of intermarriages between the Hoklo and Hakka populations, the two largest ethnic groups in Taiwan who adhered to completely different foot-binding norms. Hoklo people willingly followed the practice of foot-

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[3] Whilst Levy (1966) considered foot-binding to be a fetish practice which catered to male preferences, Bourdieu (1986) subsequently argued that since women with bound feet were considered to be more attractive, parents regarded foot-binding as an investment in the 'cultural capital' of their daughters. Young (2015) suggested that foot-binding was the equilibrium of a game in which the parents of boys favored foot-bound girls within the marriage market, and as such, the girls' parents were reluctant to renounce the practice since they feared that their daughters would fail to find good husbands.

binding, whereas Hakka women shunned the practice, preferring instead to keep their feet natural. Indeed, the reluctance of the Hakka to bind their feet is found to have persisted even when they lived in communities with large Hoklo populations. Since intermarriages between the two ethnic groups were common, and Hakka males were not seeking foot-bound brides, if the marriage competition hypothesis holds, then an increase in the Hakka population within a neighborhood would imply a lower demand for foot-bound brides within the local marriage market, thereby deterring foot-binding among Hoklo women. Taking advantage of this implication, we carry out our analysis by running a regression (at the village/district level) of the proportion of ever-bound women among Hoklo women on the proportion of Hakka in the village/district population. We find that the foot-binding rate among Hoklo women was negatively correlated with the proportion of Hakka within the village/district population. Since our subsequent robustness examinations suggest that the correlation was not driven by peer effects, these results provide support for the marriage competition hypothesis.

The findings of the present study may contribute to a broader understanding of the motives behind the practice of foot-binding. Although the focus in our study is specifically on the demise of the practice of foot-binding, our findings nevertheless complement prior studies in which economic incentives were proposed as being the driving force behind the *origin* of foot-binding (Blake 1994; Gates 2001; Bossen et al. 2011; Brown and Satterthwaite-Phillips 2018). The argument pursued in these studies was that by reducing the mobility of women, foot-binding increased their productivity in sedentary household work, such as handcrafting, cotton

spinning and weaving, thereby providing an economic incentive for parents to bind the feet of their female children.[4] However, statistical evidence on the economic motives for foot-binding remains scarce.[5] To the best of our knowledge, our study is the first to provide causal evidence of such economic motives. Furthermore, our test on the marriage incentive for foot-binding contributes valuable evidence to the related literature.[6]

Our study also adds to the extant related literature by providing evidence on the ways in which any changes in gender-specific labor productivity or employment opportunities can affect gender roles (Alesina, Giuliano, Nunn 2013; Teso 2019;

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[4] Examples include Blake (1994), Gates (2001), Bossen, Wang, Brown and Gates et al. (2011) and Brown and Satterthwaite-Phillips (2018). Blake (1994) pointed out that as opposed to completely eliminating the ability of women to engage in production, foot-binding actually diverted women's labor activities towards home production. Similarly, Gates (2001) argued that by reducing their mobility, foot-binding increased young women's productivity in sedentary light work within the household. This merit, as argued by Bossen et al. (2011), may have been exemplified by the development of the textile industry in rural China during the Ming and Qing Dynasties, providing a potential explanation for the increased popularity of foot-binding in rural areas.

[5] Some studies have shown a geographical correlation between the prevalence of foot-binding and the development of the textile or handcraft industries in China (see, for example, Bossen et al. 2011; Fan and Wu 2020). However, the only study employing rigorous econometric analysis was that of Brown and Satterthwaite-Phillips (2018), who analysed a sample of 7,683 individuals collected from a field survey in China and found that women with experience of foot-binding were more likely to have participated in home handicraft production for commercial purposes, a correlation which provides support for the 'economic motive' hypothesis. Following their development of a theory on foot-binding, Fan and Wu (2020) carried out a test of such economic motives; however, since their empirical work was based on only a small sample retrieved from an archival dataset reporting respondents' retrospective, unformatted descriptions of the local prevalence of foot-binding, quantitative analysis was difficult.

[6] Other studies have provided evidence linking foot-binding to 'marriageability'. Using the data from Taiwan's Census of 1915, Shepherd (2018) showed that in 1915, among Hoklo females (the majority ethnic group in Taiwan), the mean age at first marriage for those with no experience of foot-binding was 20.4 years, much higher than that for previously-bound females (18.6 years), thereby providing a clear indicator of better marriage prospects for those with experience of binding. Brown, Bossen, Gates and Satterthwaite-Phillips (2012) collected a sample of around 5,000 people from a retrospective survey carried out in Sichuan, China, and found that the previously-bound women were more likely (34% versus 30%) to marry upward into an economically better-off family than women with no experience of foot-binding, and less likely (20% versus 23%) to marry downward into an economically worse-off family. Using household registration data in Taiwan during the colonial era, Wolf and Huang (1980) revealed a lower foot-binding rate for adopted daughters (78%) than that for biological daughters (85%), possibly because parents were more reluctant to invest in the marriageability of adopted daughters.

BenYishay, Grosjean, and Vecci 2017), female decision power (Majlesi 2016), gender-based violence (Aizer 2010; Bulte and Lensink 2019), sex ratio (Qian 2008; Carranza 2014; Xue 2016), restrictions on women's sexuality (Becker 2019), female's education (Jensen 2012) and health (Jensen 2012; Majlesi 2016). The design of our test on the economic motive for unbinding was inspired by Qian (2008), who used crop production favoring gender-specific labor as a source of the variations in gender-specific income. Qian showed that tea cultivation, which favored female labor, raised female income and their within-household bargaining power in rural China. This in turn improved the survival rates for young girls. Our study focuses on another important crop, sugarcane, the cultivation of which warranted much higher female labor inputs than that required for rice cultivation. Our findings agree with those of Qian (2008), among others, on the importance of female labor productivity in determining the well-being for females and the shaping of gender norms.

Our study also relates to other recent studies assessing the role played by a railroad network in the early stage of a country's economic development, with the primary findings of these studies suggesting that railroad network construction had the effect of significantly altering the industrial landscape by integrating markets and facilitating factor mobility (Donaldson and Hornbeck 2016; Donaldson 2018; Banerjee, Duflo, and Qian 2020). We extend the scope of this literature to privately own railroads through our exploration of the cane railroads in Taiwan. Consistent with the existing evidence, we find that the railroad network built by the entrepreneurs gave rise to a leading industry in the early stage of modern economic

development of Taiwan.

The remainder of this paper is organized as follows. Descriptions of the historical background on foot-binding, the sugar industry and the railroad network in Taiwan are provided in Section 2, followed in Section 3 by a description of the conceptual framework of this study. Section 4 provides explanations of the data and the key variables used in this study, followed in Section 5 by our examinations of the economic motive and marriage competition motive for foot-binding. Finally, the conclusions drawn from this study are presented in Section 6.

2. Background

2.1. Foot-binding and its demise in Taiwan

The practice of foot-binding involved the tight wrapping of young girls' feet, usually starting at the age of 5 or 6 years, and lasting for up to 10 years. It was a painful process that permanently deformed feet, jeopardizing the ability of women to walk over long distances or engage in activities requiring physical strength. Historians commonly believed that foot-binding in China originated in the royal court in the Five Dynasties around the 10th century, with the practice later spreading to the entire upper class as a sign of gentility in the Song Dynasty (960-1279) and gaining popularity among the lower classes during the Ming (1368-1644) and Qing (1636-1912) Dynasties. The prevalence of foot-binding varied across regions and ethnic groups in China, and indeed, it was widely practiced among most Han Chinese women, whereas it was rarely seen among the Hakka, a subgroup of Han Chinese.[7]

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[7] Whilst researchers have proposed various theories on the resistance of Hakka people to foot-binding, very little evidence has been put forward to justify these theories. Historians, such as Zhang (1994),

The Hakka account for around 4.4 percent of China's current population, and in 1905 (the commencement year of our sample) accounted for around 13.1 percent of Taiwan's population.

Throughout the 17th to 19th centuries, the main flow of settlers to Taiwan came from the southern Fujian Province of China and, to a lesser extent, the eastern Guangdong Province, both of which are geographically close to Taiwan. By 1905, which marked the completion of the first population census in Taiwan, 95.1 percent of the island's residents had migrated from these two provinces, with Fujian accounting for 82 percent and Guangdong accounting for the remaining 13.1 percent. The Fujian immigrants were ethnically Hoklo, whilst the Guangdong immigrants were Hakka. Since the practice of foot-binding was inherited from their ancestors in China, it was common among Hoklo women, but was rarely seen among Hakka women.[8]

Although the Japanese colonial government, which ruled Taiwan from 1895 to 1945, regarded foot-binding as a corrupt custom, in the early years of Japanese rule, the authorities did not resort to edicts prohibiting foot-binding due to concerns about disobedience or even a backlash from civil society. Instead, the government adopted several strategies aimed at discouraging foot-binding in the hope that it

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proposed the following three diverse hypotheses on the unwillingness of the Hakka to engage in foot-binding: (i) prior to the Five Dynasties when foot-binding first emerged in northern China, the Hakka people had migrated to the south, which geographically distanced them from the practice; (ii) after their long-distance migration, the majority of the Hakka settled in mountainous areas where physical mobility was desirable, perhaps even a prerequisite, for both men and women; and (iii) as compared to other Han groups, Hakka women tended to play a more active role in farming.

[8] Following their natural-foot custom in the Mainland, Hakka women in Taiwan rarely bound their feet; the 1905 Taiwan Descriptive Statistics Report shows that the proportion of foot-bound Hakka women was only 0.75 percent in that year, in sharp contrast to the 68 percent of foot-bound Hoklo women.

would gradually disappear. First, starting in late 1895, the government launched a public health media campaign against foot-binding through articles published in newspapers and magazines (Chang 2008). This was a continuous effort aimed at raising public awareness of the disadvantages of foot-binding. Second, visits to schools by health professionals and intellectuals were arranged to advocate the natural growth of feet and discourage female students from agreeing to be foot bound. Third, the government sponsored civil organizations, such as the Natural Foot Society and Foot-binding Liberation Society, which were established and operated by local elites including medical doctors, local leaders, businessmen and scholars.

The goal of these campaigns was two-fold: (i) to discourage parents from binding the feet of young girls, and (ii) to encourage unbinding among existing bound women. In the first ten years of these campaigns (1895 to 1904), very little had been achieved in terms of encouraging unbinding; by 1905, only 0.72 percent of ever-bound women had engaged in unbinding, with 68 percent of the Hoklo women remaining bound. However, despite the minimal effect on unbinding, it is likely that these campaigns were responsible for a significant reduction in the number of young girls engaging in foot-binding. Figure 1 presents the proportion of bound women across age groups, using data from the Census of 1905. The curve in Figure 1 shows that the proportion of foot-bound women was fairly constant (ranging between 75 and 80 percent) for those aged 26-30 or older in 1905. Since in 1895 these cohorts were already older than 10 years old, prior to which the process of foot-binding must commence, so their decisions on entering into the foot-binding

process were not be affected by the anti-foot-binding campaigns or movements occurring after 1895. Thus, we can consider their foot-binding rates as a 'benchmark' that indicates the prevailing rate prior to 1895. For younger cohorts, the scenario is different. Figure 1 shows that the proportions are 54.6 percent for girls aged 11-15 and 67.9 percent for those aged 16-20 in 1905, both of which are significantly lower than the benchmark foot-binding rate. The lower rates suggest that the number of girls who entered the foot-binding process decreased between 1895 and 1905, arguably due to the anti-foot-binding campaigns altering people's attitude towards the process during that period.

Why did the campaigns persuade some parents not to bind their daughters' feet and yet fail to encourage already bound women to unbind their feet? One possible answer is that the two decisions involve different cost-benefit considerations. For unbinding, a major cost was that once the feet were bound and reshaped, attempting to reverse the process by unbinding incurred disutility given the pain involved. On the other hand, however, a benefit for women was that unbinding could partially restore their mobility and physical strength (DeMello, 2007). If the individuals involved were acting rationally, unbinding would have been undertaken only if the cost of the procedure was outweighed by the benefit. To shed some light on this issue, we examine the association between unbinding and the age of the women in 1915, a time when 63.1 percent of ever-bound women had unbound their feet. The ever-bound women were comprised of those undertaking unbinding and those remaining bound in 1915. On the cost side, unbinding was biologically easier for younger females, particularly teenagers or younger girls whose feet were

still soft, such that the rehabilitation process involved less pain. On the benefit side, unbinding was more desirable for younger females whose lifetime return to improved mobility and physical strength was higher. The combination of these two factors, the higher benefit and the lower cost, would have encouraged more unbinding among younger females than older ones, and indeed, our data reveal such a correlation.

Despite the resistance to unbinding among certain groups of women between 1895 and 1905, such inertia did not persist after 1905. Indeed, the 1905-1915 decade witnessed a dramatic wave of unbinding, with the proportion of unbound women among all ever-bound women rising from 0.7 percent in 1905, to 63.1 percent in 1915. Binding young girls' feet was finally outlawed in 1915, marking the onset of a new stage of the government's overall anti-foot-binding plan. Although adult women were allowed to remain bound, it fueled the momentum in the unbinding trend. By 1920, the proportion of bound women among all Hoklo women had further declined to just 11 percent, and the practice ultimately died out completely in the years thereafter.

This raises a question concerning what it was that triggered such a land-slide shift towards unbinding after 1905, the outcome of which was so different from the pre-1905 decade. As argued above, the social movements and public campaigns in the pre-1905 decade had little impact on unbinding; thus, although this anti-foot-binding effort continued into the post-1905 era, it was unlikely to have been the driving force behind the unbinding wave. A more likely scenario is that certain other factors changing the cost-benefit structure for unbinding had come into play. In the

following section, we document the rapid development of cane cultivation in the post-1905 era and evaluate its impact on female participation in agricultural production, and thus, their decisions on unbinding.

2.2. The sugar industry in Taiwan

At the start of the Japanese occupation of Taiwan, agricultural production was dominated by rice cultivation, whilst cane cultivation was relatively rare, accounting for only 3.9 percent of all arable land in 1905.[9] At that time, the extraction of raw sugar was processed in traditional, small, household-based, stone-built mills, which were powered by ox carts. The development of the modern sugar industry in Taiwan commencing in the 1900s was planned out by the colonial government, closely following the Empire of Japan's guidelines to develop Taiwan as an agriculture base to support Japan's mainland as an industrial headquarter. The sugar industry in Taiwan featured the establishment of mechanized sugar refinery factories powered by electricity, and unlike the traditional family-based mills, investment in new factories was undertaken by large, private corporations from Japan, with subsidy from the government. The two decades after 1905 witnessed the rapid expansion of such modern factories, and at its peak, 42 sugar refinery factories had been established and brought into operation.

Each sugar corporation was assigned a catchment area by the colonial government within which the corporation became the only buyer of the canes planted inside the area; thus, each catchment area was essentially a local monopsony

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[9] Data obtained from the 9th Governor General of Taiwan Statistics Book, 1905.

market, a scenario which was designed to mitigate any competition between the sugar corporations. By ensuring the sugar corporations' returns, the system incentivized them to invest in railroad construction within their catchment area. In stark contrast to the systems in Java and the Caribbean, where farmers were coerced into growing cane, cane cultivation in Taiwan operated under a system of contract farming. Although farmers were free to choose between crops, usually rice or cane, in order to promote cane farming, the sugar corporations often offered a guaranteed purchase price at the time of harvest, with the price being set at a sufficiently high level to make cane farming more profitable than the alternatives.[10]

Annual cane production, measured in thousands of tonnes, are provided in Figure 3, with part (A) showing that total cane production experienced enormous growth from the 1900s to the 1930s; production rose from 410 million tonnes in 1903, to over 8 billion tonnes in 1935, almost a 20-fold increase, with two major forces driving such growth.[11] From 1903 to 1918, growth had been driven primarily by continuous expansion in the amount of land used for cane cultivation. As shown in part (B), the land used for cane cultivation (blue curve) grew from 16,526 Jia in 1903 to 150,450 Jia in 1918, a nine-fold increase. A Jia is a unit of land area equal to 0.9699 acre. However, the output per Jia increased only slightly over the same period, from 41,338 to 45,314 Jin (A Jin is a unit of mass equal to 600 grams), which

[10] In addition to contract farming, the sugar corporations also purchased land which they used to cultivate their own cane; however, Koo and Wu (1999) demonstrated that the factory-owned land provided only 15-25 percent of the cane processed by the factories, indicating that contract farming was the main source of the cane needed by the corporations.
[11] Annual production fluctuated noticeably over time, with significant troughs occurring in 1913, 1920 and 1933-34. These sharp reductions were primarily attributable to the tropical storms that hit Taiwan, damaging a sizable area of cane land either in the year of the harvest or in the previous year.

indicates that there was only a limited gain in productivity. Nevertheless, the scenario changed significantly in 1918, a year which heralded the start of a substantial decline in the land used for cane cultivation, leading to a 19 percent reduction by 1935 (from 150,450 to 121,628 Jia). During that same period, however, the amount of cane produced per Jia increased by 146 percent (from 45,314 Jin to 110,807 Jin).[12] The period prior to 1918 has much greater relevance to the present study, since it was a period which exhibited a rapid increase in the land used for cane farming, leading to the growth in demand for labor. As noted earlier, a wave of unbinding was witnessed over the same period, and thus, this period offers a unique opportunity to estimate the effects of cane cultivation on unbinding.

2.3. Sugarcane, female labor, and the railroad

There are two features of cane farming in Taiwan distinguishing it from rice farming. Firstly, cane cultivation induced a much greater demand for female labor. Secondly, railroads were indispensable for transporting canes to the refineries.

For the same area of land, cane cultivation required much higher labor inputs than rice cultivation. To show this, we use the data reported in the *Agriculture Fundamental Survey No. 5: The Second Report on Farming Household Economy*, which collected production information from a sample of 68 rice-farming and 25 cane-farming households in 1919.[13] The number of days of work spent by adult males and females on a Jia of land for the two types of farming households are reported in Table 1, which shows that 94.4 days of male labor and 15.8 days of

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[12] The increase in productivity was driven by a combination of factors, including improvements in plant breeding, soil quality, plantation methods, and fertilizer usage.
[13] The sample is largely representative of the population.

female labor were devoted to rice cultivation on a Jia of land. If male and female labor are considered comparable and addable, then the proportion of female labor accounted for 14.4 percent of the total labor input (male and female days combined). In contrast, cane cultivation on a Jia of land used 138.4 days of adult male labor and 78.9 days of adult female labor, with female labor accounting for 36.3 percent of the total labor input. This implies that female labor, in either absolute and relative terms, had a much more important role to play in cane cultivation than in rice cultivation. In absolute terms in particular, the female labor input for cane cultivation was more than five times that required for rice cultivation for the same area of land.

Where did the extra manpower come from to meet the labor demand boosted by the expansion of cane cultivation? Back in the 17th century, when the sugar industry was booming in Brazil and the Caribbean, the surge in the demand for labor was satisfied by the massive inflow of enslaved men from Africa. Such a solution, however, was not an option for Taiwan. Alternatively, cane farmers in Taiwan came up with two solutions. First, they toiled female household members to spend more time in farming. Second, they employed more temporary workers, both males and females, mostly from neighboring households.

Table 2 provides comparisons between rice-farming and cane-farming households in terms of the days of work undertaken by adult household members and hired workers (listing males and females separately).[14] It should be noted that since the days of work are measured here at individual level, they do not refer to the

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[14] The data source for Table 2 is the same as that for Table 1.

days of work required to cultivate a Jia of land, as reported in Table 1. The results reported in column 1 of Table 2 show that an adult male in a rice household spent 165.2 days on rice farming in 1919, which is only slightly below the 176.7 days spent by an adult male in a cane household. The corresponding figures for adult female members, as shown in column 2, are 67.7 days for rice households and 110 days for cane households, suggesting that female members of cane households spent 32.3 more days per year on cane farming than their counterparts in rice households. Column 3 further reveals that rice households hired a total of 216.1 days of adult male labor, which was around 40 days less than the 255.8 days required by cane households. The difference is even greater for hired female labor, as rice households hired just 31.2 days of adult female labor, whilst cane households hired a total of 79.4 days of adult female labor, a difference of 48.2 days (column 4).

The details reported in Table 2 on hours worked in the different households indicate that when households decided to switch from rice farming to cane farming, the increase in the demand for labor would have been supplemented primarily by their own female household members, along with hired male and female workers. Overall, the expansion of cane farming in the early 20th century greatly enhanced the role of females in agricultural production. Females within a farming household were not only required to work harder on agricultural production, but they were also more likely to be hired by nearby farms as temporary workers.

As noted earlier, given that sugar processing traditionally operated in household-scale mills, it did not rely on the long-distance transportation of canes. However, following the establishment of the modern factories, sugar processing

became centralized, and in order to ensure sugar quality, the harvested canes had to be promptly conveyed to a refinery factory, which could be miles away from the farmland. Thus, the sugar corporations built a dense railroad network for cane shipping, since no traditional transportation methods could accommodate the movement of a large volume of canes over long distances.

Prior to 1895, the railroad system was almost non-existent. The only available railroad was a line connecting two main cities in northern Taiwan, and it was subsequently replaced for the Western Trunk Line (WTL) completed by the Japanese colonial government in 1908. The WTL connected all major cities in western Taiwan, offering transportation of both passengers and freights. Following the assignment of catchment areas in the 1900s, the sugar corporations embarked on the construction of railroads within their own catchment territory. These privately-owned railroads were designed exclusively for cane transportation. As shown in Appendix A (Figure A-1), the flatbed cars ran on narrow-gauge rails, so they were not safe or stable enough for the transportation of passengers or other types of cargo. Figure 4 illustrates the total length of railroads in Taiwan. The blue curve refers to the length of cane railroads which experienced four-fold growth between 1909 and 1941, from 451 kilometers to 2,182 kilometers. The red curve shows the total length of another type of railroads, referred to as the multi-purpose railroads, which were also constructed by the sugar corporations, but used for the transportation of passengers and various types of freight, including canes. Although the total length of these railroads increased rapidly from 1909 to 1918, there was no further expansion thereafter, presumably due to the development of the good quality roads

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that were replacing the functions of the railways.

As compared to the ordinary multi-purpose railroads, the cane railroads may be a more suitable IV for our attempts to estimate the causal effects of cane cultivation on unbinding decisions. Given that the multi-purpose railroads may have been important for local economic development and social change, they may have had a direct impact on unbinding without operating through cane cultivation, thereby violating the exclusion restriction requirement for a valid IV. Since the cane railroads were unrelated to the transportation of passengers or non-cane freight, it is unlikely that they would have affected unbinding decisions without working through facilitating cane cultivation. This qualifies cane railroads as a more suitable IV.

3. Conceptual framework

The practice of foot-binding exhibits the key features of a behavioral norm as specified by researchers, and indeed, time persistence is often observed among such features with regard to social norms and culture (Belloc and Bowles 2013; Borowiecki 2015). Given that foot-binding was practiced for centuries in both China and Taiwan, it obviously exhibited strong time persistence. In addition, it also exhibited another feature referred to by Young (2015) as 'local conformity and global diversity'. Young argued that two similar groups might end up with two separate equilibrium points with sharply different levels of the norm, an outcome which is likely to be caused by some random events in history that projected the two groups along different trajectory paths. This feature is helpful in explaining why the Hakka and the Hoklo, both of which are ethnically Han, developed contrasting

norms relating to foot-binding.[15]

Perhaps the most intriguing feature exhibited by foot-binding is the pattern of tipping. Nyborg et al. (2016), for example, argued that adherence to a social norm by one individual can help reinforce adherence to the same norm by other individuals, which in turn helps compel adherence by the first individual. This forms a vicious cycle that makes a norm stable and self-reinforcing. The tipping point is where a vicious cycle turns into a virtuous one, which is why, when a norm starts to shift, and once the proportion of non-followers passes a crucial threshold, people start changing rapidly until a new equilibrium point is reached (Schelling 1960; Nyborg et al. 2016). Indeed, such a tipping point is discernible among foot-binding followers in Taiwan.

Figure 5 plots the correlation between the proportion of bound Hoklo women and the proportion of the Hakka population, based upon the data from the Census of 1915. Our sample is comprised of 2,716 villages and districts, which were categorized into 25 bins with an equal bin width of 4 percentage points. The mean for each bin was obtained using the proportion of Hoklo women in all the villages and districts within the bin. Although the figure indicates a decline in the foot-binding rate among Hoklo women with an increase in the population share of the Hakka within the village/district, this negative correlation is not linear, as there is a tipping point where

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[15] Splitting paths can be observed in the experiments carried out by Baronchelli, Felici, and Loreto (2006) and Centola and Baronchelli (2015). Using naming games, they investigated how naming conventions arose through a trial-and-error coordination process within a network of subjects. Each subject was encouraged to come up with the same name with a paired subject within the same network in a series of trials. When cross-network interactions were banned, this resulted in different networks converging to completely distinct names; however, when the network was enlarged to involve the entire available subjects, only one name became the dominant choice.

the Hakka population share reached around 6 percent. This is to say, the foot-binding rate was much higher for Hoklo women living in a village/district where the Hakka accounted for less than 6 percent of the population, but once the Hakka population share passed the tipping point, there was a dramatic reduction in the Hoklo foot-binding rate. Although the evidence is only suggestive, the existence of the tipping point helps explain why the demise of foot-binding was sudden, rather than incremental.

Foot-binding can be best understood as a costly social norm which caused harm to all agents who engaged in it, since it inflicted pain on women and impaired their labor productivity. Thus, the immediate incentive provided by cane cultivation would seem to be evident, as unbinding facilitated participation in agricultural production that required better physical mobility and upper-body strength, thereby raising the cost of remaining bound. Nevertheless, women may not have been responsive, essentially because deviating from a norm can attract criticism and even punishment (Jindani and Young 2020). Therefore, the effect of cane cultivation on unbinding was reliant on the number of women whose gain from unbinding surpassed the corresponding loss. Furthermore, the pattern of 'tipping' implies that the marginal effect of cane cultivation on unbinding may have been amplified if the effect resulted in inducing sufficient women to cross the tipping point.

In addition to the cost-benefit analysis laid out above, cane cultivation may have also affected foot-binding/unbinding through two other mechanisms. Firstly, since it increased the (implicit) income share of women within the household relative to men, it may have increased their bargaining power (Becker, 1973). This

would have led to more unbinding if women resented binding more than men, and would have also helped prevent young daughters from engaging in the process of foot-binding if the mother was more concerned than the father about the daughter's disutility. Secondly, increased female productivity in agriculture would imply a higher lifetime income for unbound girls, resulting in parents being more reluctant to bind their daughters' feet. Unfortunately, due to data paucity, we are unable to statistically assess the importance of these two alternative mechanisms, nor are we able to distinguish between the effect on unbinding and the effect on new entry.

4. Data and sample

Demographic and foot-binding data were collected from the Census of 1915, General Volume of Statistical Tables, carried out by the Japanese colonial government.[16] The data are reported at the village/district level, which was the third level of administrative division in 1915, just below township. The key variables of interest are the number of unbound women (who had originally bound their feet but subsequently had them unbound prior to 1915) and the number of women remaining bound in 1915. Also available within the data are the populations by gender, age group and ethnicity (Hoklo, Hakka, and aborigine). For estimating the effect of cane cultivation on unbinding, the village/district-level data were aggregated at township level to accommodate our primary outcome variable, the proportion of land used for cane cultivation, which was reported only at the township level. Following the

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[16] Data collected by the Census of 1915 are reported in several different official reports. The township-level data used in this study were obtained from one of these four reports, the General Volume of Statistical Tables.

exclusion of ten special administrative townships located in the aboriginal territory, as well as four townships with no foot-binding records, our final sample for analysis is comprised of 197 townships.

We use two different outcome variables for our regression analysis. The first is the proportion of unbound women among ever-bound women, who ever experienced foot-binding regardless their binding status in 1915. The proportion is expected to be higher for a township that witnessed a higher growth in cane cultivation from 1905 to 1912, if the economic incentive was effective in determining foot-binding/unbinding. Our second outcome variable was simply the proportion of foot-bound women among all Hoklo women in 1915. If the economic incentive worked, we would expect this proportion to be lower for townships with higher growth in cane cultivation between 1905 and 1912, conditional on the initial state on foot-binding. It should be noted that the effect on the second outcome variable, if detected, can be attributed to: (i) more unbinding prior to 1915, and (ii) fewer young girls engaging in initial foot-binding prior to 1915.

Township-level foot-binding statistics for 1905, which should be controlled for as the initial foot-binding status in our regressions, were not available from our data. To address this, we used the number of ever-bound women in 1915 divided by the number of Hoklo women in 1905 as a proxy for the proportion of bound women for each township in 1905. This proxy is obviously problematic because it ignores occurrences of both inbound flows (newly bound women) and outbound flows (bound women who had died) between 1905 and 1915. This limitation is harmless only if the outbound flow minus the inbound flow is proportional to the actual

number of bound women in 1905, but evidence of such proportionality is absent. As a precautionary measure, in Section 5, we examine the robustness of our estimates by running regressions with and without controls in place for this imputed variable, and find only minor differences between the two results.

The data on cane cultivation are contained in the annual Governor General of Taiwan Statistics Books, which report land used for cane, rice and other crop cultivation at the township level. Our treatment variable is defined as the change in the proportion of land used for cane cultivation between 1905 and 1912, which is the last year of the data availability. It should be noted that due to the lack of data, we are unable to determine the number of unbound women in 1912 to 'synchronize' our treatment variable (change in the percentage of cane land between 1905 and 1912) and outcome variables (percentages of bound and unbound women in 1915). We should bear in mind that this will inevitably result in measurement errors unless the cross-township variation in the percentage of unbound women in 1912 was proportional to that in 1915.

Figure 6 illustrates the geographical correlation between cane cultivation and unbinding in Taiwan, with part (A) showing the changes between 1905 and 1912 in the proportion of arable land used for cane cultivation at township level. For simplicity, we focus solely on townships in southwest Taiwan, where cane cultivation was most prevalent. Since townships surrounding the local capital city, Tainan, are shown in a lighter color, this suggests relatively slow growth in the proportion of land used for cane cultivation between 1905 and 1912. Radiating from Tainan, the color turns darker for townships located farther away, indicating a higher

1905-12 growth in cane cultivation. A similar radiation pattern is also observed in part (B), which indicates the proportion of unbound women in 1915. The proportion is found to be particularly low in townships near Tainan, and becomes larger with an increase in the distance from Tainan. Obviously, the similarity in the radiation pattern demonstrates a geographical correlation between the development of cane cultivation and unbinding.

Finally, we were able to obtain the exact location of each cane railroad by digitizing a detailed raw map of railroads published in the Sugar Industry Annual Report, 1919, using QGIS, a geographical information system (GIS) application. This map was the earliest one with good quality we could find from all existing colonial government archives. The digitized railroad lines are presented in Figure 7, which shows an intensive network of cane railroads (red curves) in the southwest of Taiwan where the sugar industry flourished. Our digitization provides a total of 1,122 kilometers of cane railroad. All the geographic measures, including the railroad length, township area, adjacent villages and districts, border length, and location of the centroid are constructed using the geospatial vector data provided by Center for GIS, Research Center for Humanity and Social Sciences, Academia Sinica. We generated a cane railroad density for each township, which was measured as the total length of cane railroad within the township divided by the area of the township, and then used this variable to instrument the cane cultivation within our regressions.

The summary statistics on the main variables used in our analysis are presented in Table 3, with Panel A reporting the township-level data used for our

examination on the economic incentive for foot-binding, and Panel B reporting the village/district-level data used for our examination on the marriage competition incentive for foot-binding.

5. Examining the economic incentive for foot-binding/unbinding

Our primary task in this section is to estimate the effect of cane cultivation on unbinding by estimating the following regression:

$$UBR_{1915,k} = \alpha + \beta \Delta Sugar_k + \boldsymbol{X}_{1905,k}\boldsymbol{\gamma} + \boldsymbol{X}_{natural,k}\boldsymbol{\delta} + \rho FBR_{1905,k} + \epsilon_k \quad (1)$$

where the dependent variable, $UBR_{1915,k}$, refers to the proportion of unbound women in township k in 1915 as our first outcome variable, or the proportion of women who remained bound in 1915 as our second outcome variable; $\Delta Sugar_k$ is the change in the proportion of land used for cane cultivation between 1905 to 1912; $\boldsymbol{X}_{1905,k}$ is a vector of controls measured in 1905, which is comprised of the male-to-female gender ratio, proportion of Hakka among the female population, logarithm of township population, and the proportion of arable land used for cane cultivation in 1905 as its initial status; $\boldsymbol{X}_{natural,k}$ refers to a set of controls indicating natural conditions of township k, including proportion of plains in the landscape and two dummies indicating whether township k is located in the North, Central, or South (omitted group) Taiwan; $FBR_{1905,k}$ is the proxy for the proportion of bound women in 1905 (refer to Section 4 for details on the construction of this proxy), which is used to control for the initial state of foot-binding; ϵ_k refers to the error term. The coefficient of interest is β, which indicates the marginal effect of the growth of cane cultivation on the corresponding outcome variable. Since the

population size is quite variable across the different townships, all of the regressions based upon Equation 1 are weighted by township population in order to improve the precision of our estimations. As recommended by Solon (2015), however, we also report the unweighted regression results later in this section (Table 6) as a test for the robustness of our model specification.

Given that farmers were free to choose between crops, the OLS estimate of β is potentially plagued by the omitted variables bias. One possible confounder, for example, is conservativeness: Consider a conservative male household head who worshipped traditional values and customs; he would be reluctant to adopt the cultivation of sugarcane as a modern crop, and he would ask female household members to stick to the practice of foot-binding. This drives positive correlation between $UBR_{1915,k}$ and $\Delta Sugar_k$, leading to a spurious estimate of β. To address this selection, we exploit the instrumental variable strategy using the cane railroad density as the IV.

The estimated effects of cane cultivation on unbinding are presented in Table 4, with column 1 showing that when controlling for only the 1905 variables (with the exception of the proxy for the 1905 foot-binding rate), the coefficient on the change in the proportion of cane land is 1.06, which is statistically significant. This estimate implies that a one standard deviation increase (0.1068) in the proportion of cane land is associated with an 11.3 percentage points increase in unbound women in 1915. This coefficient estimate declines to 0.76 when natural condition controls are added into regression (column 2), and declines slightly further to 0.75 when the proxy for the 1905 foot-binding rate is controlled for in regression (column 3),

although both remain statistically significant.

Columns 4 to 6 of Table 4 respectively report the first-stage, reduced-form and second-stage results of the 2SLS estimation using cane railroad density as the IV. The 2SLS estimate of interest is 1.77, which is much larger than the corresponding OLS estimate shown in column 3. The large 2SLS estimate suggests that a one standard deviation increase in the proportion of cane land led to an 18.9 percentage points increase in unbound women in 1915. The effect is sizable when compared to the mean proportion of unbound Hoklo females (60.7 percent) in the sample.

Multiple possible reasons may explain why the 2SLS estimate is larger than the corresponding OLS estimate, one of which is that the 2SLS estimate captures the treatment effect on the compliers – those farmers who shifted to cane cultivation in response to the provision of railroad access. Compared to the never-takers who persisted in rice cultivation (the conventional crop) regardless of any railroad access, the compliers were likely to be more adaptive and less devoted to traditional ways of life, including the practice of foot-binding. In that case, the compliers would have been more inclined to engage in unbinding in response to the adoption of cane cultivation, which would mean that cane cultivation had a greater effect on unbinding.

Table 5 presents the estimation results using the proportion of the remaining foot-bound women in 1915 as the outcome variable. The estimates confirm the main findings drawn from Table 4, that the growth in cane cultivation discouraged the practice of foot-binding, leading to a lower proportion of bound women in 1915.

Specifically, the OLS estimates in columns 1 to 3 suggest that a one standard deviation increase in the proportion of cane land is associated with a 4.9 to 7.2 percentage points reduction in bound women in 1915, depending on various controls. Again, these OLS estimates are smaller than the 2SLS estimate, as shown in column 6, which suggests that a one standard deviation increase in the proportion of cane land in 1915 would have led to a 12.8 percent reduction in the proportion of bound women.

We carry out two tests on the robustness of our results in Table 6, with column 1 replicating the 2SLS estimation on unbinding without population weighting. Although the estimate of interest (β) is reduced to 1.02 – from the weighted estimate of 1.31 reported in column 6 of Table 4 – it remains both statistically and economically significant. Column 2 reports the estimation results using a sample which excluded 14 townships that were located either on the east coast or the Penghu Islands, both of which are relatively remote areas of Taiwan. The estimate of interest is 0.98, which implies a smaller effect of cane cultivation on unbinding, although the difference from the full-sample estimate is somewhat limited.

6. Examining the marriage incentive for foot-binding/unbinding

The marriage competition hypothesis refers to, again, that foot-binding enhanced the marriageability of a girl, and thus, incentivized parents to bind the feet of their female children. In this section, we use intermarriages between Hoklo and Hakka people to shed light on the hypothesis. More specifically, we examine whether

Hoklo females living in communities with high proportions of Hakka people had a reduced likelihood of engaging in foot-binding.

Prior to specifying the test, four important features regarding Hoklo-Hakka connectedness are worth noting. First, intermarriage was quite common between the two ethnic groups, with the national statistics suggesting that around 7 to 15 percent of Hakka men married Hoklo women each year between 1905 and 1915, although the proportion must be higher in communities where both Hakka and Hoklo populations are sizable. Second, the prefecture-level statistics suggest that Hoklo females living in prefectures with higher proportions of Hakka people exhibited lower foot-binding rates; however, no such association is discernible in the reverse direction. Hakka women were unwilling to bind their feet regardless of the density of the Hoklo population in the prefecture. Indeed, the data from the Census of 1905, General Volume of Statistical Tables, show that in the ten prefectures where the proportion of the Hakka population was less than 1 percent, 77.5 percent of Hoklo women bound their feet, but this reduces to only 34.6 percent for those living in the four prefectures where the Hakka accounted for over 40 percent of the population. By sharp contrast, in the same four prefectures, the proportion of foot-bound Hakka women was only 0.25 percent, despite the large Hoklo population in these prefectures. Third, both within-village/district and cross-village/district marriages were common during our sample period. Although there are no nationwide statistics to support this inference, multiple case studies have provided supporting evidence: In a study on a village located in central Taiwan, Chiu and Katz (2010) found that only 224 out of 811 (30.1%) marriages recorded during the colonial period had been

matched within the village; thus, most of the remaining couples found their partners from neighboring villages. Chuang (1994) examined a village where the majority population was Hoklo and found that the proportion of within-village marriage matches was only 39.3 percent during the colonial period. Finally, the geographical distribution of the Hakka population was uneven, with over 84 percent of Hakka residing in the north-central area of Taiwan. Such a large geographical variation facilitates our examination on how Hoklo's decisions on foot-binding reacted to the ethnic composition within the local population.

Based on the features presented above, we use the data from the Census of 1915 to design a test on the marriage hypothesis as follows:

$$FBE_v = \alpha + \beta_1 Hakka_v + \beta_2 Hakka_{v\_a} + X_v \gamma + \delta_k + \epsilon_v \qquad (2)$$

where $Hakka_v$ is the proportion of Hakka population in village/district v, and $Hakka_{v\_a}$ is the proportion of Hakka population in all villages and districts adjacent to village/district v; X_v is a set of controls, which is comprised of the logarithm of 1905 population in 1905, male-to-female gender ratio in 1905, and logarithm of 1915 population; δ_k is township fixed effects, and ϵ_v is the error term. The dependent variable in Equation 2, FBE_v, is the proportion of the ever-bound women (again, those women who experienced foot binding prior to 1915, regardless of whether or not their feet were unbound in 1915) in village/district v. Specifically, it is the sum of existing foot-bound women and unbound women among the entire female population above 5 years of age.

One limitation here is that the coefficient β1 can be interpreted in at least two different ways, indicating two different potential effects that the Hakka may

potentially have on foot-binding decisions among Hoklo women. The first effect, the one that we intend to capture, is that a higher proportion of Hakka in the marriage market will lead to a lower foot-binding rate among Hoklo females. The second effect resembles the conventional peer effect, that the Hoklo were encouraged to abandon foot-binding as a result of their interactions with the Hakka.

To address the limitation, in Equation 2 we control for both the proportion of Hakka population within the village/district ($Hakka_v$) and the proportion of Hakka population in all the adjacent villages and districts ($Hakka_{v\_a}$). Our hypothesis is that if there was no marriage consideration and the peer effect dominated, the within-village/district Hakka would be expected to have had a larger peer effect than the Hakka in adjacent villages and districts because of the difference in interaction intensity. In such cases, β_1 should be larger than β_2. Conversely, if β_1 is found to be equal to or even smaller than β_2, then marriage was likely to be an important consideration in foot-binding decisions.

The results obtained from the estimation of Equation 2 are reported in Table 7. In column 1, the first estimate ($\hat{\beta}_1$) suggests that one percentage point increase in the Hakka population within the village/district is associated with a 0.112 percentage point decrease in the foot-binding rate for the Hoklo females in the same village/district. This is somewhat higher than the second estimate, $\hat{\beta}_2$, which suggests that one percentage point increase in the Hakka population in the adjacent villages/districts is associated with a 0.087 percentage point decrease in the foot-binding rate in the reference village/district. Although $\hat{\beta}_1$ appears to be larger than $\hat{\beta}_2$, a formal F test cannot reject the hypothesis that the two estimates are equal,

as suggested by the p-value (0.7369). Column 2 repeats the estimation of Equation 2 without applying the population weighting. Now, $\hat{\beta}_1$ turns smaller than $\hat{\beta}_2$, but again, the F test fails to reject the hypothesis on the equality of the two estimates. Column 3 presents the estimation results following the removal of 229 villages/districts in Changhua prefecture (8.43 percent of the full sample) from the estimation sample. The Hakka residents in these villages/districts were migrants from an area in Southern China where the Hakka were culturally assimilated to other Han Chinese. Their ancestors had started practicing foot-binding hundreds of years earlier, and the custom had been inherited by their descendants, including those later migrating to Changhua, Taiwan. As suggested by column 3, the resulting estimates of $\hat{\beta}_1$ and $\hat{\beta}_2$ are both fairly similar to those presented in column 1 using the full sample.

To be sure, given the lack of a proper research design, $\hat{\beta}_1$ and $\hat{\beta}_2$ may not be causal. Selection is potentially a concern since people could choose a community to reside in through migration or marriage, although migration was not as easy then as it is now in a modern society. Both estimates will be biased if, for example, only those Hoklo who were less cohesive to traditional norms chose a community with a large Hakka population. To the extent of such selection biases, our findings in Table 7 are in line with the marriage competition hypothesis.

7. Conclusions

In this study, we examine the demise of foot-binding, a very persistent custom in both China and Taiwan, and show that a change in agricultural productivity for

females may have had a significant effect on the practice. Given that cane cultivation was substantially more demanding for female labor than traditional rice cultivation, the expansion of the sugar industry in the early 20th century induced a considerable amount of female labor into agricultural production. Using unique historical data on Taiwan, we show that the shift to cane cultivation incentivized bound women to unbind their feet, a finding which favors the economic incentive hypothesis as proposed by researchers who have argued that foot-binding was practiced as a means of pursuing economic benefits.

It is important to note that our test on economic incentives focuses on the demise in foot-binding that mainly occurred in the first two decades of the 20th century. Our results confirm the importance of economic incentives in determining unbinding, although it must be noted that we have been unable to identify any clear association between economic considerations and the origin of foot-binding. Furthermore, our findings do not rule out the possibility that other motives were coming into play. Indeed, the second half of our empirical work in this study provides evidence to suggest that foot-binding functioned as a marriage investment.

Although foot-binding has now been consigned to the distant past, other costly, gender-specific norms still prevail. Among these the most heinous is the practice of female genital mutilation, experienced by more than 200 million African females still alive today (UNICEF 2016). Our findings in the present study reveal that an increase in the demand for female labor accelerated the abandonment of a persistent custom that was costly for females, although the mechanisms delivering the effect remain unclear. To the extent that the cane effect functioned through enhanced

within-household bargaining power for women and/or enhanced women's expected life-time income that prompted parent's investment on girls' health, our findings imply that the development of female-labor-favoring crops (such as tea and coffee) or industries (such as textiles and electronics assembly) may also be helpful in eliminating the practice of FGM in the future.

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Table 1: Days of work spent cultivating a Jia of land

	(1) Male	(2) Female	(3) Female labor (%)
Rice farming	94.4	15.8	14.4
Cane farming	138.4	78.9	36.3

Notes: The statistics are calculated based upon data obtained from the Agriculture Fundamental Survey No. 5: The Second Report on Farming Household Economy, which collected information from 68 rice-farming and 25 cane-farming households. The numbers in the Male and Female columns indicate the total number of days spent cultivating a Jia of land during the year of the survey. A Jia is a unit of land area which is equal to 0.9699 acre.

Table 2: Days of work per houshold member and total hired labor

	Per household member		Total hired labor	
	(1) Adult male	(2) Adult female	(3) Adult male	(4) Adult female
Rice households	165.2	69.7	216.1	31.2
Cane households	176.7	110.0	255.8	79.4

Notes: The statistics are calculated based upon data obtained from the Agriculture Fundamental Survey No. 5: The Second Report on Farming Household Economy, which collected information from 68 rice-farming and 25 cane-farming households. The numbers in the table cells indicate the total number of days spent cultivating crop during the year of the survey.

Table 3: Summary statistics

	(1) Mean	(2) Standard deviation
A. Township-level data (Observations: 201)		
Proportion of unbound women, 1915	0.40	0.23
Proportion of bound women, 1915	0.24	0.21
Proportion of cane land, 1912	0.11	0.11
Log population, 1915	9.07	1.17
Township characteristics, 1905		
Male-to-female gender ratio	1.12	0.09
Proportion of Hoklo female population	0.92	0.48
Log population	8.99	1.18
Proportion of cane land	0.05	0.08
Proxy for percent bound females	0.58	0.23
Proportion of Plain landscape	0.89	0.22
Cane railroad density	9.71	12.99
B. Village-level data (Observations: 2,675)		
Proportion of ever-bound women, 1915	0.60	0.28
Proportion of Hakka within the village	0.14	0.31
Proportion of Hakka in adjacent villages	0.14	0.30
Male-to-female gender ratio, 1905	1.15	0.26
Log population, 1905	6.60	0.91
Log population, 1915	6.71	0.84

Notes: Demographic variables and foot-binding data are collected from the 1915 Taiwan Census Primary Statistics Tables. Railroad data are from the Sugar Industry Annual Report, 1919. Land cultivation data are from the Governor General of Taiwan Statistics, 1905 and 1912.

Table 4: The effects of cane cultivation on unbinding

	OLS			IV		
				1st-stage	Reduced form	2nd-stage
	(1)	(2)	(3)	(4)	(5)	(6)
Change in proportion of cane land (1905-12)	1.06***	0.76***	0.75***			1.77***
	(0.19)	(0.20)	(0.20)			(0.58)
Township characteristics, 1905						
Male-to-female gender ratio	0.89***	0.57*	0.39	-0.021	0.382	0.42
	(0.32)	(0.30)	(0.31)	(0.098)	(0.296)	(0.33)
Proportion of Hokko female population	-0.02	-0.02	-0.04	-0.006	-0.047	-0.04
	(0.04)	(0.03)	(0.04)	(0.007)	(0.033)	(0.04)
Log population	-0.01	-0.41**	-0.43**	-0.195***	-0.655***	-0.31
	(0.02)	(0.20)	(0.19)	(0.062)	(0.199)	(0.21)
Proportion of cane land	0.77***	0.74**	0.74**	-0.530***	0.062	1.00***
	(0.27)	(0.32)	(0.32)	(0.136)	(0.264)	(0.34)
Township natural conditions						
Proportion of plain landscape		0.01	-0.01	-0.038	-0.065	0.00
		(0.06)	(0.06)	(0.030)	(0.074)	(0.07)
Located in Northern Taiwan		-0.10	-0.11	-0.059***	-0.104*	0.00
		(0.07)	(0.07)	(0.017)	(0.063)	(0.09)
Located in Central Taiwan		0.16***	0.16***	-0.021	0.160***	0.20***
		(0.05)	(0.05)	(0.020)	(0.049)	(0.06)
Log population, 1915		0.41**	0.44**	0.202***	0.670***	0.31
		(0.20)	(0.19)	(0.062)	(0.195)	(0.21)
Proxy for percent bound females, 1905			0.12	0.011	0.116	0.10
			(0.08)	(0.024)	(0.074)	(0.09)
Cane railroad density				0.004***	0.008***	
				(0.001)	(0.002)	
Population weighted	Y	Y	Y	Y	Y	Y
Mean dependent variable	0.607					
Observations	201					
R-squared	0.243	0.411	0.419	0.422	0.439	0.315

Notes: All of the regressions, which are estimated at township level, are population weighted. The dependent variable is the proportion of ever-bound Hoklo females whose feet were unbound prior to 1915. The instrumental variable is cane railroad density, which is defined as the length of cane railroad within the township divided by the township land. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: The effects of cane cultivation on foot-binding in 1915

	OLS			IV		
				1st-stage	Reduced form	2nd-stage
	(1)	(2)	(3)	(4)	(5)	(6)
Change in proportion of cane land (1905-12)	-0.68***	-0.46***	-0.50***			-1.21***
	(0.13)	(0.13)	(0.13)			(0.40)
Township characteristics, 1905						
Male-to-female gender ratio	-0.14	0.14	-0.39	-0.022	-0.385*	-0.41*
	(0.26)	(0.23)	(0.24)	(0.098)	(0.225)	(0.25)
Proportion of Hokko female population	0.07*	0.06*	0.01	-0.006	0.017	0.01
	(0.04)	(0.04)	(0.02)	(0.007)	(0.019)	(0.02)
Log population	-0.03**	0.56***	0.48***	-0.194***	0.632***	0.40***
	(0.01)	(0.14)	(0.14)	(0.061)	(0.141)	(0.15)
Proportion of cane land	-0.43*	-0.44*	-0.44**	-0.529***	0.016	-0.62***
	(0.23)	(0.26)	(0.22)	(0.136)	(0.194)	(0.23)
Township natural conditions						
Proportion of plain landscape		0.02	-0.05	-0.038	-0.006	-0.05
		(0.05)	(0.05)	(0.030)	(0.059)	(0.05)
Located in Northern Taiwan		0.07	0.05	-0.059***	0.049	-0.02
		(0.05)	(0.04)	(0.017)	(0.042)	(0.06)
Located in Central Taiwan		-0.10***	-0.11***	-0.021	-0.111***	-0.14***
		(0.04)	(0.04)	(0.020)	(0.034)	(0.04)
Log population, 1915		-0.59***	-0.48***	0.201***	-0.636***	-0.39***
		(0.14)	(0.14)	(0.062)	(0.140)	(0.15)
Proxy for percent bound females, 1905			0.35***	0.012	0.347***	0.36***
			(0.05)	(0.024)	(0.050)	(0.06)
Cane railroad density				0.004***	-0.005***	
				(0.001)	(0.001)	
Population weighted	Y	Y	Y	Y	Y	Y
Mean dependent variable	0.235					
Observations	201					
R-squared	0.153	0.344	0.467	0.422	0.485	0.377

Notes: All of the regressions, which are estimated at township level, are population weighted. The dependent variable is the proportion of Hoklo females remaining bound in 1915. The instrumental variable is cane railroad density, which is defined as the length of cane railroad within the township divided by the township land. Robust standard errors are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 6: Robustness examinations

|	2SLS	
	(1)	(2)
	Unweighted	Excluding remote townships
Change in proportion of cane land (1905-12)	1.37**	1.36**
	(0.53)	(0.55)
Township characteristics, 1905		
Male-to-female gender ratio	0.86***	0.14
	(0.22)	(0.08)
Proportion of Hokko female population	-0.02	0.11
	(0.02)	(0.34)
Log population	-0.25	-0.05
	(0.15)	(0.04)
Proportion of cane land	0.97***	-0.18
	(0.34)	(0.19)
Township natural conditions		
Proportion of plain landscape	0.09	0.58
	(0.09)	(0.37)
Located in Northern Taiwan	-0.05	-0.02
	(0.08)	(0.06)
Located in Central Taiwan	0.14***	-0.05
	(0.05)	(0.09)
Log population, 1915	0.29*	0.19***
	(0.15)	(0.06)
Proxy for percent bound females, 1905	0.15**	0.17
	(0.07)	(0.19)
Population weighted	N	Y
Mean dependent variable	0.607	0.650
Observations	197	183
R-squared	0.321	0.359

Notes: Both regressions are estimated at the township level. The dependent variable is the proportion of ever-bound Hoklo females whose feet were unbound prior to 1915. The instrumental variable is cane railroad density, which is defined as the length of cane railroad within the township divided by the township land. Robust standard errors are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 7: The effects of the proportion of Hakka population on foot-binding

	(1) Population weighted	(2) Unweighted	(3) Excluding Hakka in Changhua
Hakka proportion within village (β_1)	-0.112***	-0.101***	-0.112***
	(0.033)	(0.029)	(0.033)
Hakka proportion in adjacent villages (β_2)	-0.087**	-0.118***	-0.088**
	(0.042)	(0.035)	(0.042)
Male-to-female gender ratio, 1905	0.018	-0.007	0.018
	(0.016)	(0.009)	(0.017)
Log population, 1905	-0.000	0.004	-0.001
	(0.009)	(0.007)	(0.010)
Log population, 1915	0.010	0.004	0.010
	(0.011)	(0.008)	(0.011)
p-value of F test on equality of β_1 and β_2	0.7369	0.7750	0.7384
Township fixed effects	Y	Y	Y
Population weighted	Y	N	Y
Mean dependent variable	0.595	0.595	0.582
Observations	2,675	2,675	2,446
R-squared	0.778	0.795	0.833

Notes: All regressions are estimated at the village level. The dependent variable is the proportion of ever-bound Hoklo females in 1915. The sample excludes villages in the aboriginal territories. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Figure 1: Proportion of foot-bound women by age group in 1905
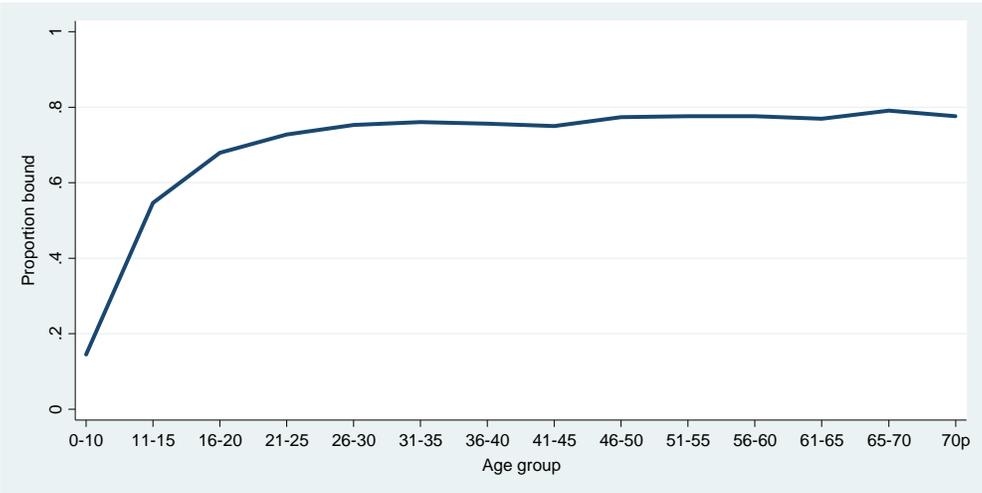
Source: Census of 1905, General Volume of Statistical Tables, pp.388-389.
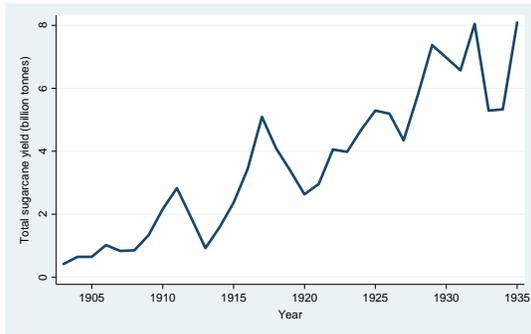
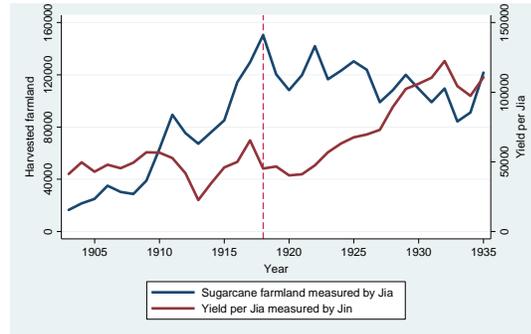## Figure 2: Proportion of unbound women by age group in 1915
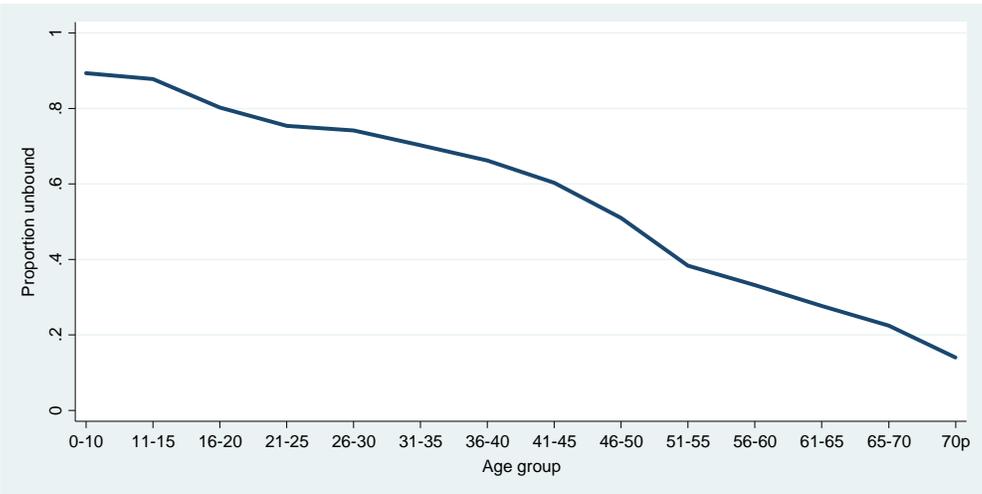
Source: Census of 1915, General Volume of Statistical Tables, pp.442-443.

Figure 3: Development of cane cultivation in Taiwan, 1903-35
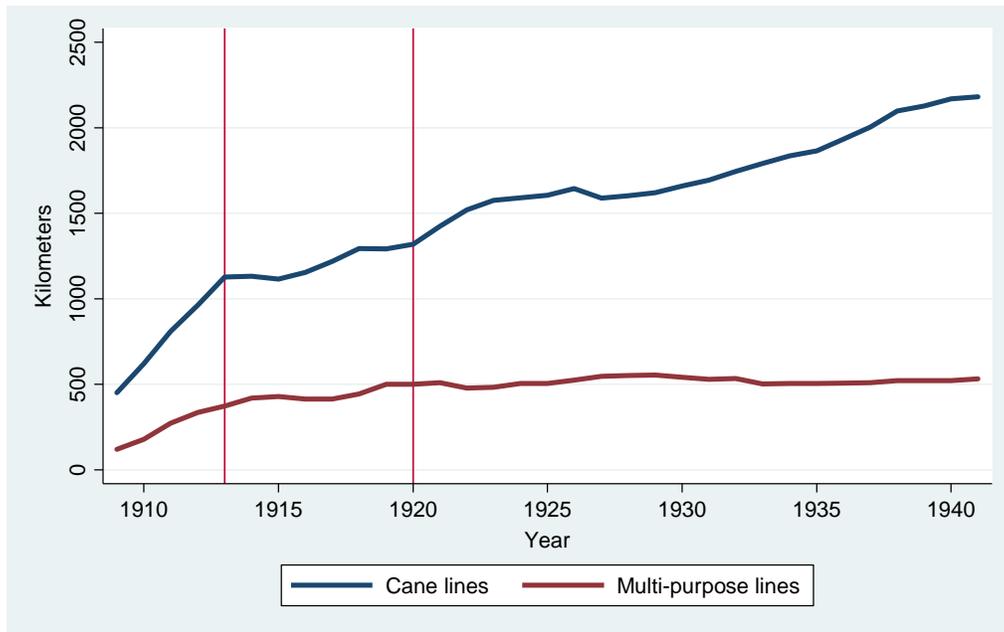
(A) Cane yield
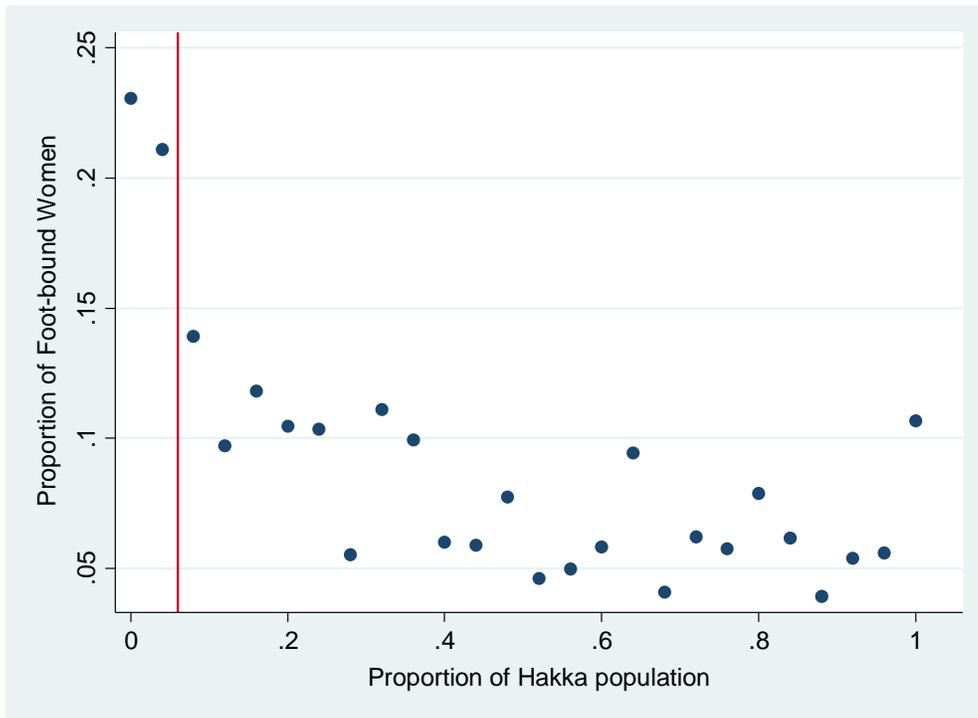
(B) Cane land and yield per *Jia*

Notes: Data are from the 27th Taiwan Sugar Industry Statistics, 1938, pp.15. A Jia is a unit of land area which is equivalent to 0.9699 acre.

Figure 4: Length of cane railroads and multi-purposed railroads

Source: Data are from Ministry of Railroads Annual Report, 1941, p.543.

**Figure 5: Foot-binding exhibits tipping**

Notes: Data are obtained from the Census of 1915, General Volume of Statistical Tables. All the 2,716 villages and districts are categorized into 25 bins, each of which has an equal bin-width of 4 percentage points. The mean for each bin is obtained using the proportion of Hoklo women of all the villages and districts within the bin.

**Figure 6: The geographical correlation between cane cultivation
and foot unbinding**

(A) Change in proportion of cane land,
1905-12
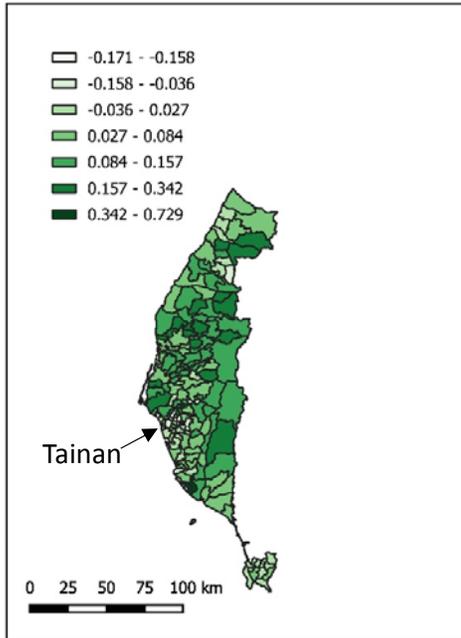
(B) Proportion of unbound women,
1915
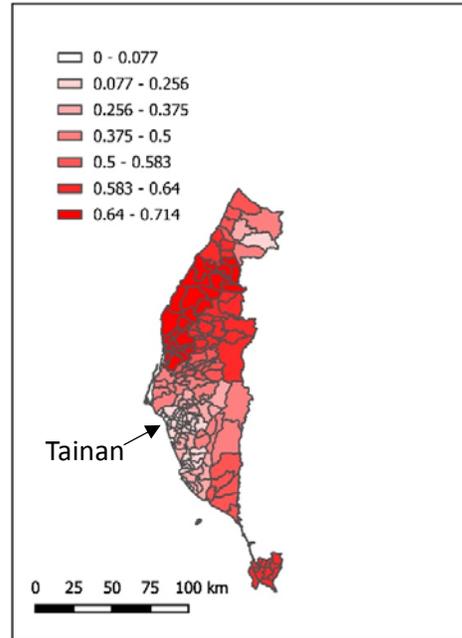
Notes: Data in panel (A) are from the Governor General of Taiwan Statistics Books, 1905 and 1912.
Data in panel (B) are from the Census of 1915, General Volume of Statistical Tables.
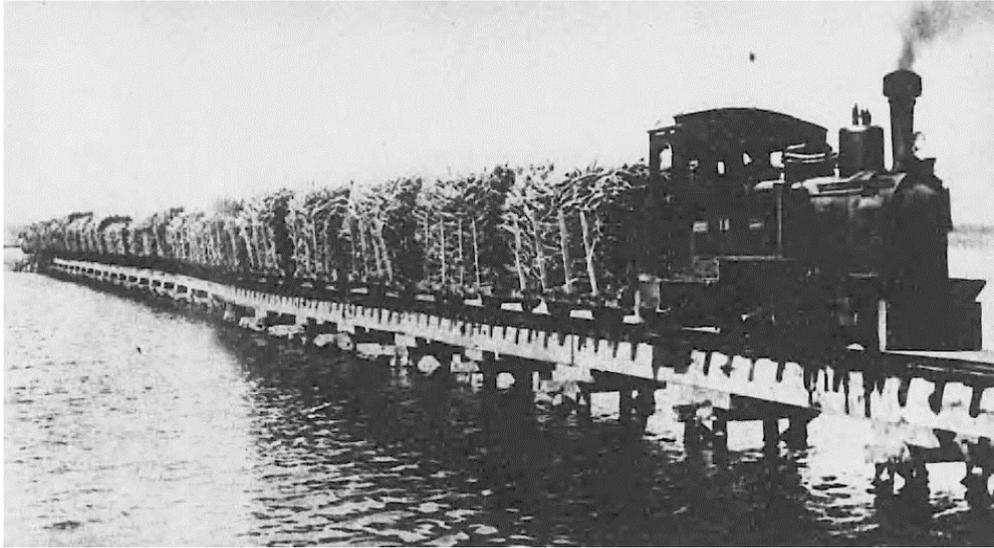
Figure 7: Cane railroads in 1919

Notes: The geospatial vector data are provided by Center for GIS, Research Center for Humanity and Social Sciences, Academia Sinica, Taiwan. Each cane railroad is digitalized using a raw map published in the Sugar Industry Annual Report, 1919.

Appendix

Figure A1: Historical photograph of the cane railroad train

Note: The photo was taken during the colonial period with the exact year being unknown. Source: Ito (1939).