Cotton Revolution and Widow Chastity in Ming and Qing China

RUOBING LIANG, XIAOBING WANG, AND FUTOSHI YAMAUCHI

The historical practice of widow chastity in China is regarded as an outcome of traditional Confucian thought. This study examines how economic factors played key roles in the formation of this cultural tradition by studying the causality between technological progress in the cotton textile sector and the increase in the number of widow chastity cases between the Ming and Qing Dynasties. We find that the incidence of widow chastity increased significantly with rapid technological change in the cotton textile sector and increased demands for female labor. This result remains robust when the issues of widow chastity selection and alternative economic and cultural channels are addressed.

Key words: Cotton revolution, economic rationality, technological progress, widow chastity.

JEL codes: D1, N5.

The formation and persistence of culture have become increasingly exciting research areas in the field of economics. Several studies document the evolution and transmission of gender roles, norms (Alesina, Giuliano, and Nunn 2013; Hansen, Jensen, and Skovsgaard 2015; Giuliano and Nunn 2017), and social capital (trust) (Guiso, Sapienza, and Zingales 2008, 2016; Durante 2009; Nunn and Wantchekon 2011; Lowes et al. 2017). Historical events, such as natural disasters, technological advances, social movements, revolutions, and wars play key roles in cultural evolution. Most studies focus on cultural traits that appear in many cultures, such as the preference for boys over girls, polygamy, religious beliefs, trust, and trustworthiness. The widespread and long-lasting historical tradition of widow chastity has been more popular in China than in other cultures. The practice is stereotypically assumed to be a unique outcome of Confucianism, but its origin has rarely been discussed in economic studies.

Why is chastity culture popular in China? Does chastity represent a unique feature of Chinese culture or, more specifically, reflect a unique environment of cultural evolution? According to Chang (1999), the invasion and conquest of Mongolia in the thirteenth century and the technological progress of the cotton industry in the late Ming and early Qing Dynasties represent key events in the proliferation of widow chastity. The Mongolian conquest laid a foundation for the chastity tradition from an institutional perspective. Specifically, a *Han* widow could choose only between preserving her chastity and remarrying one of her late husband's brothers to maintain ownership of the family's assets. In other words, the Mongolian invasion intensified aspects of the cultural environment conducive to widow chastity. From an economic perspective, the cotton revolution provided widows with a means of livelihood. During the late Ming and early Qing Dynasties, cotton textile work better suited women's

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physical characteristics than traditional agricultural production and could provide a potential means to meet basic living demands.[1]

Since the seminal work by Becker (1973), economic theory has been directly applied to the analysis of social questions regarding marriage, divorce, remarriage, and polygamy (Becker 1991; Becker and Murphy 2000). The rationale underlying family formation is based on the presumption that the benefits of marriage are greater than those of staying single or cohabiting without formal marriage. In marriage, higher incomes among men has tended to support the division of labor between men and women, with husbands working outside the home and wives working at home. However, due to improvements in women's educational attainment and earnings, they are more likely to seek employment than to remain at home as housewives. This trend has delayed the timing of marriage and increased the likelihood of remaining single. This hypothesis has been empirically supported by an aggregate analysis performed in the US (Preston and Richards 1975; Lichter, LeClere, and McLaughlin 1991; Cready, Fossett, and Kiecolt 1997), which showed a correlation between the lower rate of marriage and the higher employment rate among women.

Becker conceived of marriage as an investment; thus, women's marriage decisions heavily depend on the tradeoff between its costs and benefits. This conjecture has been confirmed by a historical analysis of women's marriage behaviors in Europe. Hajnal (1965) was the first to discover the late medieval European marriage pattern (EMP): west of the line between St. Petersburg and Trieste, women's marriage rates were low, a significant proportion of women remained celibate, and even those who married chose to marry late and had a low fertility rate. The EMP not only accelerated economic development in Northwestern Europe but also laid a foundation for the industrial revolution by facilitating human capital accumulation (De Moor and Van Zanden 2010; Voigtländer and Voth 2013; Foreman-Peck and Zhou 2014). The institutional reason underlying the EMP is that in most Northwestern European countries, daughters have inheritance rights that are similar to those of their brothers regardless of their marriage status, whereas in Southern Europe, women can receive property only if they marry. Another important underlying cause is that after the Black Death, an increase in employment opportunities created sufficient economic conditions for women who remained single (De Moor and Van Zanden 2010; Voigtländer and Voth 2013).

A similar mechanism also exists in remarriage behaviors among widows. Brien, Dickert-Conlin, and Weaver (2004) found that Canadian widows decided to remarry after the age of sixty because of the punitive provision on their remarriage before age sixty in the Canadian pension system before 1979. The 1979 change that eliminated the marriage penalty for those at least age sixty resulted in a significant increase in remarriage. Baker, Kantarevic, and Hanna (2004) also found that these provisions on widows' remarriage negatively affected their remarriage rate. Salisbury (2017) recently analyzed the remarriage behaviors of the widows of soldiers killed in the US Civil War with reference to the Civil War Pension Act enacted in 1862, which states that once widows of soldiers remarry, they no longer qualify to obtain a pension. Following the Civil War Pension Act, the probability of widows remarrying decreased by 25%, and the interval between a husband's death and a widow's remarriage extended by 3.5 years.

In contrast, widows who are more financially independent are less concerned about remarriage. In Medieval Europe, particularly in England, a woman could request asset transfer from her husband after marriage; after the husband died, the widow's right to the assets remained legally secured and even a consuetude. The wife's assets could account for more than one third or even half of the total assets, and she could be entitled to the assets under the testament. This institution rendered widows more financially independent and being more competitive in the marriage market may have caused such widows' remarriage rate to increase (Bennett 1981; Hanawalt 1986, 1993). However, when the widow remarried, asset ownership was transferred to her new husband; thus, on average, financially well-off widows were less likely to remarry than otherwise (Todd 1985).

Other studies have shown that women's increased financial capability improves their social status and sex ratio. Qian (2008) found that the sex ratio of men to women decreased

[1]Beginning in the Song Dynasty, foot binding had become very popular among Han women, and this custom reached an apex in the Ming and Qing Dynasties. It also bound women to handcraft production by depriving them of their ability to engage in food production.

and the educational attainment of women significantly increased in tea production areas during the economic reform that began in 1979. Xue (2014) found that in the areas where textile industries developed in China during the thirteenth century, women had a higher social status and there was a more balanced sex ratio than in areas where the textile industries were underdeveloped. Alesina, Giuliano, and Nunn (2013) found that the traditional use of the plow in agricultural production influenced the evolution of gender norms, and in plow-using areas, there is still less female participation in the workplace, politics, and entrepreneurial activities. Thus, the development of industries that demand more female laborers improves the social status of women, and women become less likely to depend on their husbands. Particularly in conservative societies, such as those of the Ming and Qing Dynasties, when Confucianism was dominant in China, whether widows remained unmarried (widow chastity) was influenced by their financial capability.

Using two-period panel data of prefectures in the Ming and Qing Dynasties, this paper aims to identify the effect of the technological progress in cotton textile production on the number of chaste widows in a society dominated by Confucianism. First, we discuss the institutional background of the origin of widow chastity, including the inheritance of assets since the Yuan Dynasty and the potential social recognition and gratification one could obtain through widowhood in the Ming and Qing Dynasties. Second, we theoretically and empirically establish that the increase in the number of widow chastity cases from the Ming to Qing Dynasties is explained by the "cotton revolution", which improved the financial status of women. Our results show that the incidence of widow chastity increased significantly with rapid technological change in the cotton textile sector and increased demand for female labor. Third, we introduce a series of tests to support the robustness of our baseline results. With proxy variables representing Confucianism and norms, the tests show that strict adherence to Confucianism promotes the growth of widow chastity and the impact of technological progress in the cotton textile sector remains robust. In the falsification tests, it is explicit that Confucianism promotes the growth of widow chastity from the Ming to Qing Dynasties and prevents widows' irrational behavior—martyrdom. We also use the economic index, other geographical variables, conflicts and war, and the production of other commodities, such as silk, linen and tea, to address the selection issue in this study. When controlling for the above factors, the coefficients of interest remain stable. Finally, the mechanism analysis also provides evidence that technological progress in cotton textile production explains the growth in widow chastity from the Ming to Qing Dynasties better than traditional cotton planting areas do. Based on additional data on labor participation and income in industrial sectors from the 1920s and 1930s, the results confirm that technological progress in cotton textile production increased female labor participation as well as women's wages, suggesting that the cotton revolution improved the financial capability of widows, thereby explaining the increase in the incidence of widow chastity.

The paper is organized into seven sections. Section 2 summarizes the historical background of the institutional shift and technological progress of the cotton textile industry. Section 3 presents the datasets and theoretical and empirical models. Section 4 presents the baseline results. Section 5 presents the results of the robustness tests, taking into account the cultural influences of Confucianism, issues of selection bias, and the influence of alternative crops and performing other sensitivity tests. Section 6 further discusses the possible mechanism of the cotton revolution's influence on widowhood. The final section presents the conclusions.

Historical Background

Institutional Background of Widow Chastity

The historical practice of widow chastity in China is considered a product of Confucian ethics. "The three guidelines and five rules" and "the three obediences and four virtues" were followed extensively in China, which led to the institution of honoring widow chastity.[2,3] Despite the existence of this institution,

[2]The three guidelines posit that the monarch guides the ministers, the father guides the children, and the husband guides the wife. The five rules are benevolence, righteousness, propriety, wisdom, and trust.

[3]The three obediences advocate that before marriage, a girl must follow her father's guidance; after marriage, the wife must follow her husband's guidance; and if the husband dies, the widow must follow her son's guidance. The four virtues are virtue in behavior, words, comportment, and honor.

lifetime widowhood was rare, and remarriage was common before the Ming Dynasty. According to the *New Book of Tang* and the *Tang Huiyao*, more than one-fifth of Tang Dynasty princesses remarried after their husbands passed away.[4] Thus, most Chinese individuals did not conform to the norm under traditional Confucianism. However, in the Song and Yuan Dynasties, the number of widows who did not remarry increased.

It is traditionally thought that the popularity of widow chastity was highly influenced by Neo-Confucianism during the Song Dynasty. Confucian representatives, including Yi Cheng and Xi Zhu, advocated for the "maintenance of justice at the expense of human desire" and the idea that "starvation is trivial while disloyalty is serious," considering remarriage a severe act of betrayal. These theories overlook the economic factors that played significant roles in the formation and evolution of this norm. Holmgren (1985) and Chang (1999) explored the levirate tradition in Mongolian ethnicities and drew evidence from the Yuan Dynasty.[5] During the Yuan Dynasty, due to the Mongolian takeover and the domination of the nomadic people in China, the Yuan government stipulated that after marriage, a woman's rights and assets would transfer from her parents to her husband's family and that even after the husband's death, the husband's family would retain control over the wife's assets. Mongolia implemented the levirate system primarily for economic reasons. Because nomadic families are highly mobile, the husband's family would suffer severe economic losses if a widow remarried a man outside the tribe and took her late husband's assets with her. Hence, if a Mongolian widow remarried or returned to her parents, she would lose ownership of her assets, including the guardianship of her children. However, the Han population intensively resisted this levirate system, forcing the government to compromise; thus, a Han widow was not required to remarry within her husband's family or to marry anyone else (Holmgren 1985, 1986; Birge 1995; Chang 1999).

In the Ming and Qing Dynasties, to maintain social order, rulers instituted a portfolio of social regulations inspired by Neo-Confucianism and Mongolian customs. For example, Emperor Yuanzhang Zhu enacted a government policy honoring women who were widowed before the age of 30 years and did not remarry for more than 20 years.[6] He also followed the Yuan inheritance law that stated that a remarried widow waived the right to inherit her husband's assets. In 1723 (the early Qing Dynasty), the government reduced the chastity requirement to 15 years; in 1824, the duration was reduced to one decade, and in 1871, it was reduced to 6 years (Shen 1936; Tien 1988; Chang 1999). The positive attitude toward widow chastity in mainstream ideology and propaganda might have led to the observed increase in the number of widows who did not remarry in the Ming and Qing Dynasties. Though the government encouraged widow chastity, widows were still not forbidden from remarrying. More importantly, widow chastity was not rewarded in kind or with cash. Although a chaste widow's family was exempt from labor services, such a privilege would not materialize until at least 10 years after a widow lost her husband, that is, the time when the government could honor her widow chastity.[7]

Consequently, widow chastity resulted in social esteem but not material or economic support. Furthermore, a widow continued to face financial burdens and was likely to be trapped in poverty because of obligations to care for her dependents, including her elders and her children, during her widowhood. Obviously, the government's and society's encouragement of long-term widowhood and the government-issued honors did not solve the financial constraints of widows; thus, these mechanisms are not convincing explanations of the tremendous growth in the number of widows who did not remarry. Based on Li's

[4]During the Tang Dynasty, one hundred and thirty-four princesses married, twenty five of whom remarried. Three of these married three times and one married four times.

[5]The husband's family took charge of the widow's remarriage. This act could be categorized as remarriage to the same or to the next generation. For example, remarriage to the same generation means that after a husband has died, his wife (the sister-in-law) is remarried to his elder or younger brother. Remarriage to the next generation means that after a husband has died, his wife is remarried to a son of his brother; if the uncle died, his wife is remarried to her nephew. A summary of this remarriage system can be found in Guo (2000).

[6]In principle, widows who met those requirements were eligible to be honored with widow chastity by the central government. In practice, however, many qualified women were never honored due to information asymmetry and the complex application process. Please see Section 5.2 for detailed information on the application process.

[7]In the Qing Dynasty, the prize honoring widow chastity was as follows: the local government paid thirty *liang* (tael) silver coins to build a memorial gateway for widow chastity; the family was exempt from servitude and offered grain crops in kind in the event of a natural disaster. However, these incentives hardly improved a widow's well-being under normal circumstances.

(1998) findings from the lower reaches of the Yangtze River, Chang (1999) hypothesized that the introduction of cotton and textile production affected widows' welfare: the cotton textile sector's rapid development beginning in the middle of the Ming Dynasty granted widows greater economic capability, enabling them to live without resorting to remarriage.

Cotton Revolution and Women's Financial Capabilities

In general, widows in the Ming and Qing Dynasties secured their livelihoods by inheriting their husbands' assets and by earning their own income. Inheritance appeared only among wealthy families, and widows were able to take over the assets only on behalf of their children, that is, they did not have the right to directly inherit. Other relatives in the family could force the widow to remarry to keep the assets within the husband's family. If the husband's family was not rich enough, the widow could not depend on the husband's assets. Most widows had to work in spinning, agriculture, housekeeping, and small businesses. The first panel in Figure A1 shows the change in widow chastity patterns from the Ming to Qing Dynasties by prefecture. An increase in widow chastity is observed from the Ming to Qing Dynasties. However, the rapid growth in widow chastity during the Qing Dynasty cannot be explained solely by Confucianism's influence. Following the historical study by Chang (1999), we empirically test the hypothesis that widows' improved financial conditions contributed to an increase in the number of chaste widows.

The cotton revolution during the mid-Ming Dynasty refers to the rapid introduction of cotton production and the development of the textile handcraft industry (Chang 1999). By the early Qing Dynasty, the textile sector had evolved from sideline production within a rural family (cottage) to commercialized or even mainline production due to the significant technological progress at the end of the Ming Dynasty and the early Qing Dynasty (Li 1998). The second panel in Figure A1 shows that approximately one-fifth of China, clustered along the Yangtze River and in the Huang-Huai-Hai (Yellow River, Huaihe River, and Haihe River) plain, is suitable for cotton production. According to the Compilation on Agriculture published during the Ming Dynasty (Xu 1930), spinning machines with four or five axes appeared in Southeast China at the end of the Ming Dynasty. By the Qing Dynasty, spinning machines that could produce 0.5 kg of cotton textile per day were widely used (Li 1998).

Even in the late Song and early Yuan Dynasties, the spinning sector had already experienced significant technological progress. Daopo Huang in Songjiang Prefecture applied "defend, flick, spin and weave" to rolling carts, arches, spinning machines, and weaving machines as well as techniques such as mixing different colored threads to produce knitted and patterned textiles.[8] The weaving machine was invented by Daopo Huang 400 years before the cotton gin was invented by Whitney in the US. This invention transformed Songjiang Prefecture into the center of the textile industry in the Yuan, Ming, and Qing Dynasties. Subsequently, the sea journey ban (1371–567) in the Ming Dynasty was lifted to promote the development of the textile sector. Following porcelain and silk, cotton textile was the third most important product exported to Europe, Japan, and Southeast Asia. Moreover, as proof of cotton production's commercialization, 15 to 20 million *pi* of cotton cloth (1 *pi* = 13 m) was consumed annually by the government alone during the Wanli era (1573–620) of the Ming Dynasty (Yan 1955).

Due to technological progress in the cotton textile sector, the share of textiles in the total value of exchanged products reached 27%, while that of grain crops and silk was approximately 40% and 7%, respectively. More than half of cotton textile products entered the market (Wu and Xu 1985). Cotton textile commercialization also improved women's financial status. Pomeranz (2005) estimated that for a farmer who cultivated rice and wheat on 0.67 ha (10 *mu*) of land, the agricultural production profit was equivalent to 14 *shi* (1 *shi* = 90 *kg*) of rice. One rural laborer who worked 200 days per year would earn less than 5 *shi* of rice. However, one female textile worker could earn more than 7 *shi* of rice. During that time, many women worked in the cotton textile sector; thus, the role of women in their families changed from working at home to working outside the home and financially supporting their families. This change also allowed widows not to remarry.

[8]Songjiang Prefecture in the Ming and Qing Dynasties was located near today's Shanghai municipality.

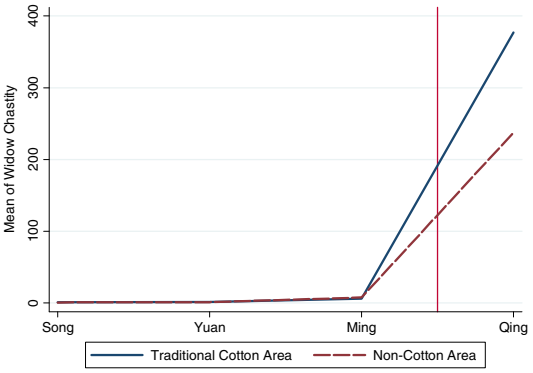

Figure 1. Traditional cotton areas and the number of widow chastity cases [Color figure can be viewed at wileyonlinelibrary.com]

Figure 1 presents the uptrend in the incidence of widow chastity between the Ming and Qing Dynasties; on average, the number of widow chastity cases in traditional cotton-planting areas increased faster than that in noncotton areas. Figure 2 shows the negative relationship between the increase in the number of widow chastity cases and the distance to Songjiang Prefecture, which was the cotton textile technological center in the Ming and Qing Dynasties.

Before the end of the Ming Dynasty, men worked more efficiently than women because men could handle more labor-intensive work and were more skilled than women, for example, traditionally, only men inherited weaving techniques (Li 1998). However, due to the technological progress at the end of the Ming Dynasty, women could work more efficiently, and men's comparative advantage diminished. Men began to play an important role in agricultural production and to work as secondary laborers in the cotton textile sector in the agricultural production off season. Although the linen and silk textile sectors were important during the Ming and Qing Dynasties, these two sectors cannot explain the increase in the incidence of widow chastity. Before the Yuan and Ming Dynasties, silk and linen were important materials for cloth, but the price of silk was high, and silk production was highly specialized. Silk production moved from rural families to workshops, and widows could not easily engage in silk production. In linen production, the added value was low, and the income from linen production was not enough to secure the livelihood of a family (Li 1998; Chang 1999).

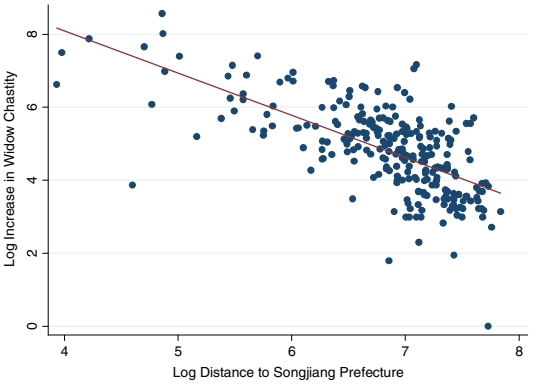

Figure 2. Relationship between distance to Songjiang prefecture and change in the number of widow chastity cases from the Ming to Qing dynasty [Color figure can be viewed at wileyonlinelibrary.com]

Theoretical Model

In this subsection, we lay out a simple model to clarify our key hypotheses. Widows decide whether they remarry or stay widowed in each period after seeing a randomly drawn value of a potential spouse. Here, we do not ask how they became widows – voluntarily or involuntarily. $V_R(v)$ is the value of remarrying to a spouse of value v. Similarly, V_W is the value of staying widowed. Subscripts R and W stand for the states of remarrying and staying widowed, respectively. Thus, the widow will compare $V_R(v)$ and V_W to make the decision.

$$(1) \quad V(v) = max_{R,W}\{V_R(v), V_W\}$$

where spouse value v~F(v). Assume that if remarrying, she will have the value of her spouse v and labor income $(1-\alpha)y(z)$. The value of α represents the time allocated to family duties and the responsibilities imposed by the new family. For example, if they are engaged in farming, she is expected to assist with fieldwork. In our context, $y(z)$ is wages from textile work at home or a workshop, which is a function of technology z. While $y(z)$ is driven by technological change, α is culturally determined. In the current setting, $V_R(v)$ is determined as

$$(2) \quad V_R(v) = (1-\alpha)y(z) + v + \beta V_R(v)$$

where β is the discount factor. The value of staying widowed V_W is determined as

$$(3) \quad V_W = y(z) - c + \beta EV(v')$$

where c is the cost associated with widowhood, and $EV(v')$ is the expected value in the next period. Note that c can be negative if the widow is socially rewarded. Solving the Bellman equation in this search model,

$$(4) \quad V(v) = max_{R,W}\left\{\frac{1}{1-\beta}[(1-\alpha)y(z) + v], y(z) - c + \beta EV(v')\right\}$$

we obtain

$$(5) \quad v^* = m[\beta EV(v') - c] + (\alpha - \beta)y(z)$$

where $m = 1 - \beta$. Here, the widow will remarry if $v > v^*$ (i.e., she stays widowed if $v < v^*$). Assume that $\alpha > \beta$. The probability of remaining widowed is $F(v^*)$. We have three observations from the above model. It is more likely for the widow to stay widowed if (*a*) textile wages increase due to an increase in female labor demands driven by technological change, (*b*) the traditional duties cast upon married women are heavier, and (*c*) the cost associated with widowhood is smaller (or widowhood is socially rewarded). These changes in (*a*) to (*c*) will increase v^*; therefore, the widow is more likely to stay widowed in the above scenario.

Econometric Models and Data Sources

Econometric Models

This paper aims to identify the economic mechanism explaining the variation in the number of widow chastity cases in a society dominated by Confucianism. Our main theory is that a dramatic improvement in women's work efficiency, driven by the technological progress in the cotton textile sector, provided better income opportunities for women to secure a livelihood; this change enabled widow chastity. We hypothesize that the large difference in widows' choice to pursue chastity between the Ming and Qing Dynasties was mainly the result of technological progress in the textile sector and the specialization of agricultural and textile production. This paper applies a fixed effects model to disentangle the factors that may explain the difference in the incidence of honored widow chastity between the Ming and Qing Dynasties.

The estimation model is described as follows:

$$(6) \quad lnwidow_{ic} = \alpha + \beta_0 t_c + \beta_1 t_c \times lndist_i + \gamma t_c \times \mathbf{Z}_i + \varepsilon_i + \mu_{ic}$$

where the dependent variable is $lnwidow_{ic}$, which is defined as the log form of the number of honored widow chastity cases (per 10,000) during period c in i prefecture; t_c is a dummy variable representing the dynasty, where 0 represents the Ming Dynasty and 1 represents the Qing Dynasty; and $lndist_i$is the log form of the distance of i prefecture to Songjiang Prefecture, the center of textile production from the Song to Qing Dynasties and the place where the famous Daopo Huang introduced and invented several new textile technologies at the end of the Song Dynasty and the beginning of Yuan Dynasty. $\mathbf{Z}_i$ is a vector of the time-invariant variables, including the geographical location, topographical, and climate variables and population density, and $t_c \times \mathbf{Z}_i$ controls for the possible influence of confounding factors; ε_i and μ_{ic} are the prefecture fixed effects and error terms, respectively. Here, geographical variables include the dummy variable of provincial capital, land area, elevation, slope, longitude, and latitude; weather data include annual mean temperature and precipitation. The interaction terms between the Qing Dynasty dummy and these variables are included as additional controls.

One of our hypotheses regards whether technological progress in the cotton textile sector had a determinant impact on the growth in widow chastity between the Ming and Qing Dynasties. We also test the effects of the cultural determinism of traditional norms (Confucianism and popular customs) on widow chastity. To address the selection issue, we test the influence of those variables, namely, the distance to Beijing and provincial capitals, economic development, the introduction of new food products (maize), natural calamities, and domestic conflict, that are associated with the number of widow chastity cases. Furthermore, other traditional textile sectors, such as silk and linen textiles, and tea production may influence widow chastity, and we also test their influence. Finally,

quasi-experimental analysis requires a common trend test to confirm that the number of widow chastity cases increased (more) rapidly in the Qing Dynasty. For this, we use data from before the Qing Dynasty.

In the mechanism analysis, we adopt two strategies to verify our logic. First, we use a traditional cotton planting variable to replace the distance variable and then put the two variables into the model together. Second, we use the interaction term of distance and cotton planting to capture the interactive effects of cotton production and technological progress.

The specifications are described as follows:

$$(7)\quad lnwidow_{ic} = \alpha + \beta_0 t_c + \beta_1 t_c \times lndist_i + \beta_2 t_c \times cotton_i + \gamma t_c \times \mathbf{Z}_i + \varepsilon_i + \mu_{ic}$$

$$(8)\quad lnwidow_{ic} = \alpha + \beta_0 t_c + \beta_1 t_c \times lndist_i + \beta_2 t_c \times cotton_i + \beta_3 t_c \times lndist_i \times cotton_i + \gamma t_c \times \mathbf{Z}_i + \varepsilon_i + \mu_{ic}$$

Specifically, $cotton_i$ represents whether cotton production occurred in i prefecture traditionally (1 = yes; 0 = no). The interaction term $t_c \times cotton_i$ captures the effect of cotton production from the Ming to Qing Dynasties on widow chastity; the triple interaction term $t_c \times lndist_i \times cotton_i$ checks whether the development of textile production is necessary for cotton production to impact widow chastity (and *vice versa*). Although cotton and textile production are vertically linked, the variable $t_c \times lndist_i$ also includes types of textiles other than cotton and therefore represents the whole effect of textile development on widow chastity (female labor demand). However, lack of cotton production would also mean the lack of a critically important input to textile production.

Data Sources

The number of honored widow chastity cases and the change in this number between the Ming and Qing Dynasties are the dependent variables of interest. More than 84,000 records of famous women are manually sourced from the "Compilation of the Qing Dynasty Revised in *Jiaqing*'s Reign" by Guwargiya et al. (2008).[9] Furthermore, we use the number of honored widows who committed suicide in the falsification tests. Distance to the technological center, Songjiang Prefecture, is obtained from the China Historical Geographic Information System (CHGIS), which was jointly developed by the Fairbank Center for Chinese Studies, Harvard University, and the Historical Geography Research Center of Fudan University.[10] The cotton production indicator is constructed based on whether cotton was produced in the prefecture (or province) in either the Ming or Qing Dynasty (Guwargiya et al. 2008).

Population data from 1600 and 1820 are obtained from the History Database of the Global Environment (HDGE) at the prefectural level to normalize the key dependent and independent variables and the population density.[11] We also use geographical data obtained from CHGIS, including the prefectures' average areas, elevations, slopes, longitudes, and latitudes. Weather data, including annual average temperature and precipitation, are collected from the National Earth System Science Data Center (NESSDC).[2] To assess the effects of the selection bias potentially created by the widow chastity procedure, we also include distance to provincial capitals, distance to Beijing, regional economic development proxied by agricultural tax (Liang 1980), the maize planting suitability index, and the frequency of conflicts and of natural calamities (see Figure A3, Chen et al. 1986).[13] Finally, in robustness tests, we select silk, linen, and tea as alternative commodities to test the possibility that the cotton textile technological progress variable captures the effects of other commercial crops closely related to women.

To test the Confucianism effect, we use the following four proxy variables to represent the influence of Confucianism and customs (cultural effect). We use the quota for the imperial examination assigned at the prefectural level (Bai and Jia 2016); this quota consists of two parts: each county in the prefecture received a quota, and the prefecture as a whole received an additional

[9]This compilation was written in three series for the Kangxi, Qianlong, and Jiaqing reigns. The final series, which was revised under Jiaqing's reign, includes 560 volumes (Figure A2). The compilation began in 1812 and was completed during the 22nd year of Daoguang's reign in 1842. All information is updated to the year 1820.

[10]The data are available at http://www.fas.harvard.edu/~chgis/, and we use the version published in April 2007.

[11]The History Database of the Global Environment is accessible at: https://themasites.pbl.nl/tridion/en/themasites/hyde/index.html.

[2]The National Earth System Science Data Center is accessible at http://www.geodata.cn/.

[13]The suitability index of maize planting is calculated based on regional temperature, moisture, soil, terrain, and water deficit conditions. Detailed information is available at http://gaez.fao.org/Main.html#.

quota that could be shared among counties.[14] The data on quotas come from Guwargiya et al. (2008) and were determined based on the Imperially Established Institutes and Laws of the Great Qing Dynasty (Aisingoro et al. 1899). Schools in the Qing Dynasty mainly taught candidates for the imperial examination, and the curricula and syllabus in these schools mainly focused on traditional classics of Confucianism (Yuchtman 2017). Thus, the number of schools at the prefectural level reported in the study by Guwargiya et al. (2008) is used to represent the impact of Confucianism. Ancestral shrines are well documented as representing the cultural/customs effect (Guwargiya et al. 2008). The number of ancestral shrines in the Qing Dynasty is also obtained from the above study.[15]

In the mechanism analysis, we employ two data sources to investigate the labor participation and income of female workers. Specifically, the employment data come from the industrial enterprise survey conducted by the Resource Committee of the National Military Council in 1936 (Liu 1937), and the wage data are obtained from the worker living survey conducted by the Ministry of Industry and Commerce (MIC) of the National Government from 1926–30 (MIC 1930). With these two data sources, we can analyze the effect of the distance to Songjiang Prefecture on female employment and wages. The descriptive statistics of the variables are presented in Table A1.

Empirical Results

This section presents the empirical results. The main results are shown in Columns 1–6 of table 1. The results show that the coefficients of the log distance–Qing Dynasty dummy interaction term are negative and statistically significant, and the coefficient magnitudes are stable across the specifications. Without the distance variable, the coefficients of the dynasty dummy variable (t) are positive and significant, suggesting that the number of widow chastity cases increased between the Ming and Qing Dynasties. This time trend captures the positive effects of the supporting policy as well as cultural factors on widow chastity. In addition, the number of widow chastity cases per 10,000 people decreased between the Ming and Qing Dynasties by 37%–44.2% as the distance to Songjiang Prefecture increased by 1% point, and the results are statistically significant. Therefore, the growth in widow chastity was high in prefectures where cotton textile technology was comparatively advanced in the Qing Dynasty.

Columns 4–6 add variables such as geographical variables, interacted with the Qing Dynasty dummy, and population density. The interaction terms between the provincial capital dummy and the Qing Dynasty dummy are positive and statistically significant, which indicates that proximity to local authority led to an increase in the incidence of widow chastity from the Ming to Qing Dynasties. We use population density at the prefecture level to test the bandwagon theory (Chang 1999). The significant and positive effects of population density indicate that chastity behavior in the Ming and Qing Dynasties was related to population density, which is consistent with our conjecture that women might be forced to act under pressure from their peers and the public. The magnitude of the parameter estimate of the interaction term between the distance variable and the Qing Dynasty dummy in Column 4 slightly decreased when controlling for population density. Interestingly, in Columns 5 and 6, the Qing Dynasty effect becomes insignificant, while population density remains significantly positive. This finding can be explained by the fact that population density is related to income level (Chen and Kung 2016). Nevertheless, the interaction term of the distance and the Qing Dynasty dummy remains significant and negative in Columns 4 to 6, which appears to support our key proposition on technological change and women's economic status.

Robustness Tests

Alternative Explanations of Cultural Influence

According to traditional explanations based on Chinese culture, Confucianism, especially

[14]Further details about the imperial examination can be found in Lin (1995), Bai and Jia (2016), and Yuchtman (2017).

[15]All of the four proxy factors exists in the pre-period (Ming dynasty or before); however, the cultural effects differ significantly between Ming and Qing Dynasties. For example, Keju imperial examination started from Sui Dynasty and formalized in Tang Dynasty. In each of dynasties, there are some reforms on the imperial examinations to select the elites. At the beginning of Ming dynasty, the numbers of elites selected from Southern China exceed those from Northern China. To balance the numbers of the elites selected between Southern and Northern China, the imperial examines were designed into two exams specified for the elites in the two regions. In Qing dynasties, the imperial examination was unified into one national exam. The quotas have been increased for the Northern China and the remoted province like Yunnan. Similarly, we also expects the expansion of schools in Qing Dynasty.

Table 1. Baseline Results

	lnwidow (1)	*lnwidow* (2)	*lnwidow* (3)	*lnwidow* (4)	*lnwidow* (5)	*lnwidow* (6)
$t \times lndist$	−0.370*** (0.046)	−0.442*** (0.045)	−0.442*** (0.046)	−0.412*** (0.045)	−0.363*** (0.078)	−0.390*** (0.082)
t	3.319*** (0.322)	3.807*** (0.309)	3.810*** (0.316)	3.095*** (0.454)	1.074 (1.653)	4.043 (3.304)
lnpopden				0.352*** (0.125)	0.416*** (0.136)	0.444*** (0.142)
$t \times capi$				0.227*** (0.086)	0.216*** (0.082)	0.218*** (0.082)
$t \times lnarea$				0.007 (0.030)	0.013 (0.028)	0.011 (0.028)
$t \times slope$					0.032 (0.024)	0.050* (0.029)
$t \times alti$					−0.000 (0.000)	−0.000 (0.000)
$t \times lati$					0.019*** (0.006)	−0.005 (0.029)
$t \times longi$					0.008 (0.011)	0.010 (0.011)
$t \times temp$						−0.001 (0.003)
$t \times lnpreci$						−0.235 (0.169)
constant	0.101*** (0.012)	0.101*** (0.013)	0.173*** (0.057)	−0.988** (0.385)	−1.185*** (0.419)	−1.273*** (0.438)
Prefecture effects	N	Y	N	Y	Y	Y
Province effects	N	N	Y	N	N	N
Observations	522	522	522	522	522	522
Prefectures		261		261	261	261
Within R^2	0.616	0.812	0.691	0.826	0.835	0.837

Notes: Coefficients are reported with standard errors, clustered at the prefecture level, in parentheses.
*$p < 0.1$.
**$p < 0.05$.
***$p < 0.01$.

Table 2. Alternative Explanation of Cultural Influences

	lnwidow (1)	*lnsuicide* (2)	*lnboth* (3)
$t \times lndist$	−0.480*** (0.076)	0.023 (0.036)	−0.409*** (0.070)
$t \times lnquota$	0.496*** (0.144)	−0.219*** (0.084)	0.269** (0.130)
$t \times lnschool$	−1.045** (0.477)	0.581* (0.327)	−0.358 (0.455)
$t \times lnshrine$	0.510 (0.379)	−0.345 (0.270)	−0.010 (0.379)
$t \times lntemple$	0.570* (0.307)	0.020 (0.160)	0.438 (0.267)
Prefecture effects	Y	Y	Y
Observations	522	522	522
Prefectures	261	261	261
Within R^2	0.856	0.288	0.832

Notes: Coefficients are reported with standard errors, clustered at prefecture level, in parentheses; control variables include *t, lnpopden, t*capi, t*lnarea, t*slope, t*alti, t*lalti t*longi, t*temp, and t*lnpreci.*

*$p < 0.1$.

**$p < 0.05$.

***$p < 0.01$.

the Neo-Confucianism developed by Yi Cheng and Xi Zhu in the Song Dynasty, played a key role in forming the chastity culture. We use additional culture-related variables to test this theory. The traditional cultural variables, including the imperial examination quota (*keju* in Chinese), the number of schools teaching the traditional Chinese classics (*Shuyuan* in Chinese), and the number of ancestral shrines (*Zongci* and *Zumiao* in Chinese), are normalized by population size and converted to log form. These variables are used to reflect the possible cultural impacts of different social factors: the direct influence, indirect influence, and folk-custom influence of Confucianism. The log form of the number of temples (*Si* and *Guan* in Chinese) per 10,000 people is used to capture the influence of Buddhism and Taoism. We estimate the interaction effects of each of these variables with the Qing Dynasty dummy to determine the magnitude and direction of these social effects.

In column 1 of table 2, the average imperial examination quota, the number of schools, and the number of temples, but not the number of traditional shrines, are statistically significant. The coefficients of the quota variable and the number of temples are positive and significant, suggesting that official Confucian education, Buddhism, and Taoism had positive influences on widow chastity. In contrast, the negative coefficient of the number of schools indicates that unofficial Confucian education had a negative and statistically significant effect on the incidence of widow chastity. Surprisingly, this contradicts the traditional explanation. Column 1 of table 2 also shows that textile technology played a significant role in widows' choices, notwithstanding the cultural factors, which also exerted influences. To test the hypothesis that women from wealthy families were more likely to comply with Confucianism's common rules in column 2, we conduct falsification tests to analyze the effect of textile technological progress on the number of widows who committed suicide.[16] The technological effect on martyrdom behavior (the number of widow suicides) is not statistically significant (Column 2), and its effect on the total number of both widow chastity cases and widows who committed suicide remains negative and statistically significant (Column 3). These results are consistent with the hypothesis that the technological development of the cotton textile sector affected widows' choice to pursue chastity instead of committing suicide. However, they failed to support the possibility that the development of the cotton textile sector decreased the number of widow suicides by improving their economic prospects.

Because the influence of traditional culture cannot be ignored in widow chastity behavior, could it also impact widow suicide? To answer this question, we examine the effect of cultural factors on martyrdom behavior. Column 2 of table 2 shows the effects of various cultural variables on martyrdom behavior. We find a significant negative effect of the quota, indicating that official Confucianism did not promote martyrdom behavior. The results partially reflect the official ideological differences

[16]Women from noble families or the courtier class were more conformist. Guo (1987) explored fifty genealogies and found only one case in courtier families in which the widow remarried. Ju (2001) also examined forty-six genealogies and found that among 5277 women, more than a quarter (1263 women) were widows.

regarding chastity and martyrdom recorded in the Emperor's Commission. Column 3 reports the estimation results for the number of widow chastity and suicide cases. Except for the quota, all other cultural variables are insignificant.

Overall, our findings are consistent with the opinion expressed by the emperors during the Qing Dynasty. For example, both Kangxi (1654–722) and Yongzheng (1678–735) had reservations regarding widow suicide but honored widow chastity on several official occasions. The Yongzheng Emperor often commented on the two behaviors, that is, widow chastity and widow suicide, and encouraged the former. For example, he said that "the widow commit[ing] suicide…she should be responsible for the family after the death of the husband…and she should not absolve her responsibility by committing suicide" (Records Commission 1985). He did not honor widow suicide, which to him was irresponsible. He also maintained a conservative opinion regarding widow chastity for those widows in the Eight Banner clans (Manchurian families). For example, he said, "If Banner widows are young, childless and without clansmen, it is not beneficial to them to maintain widow chastity" (Aisingoro et al. 1976). The reason for his stance was that once a widow from any of the Eight Banner clans chose to maintain widow chastity, her expenses would be covered by the government. To reduce the costs incurred by widow chastity, the government decided whether to allow the widow to maintain her chastity. In contrast, a Han widow, whose expenses were not covered by the government, was free to maintain her chastity.

Widow Chastity Selection

The Qing government was in fact likely to approve widow chastity, although not all chaste widows could be honored, as widow chastity selection was subject to the following procedure. The nomination for widow chastity was made by the husband's clan or the local gentry; then, the central government honored widows upon the submission of the applications by the local authorities. Guo (2000) noted that widow chastity was mainly recognized in families in either wealthy areas or areas with accessible geographical locations. Widows who resided in remote areas or originated from poor families in poor areas were less likely to be honored for widow chastity. The variable representing technological progress in the cotton textile sector could capture the selection effects of widow chastity; therefore, this variable may lead to bias.

We use the following two groups of variables to explore the variation in widow chastity selection: an economic index and a vector of distance variables. Here, agricultural productivity proxied by the agricultural tax revenue per capita is used as an economic index, and two distance variables represent the distance from the prefecture seat to the capital of China (Beijing) and the distance between the prefecture seat to the province's capital city. The interaction terms between the Qing Dynasty dummy and these variables are included as additional controls for the robustness check. Column 1 in table 3 presents the results controlling for the interaction terms between the Qing Dynasty dummy and the additional control variables of the economic index and two distance variables. The coefficients of the interaction terms between the agricultural tax revenue per capita and the Qing Dynasty dummy are positive and statistically significant. Thus, the results overall lead us to the following two conclusions: first, rural income had a positive impact on the number of widow chastity cases; second, widows residing in wealthy regions, likely located in eastern China, had better financial capacity. After controlling for the above factors, the coefficient slightly increases for the interaction term between technological progress and the Qing Dynasty dummy. Regional differences in the male mortality rate can cause selectivity bias, because the number of widows itself is affected by the number of adult male deaths. Thus, if the observed regional differences in honored widow chastity cases could have resulted from differences in the number of widows caused by unobserved factors or correlated with male mortality and the technology variable is also potentially correlated with such factors, as mentioned above, the parameter of interest could be biased.

We include the maize suitability index (SIM) to proxy the extent of maize production during the early Qing Dynasty, when rapid population growth occurred due to the spread of maize cultivation (Chen and Kung 2016). We also use the frequency of conflicts and natural calamities to control for the effects of the male mortality rate on widow chastity.[17]

[17]Wars and natural calamities also affect the female mortality rate, rendering the total effect on the number of widows ambiguous when combined with the effect on the male mortality rate.

Table 3. Widow Chastity Selection and Alternative Crops

	lnwidow (1)	*lnwidow* (2)	*lnwidow* (3)	*lnwidow* (4)	*lnwidow* (5)
t × *lndist*	−0.448*** (0.081)	−0.388*** (0.081)	−0.393*** (0.081)	−0.447*** (0.080)	−0.503*** (0.074)
t × *lnagrtax*	0.064*** (0.023)			0.073*** (0.022)	0.024 (0.024)
t × *lndis2pc*	−0.055* (0.031)			−0.047 (0.032)	−0.054* (0.031)
t × *lndis2bj*	−0.066* (0.035)			−0.069* (0.038)	−0.032 (0.038)
t × *lnSIM*		0.035 (0.034)		0.007 (0.038)	−0.037 (0.040)
t × *lnconf*		0.087** (0.040)		0.087** (0.040)	0.042 (0.041)
t × *lndisa*		0.018 (0.025)		0.003 (0.023)	0.016 (0.024)
t × *silk*			−0.073 (0.059)	−0.049 (0.057)	−0.031 (0.058)
t × *linen*			0.035 (0.051)	0.014 (0.051)	0.043 (0.049)
t × *tea*			0.004 (0.004)	0.010*** (0.004)	0.013*** (0.004)
t × *lnquota*					0.412** (0.164)
t × *lnschool*					−1.092** (0.496)
t × *lnshrine*					0.524 (0.415)
t × *lntemple*					0.770** (0.328)
Prefecture effects	Y	Y	Y	Y	Y
Observations	522	522	522	522	522
Prefectures	261	261	261	261	261
Within R^2	0.845	0.841	0.838	0.850	0.863

Notes: Coefficients are reported with standard errors, clustered at prefecture level, in parentheses; control variables are *t, lnpopden, t*capi, t*lnarea, t*slope, t*alti, t*lalti t*longi, t*temp*, and *t*lnpreci*.
*$p < 0.1$.
**$p < 0.05$.
***$p < 0.01$.

Column 2 in table 3 shows that the number of conflicts interacted with the Qing dummy has a significant positive effect, indicating that the male mortality rate increased with wars and conflicts; therefore, the number of widows also increased. Despite the significant effect of conflicts on widow chastity, the interaction term of the Qing Dynasty and technological progress remains significant.

Impact of Alternative Crops

The previous estimates supported the hypothesis that technological progress in cotton textile production led to an increase in the number of widow chastity cases. Although the case seems compelling, another potential cause could be that women were capable of working in handicraft sectors other than cotton textile production even in cotton production areas, enabling them to earn enough to independently support their families. We conduct placebo tests. In the following placebo tests, we highlight whether the prefecture also produced silk, linen, and tea. Thus, we analyze the evolution of the production of these other crops and their effects on the number of widow chastity cases.

Existing studies confirm that linen had a low value, and linen production was insufficient for a widow to support a family (Chang 1999). However, silk prices were higher, and silk production was more specialized. Silk production shifted from rural areas to the city and city suburbs before the Qing Dynasty (Li 1998). Women in rural areas were rarely engaged in silk production. Tea was a cash crop in which women tended to specialize (Qian 2008), but the technological progress in tea production was insignificant between the Ming and Qing Dynasties.

Our results indicate that the production of these three crops did not have a significant impact on the number of widow chastity cases in the Ming and Qing Dynasties. Column 3 in table 3 presents the results including all three crops combined. The coefficients of the interaction terms between the production of these crops and the Qing Dynasty dummy are statistically insignificant. Although the interaction term between tea and the Qing Dynasty dummy is positive and significant at the 1% level in Columns 4 and 5, the interaction term of the cotton technology variable remains stable. Though women could specialize in the production of the three alternative crops, the evolution of their production was orthogonal to the chastity effect of cotton technological progress from the Ming to Qing Dynasties.

Location Effects

There are three possible sample selection issues that could damage the robustness of the baseline results. First, because Songjiang Prefecture was close to the sea, the prefectures that are geographically adjacent to the technological center of cotton production could also be close to domestic harbors for international trade reopened during the late Ming Dynasty and the early Qing Dynasty. This could confound the widow chastity effect of technological progress with international trade. Second, the prefectures that were far from traditional cotton production regions or located in a province with no cotton production should not be included in the sample. Thus, it is not appropriate to compare them with prefectures in cotton production regions or near cotton textile technological centers. Third, the lower Yangtze River region, known as the traditional cotton-planting region and textile center of China, has a history of a high number of widow chastity cases. In contrast, other regions far from the lower Yangtze River region recorded far fewer chastity cases. It is possible that the treatment effect of technological progress decreased substantially along with the distance to Songjiang Prefecture.

To address these possible issues, we use three sample restriction strategies. The first is to run a regression with a sample that randomly drops one province at a time. Figure 3 shows the estimation results of seventeen regressions following this procedure. It is notable that even when some coastal provinces are dropped, such as Jiangsu, Zhejiang, Fujian, and Guangdong, the interaction terms of the Qing dummy and the distance to Songjiang Prefecture are all statistically significant, and the coefficients range between −0.406 and − 0.668.

The second strategy is to use provinces containing at least one cotton-producing prefecture, and the third is to use prefectures that produced cotton and prefectures next to at least one prefecture that produced cotton. The estimation results in Columns 1 and 2 of Table A2 show that the coefficients of the interaction terms of the Qing dummy and the distance to Songjiang Prefecture are −0.533 and − 0.613, respectively, both statistically significant and greater than the baseline results.

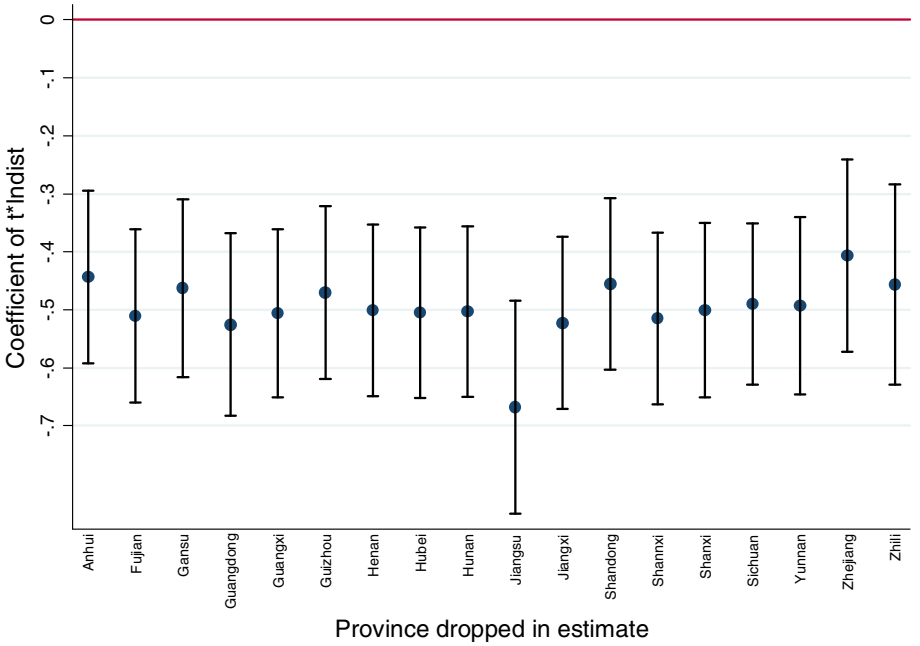

Figure 3. Estimates with one province dropped at a time [Color figure can be viewed at wileyonlinelibrary.com]

The final strategy is to use three circles of prefectures with different distances to Songjiang Prefecture (Figure A4). The inner circle includes eight provinces near Songjiang Prefecture, namely, Jiangsu, Zhejiang, Anhui, Henan, Shandong, Hubei, Jiangxi, and Fujian Provinces; the middle circle, Guizhou, Guangdong, Guangxi, Hunan, Shannxi, Shanxi, Zhili and the eastern prefectures of Sichuan; and the outer circle, Gansu, Yunnan, and the western prefectures of Sichuan. Columns 3–5 of Table A2 show that the coefficients of the estimates with different subsamples are stable between −0.503 and − 0.589, showing that the baseline result is not sensitive to sample selection issues.

Another major change between the Ming and Qing dynasties was that for most of the Ming dynasty, trade was boycotted. To test whether international trade influenced the effect of cotton technology on widow chastity, we include a new variable, the distance to the nearest of the four ports opened for trade during 1685–757.[18] The result in Column 6 of Table A2 shows no evidence directly supporting this hypothesis.

Common Trend Test

Quasi-experimental estimations assume a common trend between the treatment and control groups. Without the treatment, the common trend in the treatment and control groups should be consistent, allowing for the determination of whether the differences between the treatment and control groups are caused by the treatment, that is, the cotton revolution. To test the common trend, the trend in the treatment and control groups before the treatment's occurrence is widely used. We need to test the common trend across the prefectures located at different distances to Songjiang Prefecture before the Qing Dynasty.

More specifically, we test the differences between the Ming and Yuan Dynasties and between the Yuan and pre-Yuan Dynasties. This strategy is appropriate because the commercialization of the cotton textile sector began at the end of the Ming Dynasty and in the early Qing Dynasty; that is, no significant changes were observed in the textile sector during most of the Ming, Yuan and pre-Yuan Dynasties. Therefore, if our hypothesis is

[18]In the reign of Kangxi in the Qing Dynasty (1685), China opened four ports for trade, namely, Guangzhou, Fuzhou, Ningbo and Shanghai. Then, in the reign of Qianlong in the Qing Dynasty (1757), China closed three of the four ports and left only Guangzhou open for trade.

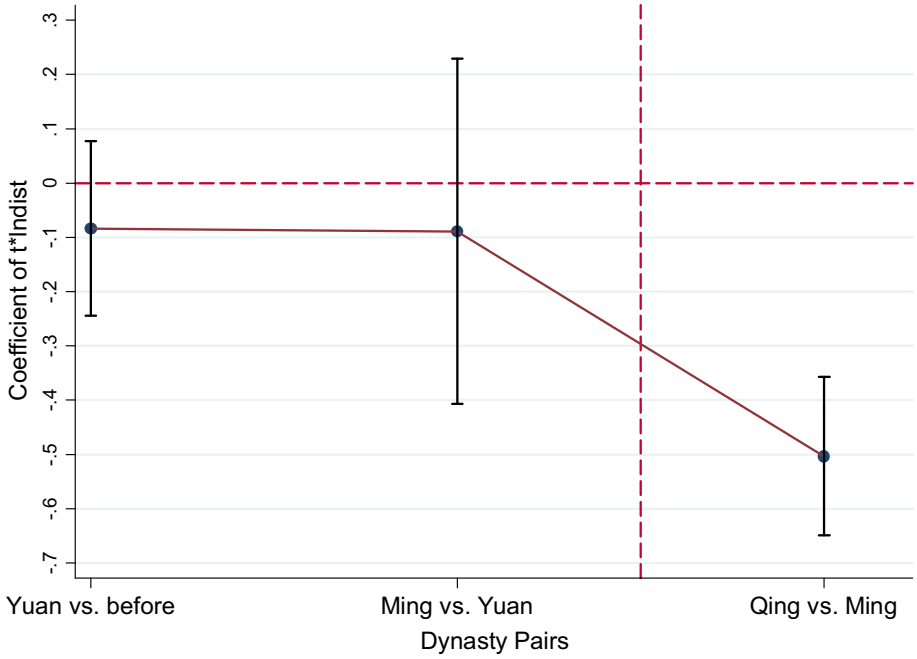

Figure 4. Common trend test [Color figure can be viewed at wileyonlinelibrary.com]

correct, the number of widow chastity cases is not expected to change before the end of the Ming Dynasty.

Columns 1–3 of table A3 present the results of the common trend tests among the Ming, Yuan and pre-Yuan Dynasties. The results in table A3 and figure 4 show that cotton textile technological progress did not have a statistically significant impact on the number of widow chastity cases before the Qing Dynasty. The common trend before the Qing Dynasty indicates that in the cotton textile sector, the weaving innovation introduced by Daopo Huang was a necessary but not sufficient condition for the evolution of textile commercialization. Other external conditions, such as cotton seeds, domestic demand and the international trade of cotton and textiles, are also necessary for textile commercialization. During the Ming Dynasty (1371–567), international trade was boycotted. The stagnation of international trade lasted until the early seventeenth century, when the boycott was lifted, but at that time, the Ming Dynasty was already in its twilight, and the prototype of capitalism did not evolve into an industrial revolution (Brandt, Ma, and Rawski 2014).[19]

Omitted Variable Test

Another threat is omitted variable bias, which is one of the key issues that leads to bias in cause-effect analysis (Wooldridge 2005). Although we control for geographical variables, cultural variables, selection variables, and competing explanatory variables, omitted variable bias is still an issue worth considering. To address this, we adopt the test strategy developed by Oster (2019), which takes into account the R-squared to establish a range from a controlled treatment effect to an unbiased treatment effect. This method builds on the theory of Altonji, Elder, and Taber (2005), which evaluates omitted variable bias by observing coefficient changes after the inclusion of control variables under the assumption that selection on observables is informative about selection on unobservables.

We perform the Oster (2019) sensitivity test by assuming the maximum of R-squared (R_{max}) to be 1, 0.95, and 0.9, and compare the results with the results of a fully controlled regression. Table A4 presents the sensitivity of technological progress results reported in Column 5 of table 3. The coefficients under

[19]Both emperors Shunzhi and Kangxi imposed "sea bans" in 1655 and 1716, respectively, but the restrictions were subsequently lifted in 1683 by Kangxi and in 1727 by Yongzheng. Even during the bans, they were not implemented restrictively.

different R_{max} are between −4.661 and −21.462, and the treatment effects are much larger than the controlled treatment effect. This result is reasonable because both baseline and fully controlled regressions have R-squared greater than 0.8, suggesting that technological progress in the cotton sector can explain the majority of the increase in the number of widow chastity cases in the Ming and Qing Dynasties. Hence, the omitted variable bias is not large enough to threaten the robustness of the baseline results.

Mechanism Analysis

Technological Progress or Cotton Planting

In addition to technological progress in the cotton sector, another important factor is traditional cotton planting, which may have a positive effect on widow chastity. Figure A1 illustrates the change in the number of widow chastity cases between the Ming and Qing Dynasties and the distribution of traditional cotton-planting regions. Widow chastity in cotton-planting areas recorded a larger increase, suggesting that the coefficient of distance variable might have captured the effect of cotton planting together with technological progress. We introduce a regression replacing the distance variable with a cotton planting dummy and then employ specifications to investigate the relationship between cotton planting and technological progress.

Columns 1 and 2 of Table A5 present the results with the cotton planting dummy without and with control variables, respectively. The magnitude of the parameter estimate decreases from 0.429 to 0.219 (49%) when including all control variables in the specification, and within R-squared increases by 0.102. The omitted variable bias test based on Oster (2019) reveals a sensitivity pattern different from that of technological progress. Due to the large difference between the controlled effect and the baseline effect, the interaction term of the Qing dummy and the cotton planting dummy decreases substantially to zero, and even becomes negative when R_{max} increases from 0.9 to 1.

When we consider the effects of both cotton planting and technological progress (Column 3 of Table A5), the coefficient of technological progress changes little, while the coefficient of cotton planting drops further to 0.106, a less significant level. The above result indicates that technological progress in cotton textile production has played a more important role than cotton planting. In column 4 of table A5, furthermore, the interaction effect of cotton planting and technological progress is insignificant and has a negative coefficient. The technological progress in the textile sector is dominant.

Female Labor Participation and Wages in the Textile Sector

To validate the logic that the cotton revolution influenced widow chastity through increased female labor demands, a key question is whether the technological progress in the cotton textile sector increased labor participation and earnings for women. Due to data limitations unique to the Ming and Qing Dynasties, we use labor participation [the industrial enterprise survey; cross section in 1936] and the wages of workers in industrial enterprises [The worker living survey; panel from 1926–30] to investigate labor market paths with samples including all industries and the textile industry.[20,21] In both surveys, the unit of observation is the city. In columns 1 to 4 of table 4, industrial survey data were used to analyze the employment structure, whereas for columns 5 to 8, labor survey data were used to analyze the wage structure. The results in columns 1 and 2 suggest that the textile industry employed more female workers in terms of both number and share, and in columns 5 and 6, female workers in the textile industry earned higher wages (relative to males) than those engaged in other industries. Columns 3, 4, 7, and 8 present the effects of technological progress on female employment and wages in the textile industry. The results are consistent with those found in the analysis of widow chastity. The technological progress in the cotton textile sector increased employment opportunities for women and their wages,

[20]The industrial enterprise survey was conducted by the Resource Committee of the National Military Council in 1936 (Liu 1937). This survey covered 18,694 industrial enterprises in 136 cities and counties; 7,740 enterprises were in the textile industry. The data we use in this paper are aggregated in one city (county)-sector cell.

[21]The worker living survey was conducted by the Ministry of Industry and Commerce (MIC) of the National Government from 1926–30 (MIC 1930) and involved over 1,104,396 workers in 1975 industrial enterprises in 34 cities and counties. This survey recorded the wages of workers by gender and sector. The data we use in this paper are aggregated in a city (county)-sector-year cell.

Table 4. Female Labor Participation and Wages in the Textile Industry, 1930s

	All industries		Textile industry		All industries		Textile industry	
	lnfemwork (1)	*shfemwork* (2)	*lnfemwork* (3)	*shfemwork* (4)	*lnfemwage* (5)	*wageratio* (6)	*lnfemwage* (7)	*wageratio* (8)
textile	2.816*** (0.650)	0.285*** (0.091)			0.697*** (0.227)	0.164** (0.057)		
lndist			−0.580 (0.905)	−0.191*** (0.060)			−2.179*** (0.000)	−0.468*** (0.000)
Prefecture effects	Y	Y	N	N	Y	Y	N	N
Year effects	N	N	N	N	Y	Y	Y	Y
Observations	918	918	161	161	1860	1860	370	370
Adj. R^2	0.269	0.225	0.394	0.600	0.217	0.165	0.294	0.181

Notes: Coefficients are reported with standard errors, column (1)–(4) cluster at the province level and column (5)–(8) at the prefecture level, in parentheses; control variables of estimates in include *lnpopden, capi, lnarea, slope, alti, lati, longi, temp, lnquota, lntemple, lnshrine, lnschool, lnagrtax, lndis2pc, lndis2bj, lnSIM, lnconf, lndisa, silk, linen*, and *tea*.
*$p < 0.1$.
**$p < 0.05$.
***$p < 0.01$.

giving widows enough economic security to live without remarriage.

Conclusions

Widow chastity behavior experienced dramatic growth during the Ming and Qing Dynasties, and the number of honored widow chastity cases in the Qing Dynasty was ten times greater than that in the Ming Dynasty. This phenomenon has long been considered an impact of Confucian culture, which belongs to the domain of social-cultural studies, whereas in our study, we discussed the institutional background and economic roots of this phenomenon from an economic standpoint. In the empirical analysis, we used proximity to Songjiang Prefecture, which emerged as the center of technological progress in the cotton textile sector after the Song Dynasty, as a key variable to explain the increase in the incidence of widow chastity observed at the prefecture level using a fixed effects panel model and found a significant positive relationship.

Several additional results reinforced the above conclusion. To isolate the technology effect from cultural influences, we considered official, unofficial, and folk-custom influences of Confucianism on chastity and martyrdom behavior. The impact of technological progress in the cotton textile sector remained stable. Furthermore, in the falsification test, we used martyrdom statistics to investigate the effect of technological progress and found that economic factors had no effect on irrational behaviors such as martyrdom.

To assess the potential effects of the chastity award selection process, we used agricultural tax revenue per capita (income level), distance between the prefecture seat and the province's capital city, distance between the prefecture seat and Beijing (political influence), the suitability index of maize planting (innovation), and the frequency of conflicts and of natural calamities (mortality). Though these effects existed, the cotton revolution continued to explain the change in the incidence of widow chastity between the Ming and Qing Dynasties.

In the placebo test, we used other production activities, such as the production of linen, silk, or tea, as placebos and found that the effects of these activities were all insignificant. In the common trend test, we found that before the Ming Dynasty, cotton technological progress did not exist, so the change in widow

chastity was parallel across the areas. To determine the extent of the omitted variable bias, we adopted the approach proposed by Oster (2019) and found that the effect of cotton technological progress survived the test.

Did cotton technological progress or cotton planting or both drive the observed increase in the incidence of widow chastity? It is true that without cotton production, textile production is seriously constrained, but what matters here is the magnitude of induced labor demands for women. Our analysis indicates that technological progress in the cotton textile sector is the dominant factor determining the incidence of widow chastity. Did the above technological progress truly increase demands for female laborers? The evidence from later periods indicates that female employment and wages in the textile sector increased as proximity to the core of technological progress in the sector increased. Labor participation and wages among women were greater in the textile industry than in other industries. Thus, we conclude that as women's economic status was enhanced by the cotton revolution, the number of widows who chose to not remarry increased accordingly.

Supplementary Material

Supplementary material are available at *American Journal of Agricultural Economics* online.

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