High-Value Work and the Rise of Women: The Cotton Revolution and Gender Equality in China*

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Abstract

The cotton revolution (1300-1840 CE) led to the prevalence of female breadwinning in affected regions. The adoption of new technologies, regional specialization and long-distance trade dramatically raised the incomes of cotton textile producers. Weaving was skilled labor and performed primarily by women, who then became major income earners and contributed close to or more than 50% of the household income. I examine the relationship between the prevalence of female breadwinning and the emergence of gender-equitable beliefs. After first documenting a negative relationship between cotton weaving and the belief that men are naturally more capable than women, I show that cotton weaving is associated with less sex selection and more women in positions of authority. This result is robust to instrumenting cotton weaving with a humidity-based index interacted with proximity to the location from which new technologies first began to spread. There was also a decline in dowry use in affected regions, and those regions later saw more female employment in the modern industrial sector until the state made labor force participation mandatory. Under centralized socialist rule, the cotton revolution continued to shape behavior and decisions in private domains, confirming the presence of a cultural channel.

Keywords: Technology, Trade, Relative female income, Beliefs about women

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I Introduction

There has been a recent trend towards married women becoming breadwinners.[1] By examining a historical episode—the cotton revolution—this study finds that a major shock to economic opportunities that allows women to become major income earners can initiate long-term cultural change.[2]

Cross-cultural research by anthropologists show that women typically possess fewer resources than men, less value is placed on women's lives, and greater control is placed on women's behavior (Gilmore, 1990). Marvin Harris postulated that the low status of women was initially determined by men's physical strength and their comparative advantage in warfare as this yields decision-making power, authority, and access to resources; and later by their relative contributions to economic production (Harris, 1993).

Female-breadwinner households have been exceedingly rare since the agricultural revolution. In this paper I study the long-run impact of a one-time technological breakthrough—the introduction of the multi-spindle spinning wheels widely improved the productivity of spinning operatives. This innovation solved a key bottleneck in cotton textile production and made home-based hand weaving one of the most productive tasks within society. Weaving demanded adroitness and persistence rather than physical strength. Having smaller hands and greater dexterity on average gave women a clear advantage in acquiring weaving skills. This breakthrough occurred in China (around 1300 AD) in the context of a market economy and trade network and in the presence of political institutions that ensured that relative female income remained high for more than 500 years. The cotton revolution thus increased women's relative contributions to close to or more than 50% of the household income and altered men's provider role in broad society.[3] I document a permanent change in the belief in the inferiority of women; in particular, the perception that women are less agentic and able.[4]

Ascribing agency and communion to different sexes is seen as fundamental to gender stereotyping.[5] Task-oriented, instrumental qualities are labeled as agentic. The perception

[1] https://www.pewsocialtrends.org/2013/05/29/breadwinner-moms/

[2] In Nunn (2012), culture is defined as heuristics or rules of thumb that aid in decision making, which typically manifest themselves as values, beliefs, or social norms. Different decision-making heuristics evolved across societies due to the environments or histories of the groups.

[3] Nock and Steven (1998) defines masculinity by three social roles: fathers to their wives' children, providers for their families and protectors of their wives and children.

[4] Scholars have examined female inferiority since antiquity. See Appendix L.1 for an overview of the belief in the weaker sex.

[5] In social psychology, following Bakan (1966), various gender stereotypes are labeled as communion and agency. Communion concerns the well-being of others (e.g. affectionate, emotional), whereas agency concerns one's own mastery (e.g. ambitious, courageous) (Eagly, Nater, et al., 2019). The two qualities, agency and competence are closely correlated (Cuddy, Fiske, and Glick, 2008). This perspective is well reflected in

that women are less agentic is a core belief people hold about women. The tendency to ascribe agentic personal characteristics to men has proven to be highly stable over time. For example, despite economic and social change in the US from 1974 to 1997, such tendency has shown little change (Spence and Buckner, 2000; L. B. Lueptow, Garovich-Szabo, and M. B. Lueptow, 2001).

There were two stages to cotton textile production: cotton cultivation, which was unskilled, and cotton spinning and weaving, which were skill intensive. After 1300, labor involved in spinning and weaving, and especially in weaving, was highly productive. "For more than 450 years Chinese cotton-spinning technology was therefore superior to the spinning methods used in any other country" (Needham and Kuhn, 1988, p. 224). The adoption of new spinning and weaving technologies created production surpluses, which served as a basis for market exchange. During this period, China accounted for one-third of the world's population and between one-third and one-half of global GDP, and had a relatively well-integrated national and regional market economy (Carol H. Shiue and Keller, 2007). Because of a strong market demand and a low trade cost, cotton cloth became one of the most traded goods. By 1840, finished cloth accounted for 24.4% of all domestic trade in China.[6]

Cotton weaving led to a substantial increase in relative female income. Between 1300 and 1840, after which date mechanized cotton cloth flooded into China, cotton cloth was produced at home, and sold to local, regional and national markets. Women readily combined childcare with their full-time weaving job and worked together, within extended family groups in specialized roles based on their age, to increase efficiency. As in many traditional societies, weaving skills, along with the handloom, were passed down across generations, typically from mother to daughter (Buckley and Boudot, 2017). This resulted in a "Golden Age" for women's earning power.

An unusual feature of the cotton revolution is that it boosted women's incomes to a level comparable to or greater than those of their husbands and made them major income earners within households. Women occupied the role of weavers because they were more productive and skilled. In home-based proto-industrial weaving, they enjoyed an *absolute*, not just *comparative* advantage, which formed the basis for their sustained high earnings. Pomeranz's 2002 work suggests that an ordinary female weaver could earn 400% as much as an unskilled male laborer. Allen (2009) shows that one day's work by a weaver in the late 17th

Western Intellectual Tradition. In *Emile* Rousseau wrote: "Men and women are not equal, it is the part of one to be active and strong, the other to be passive and weak. Woman is intended to please man and their education must be whole directed to give them pleasure, and to be useful to them."

[6]Table I shows a breakdown of trading goods just before 1840. As much as 94,553,000 *tael* worth of cotton cloth was traded, second only to that of grain.

century produced 7,684 calories, which was adequate to support a family. This distinguishes the cotton revolution from other episodes of expansion of labor market opportunities for women; during those episodes women increased their participation through activities at which they had a comparative advantage, but usually not an absolute advantage. They continued to work in limited segments of the labor market and receive less pay than men. In the main analysis, I discuss the implications of this unusual feature of the cotton revolution for household bargaining and compare the effect of cotton weaving and that of lower-earning economic activities performed by women on long-run cultural change.

Exploiting the variation between counties with cotton weaving (1300-1840) and those without, I aim to estimate the difference in beliefs about women, comparing when women are the major income earners versus only supplemental income earners.

Counties with cotton weaving (1300-1840) had high relative female income. These counties are in the treatment group. As women became major income earners in cotton weaving regions, in the rest of China women continued to play a limited role in economic production of the household. Women in those places produced hemp textiles, but they were not major income earners. Hemp plants had lower average yields per unit of land and led to a much lower output. For those counties, the economic conditions faced by women were similar before and after 1300. They comprise the control group.

I collect information on cotton weaving (1300-1840) from historical gazetteers to construct a binary variable of cotton weaving. My main sample comprises a total of 1,474 counties. I do not have sufficient information to examine county-level variation in when cotton weaving emerged. The estimated effect should be viewed as the average treatment effect of all counties in which cotton weaving took place at any point between 1300 and 1840.

To distinguish between the effects of the cotton revolution on economic versus non-economic factors, I focus on the post-1840 period when the economic significance of the cotton revolution had already faded. I restrict my main analysis to the post-1949 socialist period, during which the national government mandated full-time employment for men and women, centralized law- and policy-making and explicitly introduced policies to minimize gender differences. This helps to break the feedback loop between economic payoffs of being female and the perception of women being less able, in order to obtain a clean estimate of the effect of perceptions and beliefs on economic behavior and decisions.

As shown in contemporary surveys, the cotton revolution is negatively correlated with the belief that men are naturally more capable than women. There is no relationship between the cotton revolution and progressive attitudes such as acceptance of same-sex marriage or premarital sex or belief in science. This is consistent with the hypothesis that the cotton

revolution, during which weavers possessed valuable skills and earned a high income, led to a change pertaining to beliefs about women's ability and worth and the change is likely permanent.

Using the 2000 census, I show that there is a strong negative relationship between the cotton revolution and the skewdness of the birth sex ratio, whether or not I control for economic factors such as GDP per capita and sectoral composition. The baseline estimates suggest that the cotton revolution is associated with a reduction of 3.5 boys per 100 girls in the birth sex ratio, or a quarter of its standard deviation. This relationship only emerged in the mid-1990s when prenatal gender tests became easily accessible across the country. A related outcome is that cotton weaving (1300-1840) predicts more women in positions of authority. These results cannot be easily explained by economic factors such as women's participation in paid employment, as the state mandated full-time employment for both men and women.

The correlation between cotton weaving (1300-1840) and the birth sex ratio is stronger in places that had the plough technology, suggesting that home-based proto-industrial production of cotton textiles helped women overcome the disadvantage formed in a plough-based agricultural society and led to the rise of women despite conservative gender norms (Alesina, Giuliano, and Nunn, 2013).

I find no significant relationship between the birth sex ratio and a wide range of low-earning economic activities performed by women, suggesting that the relationship between relative female income and core beliefs about women is not linear. This provides further evidence that women's relative contributions being close to or more than 50% of the household income, or female breadwinning, is a crucial condition for changing core aspects of beliefs about women. I additionally investigate the role of intervening shocks such as industrialization in the 19th century, expansion of Christianity and post-1979 economic liberalization and do not find them to affect my main estimate.

To account for county-level selection into cotton weaving, I adopt a number of strategies. One is to match counties on pre-1300 characteristics. My estimate increases in magnitude and remains highly significant when I restrict the sample to as few as 202 counties using more stringent matching criteria.

Another strategy is to use variation within the Han subgroups only. The Han Chinese, with a population of 1.3 billion, contains distinct linguistic groups (Gan, Hakka, Hui, Jin, Mandarin, Min, Wu, Xiang, and Yue), each of which has a distinct tradition. I find that even in counties within the same subgroup, it was those counties that switched to cotton weaving after 1300 that saw the transformation of beliefs about women.

To proxy for pre-1300 beliefs about women, I construct a county-level measure of the visibility of women in society based on poetry written by authors from a given county. I include it both as a control and use it to build a naive difference-in-differences model. The naive difference-in-differences estimate suggests that cotton weaving (1300-1840) is responsible for up to a 0.4-standard-deviation change in beliefs about women.

In addition, I employ an instrumental variable strategy and use as an instrument the interaction term between the humidity-for-weaving index and proximity to the location from which new technologies first began to spread (Songjiang). Both the humidity index and proximity to Songjiang are predictors of the location of the adoption of new technologies. The rationale behind using proximity to Songjiang is that the further away from the location from which new technologies first began to spread, the less likely new technologies would have been adopted. The IV estimate is larger than the OLS estimate and of a similar magnitude to the difference-in-differences estimate.

In order to understand the mechanisms, I first discuss the properties of the prevalence of female breadwinning as the treatment. As major income earners, women became financially indifferent between being married and single. This could materially affect their bargaining outcome within the household because it was then credible for them to leave the marriage. Because this economic change affected an unusually large percentage of the population, female breadwinning became prevalent which in turn affected beliefs about women in a large share of the population. Lastly, because the shock affected married households, vertical transmission of newly formed beliefs about women from parents to children was more likely to happen.

To provide further evidence on cultural change, I use pre-1949 gazetteers to build another indicator of culture: the cultural practice of dowry. My prediction is that cotton weaving (1300-1840) would have undermined the cultural practice of dowry because women became more able to contribute to the marital household, lowering the cost of supporting them. This result, together with the result on the positive relationship between cotton weaving (1300-1840) and gender-equitable beliefs in 2010, provides further evidence that cultural change occurred in response to the cotton revolution.

I then examine the effect of the cotton revolution on female employment in the modern industrial sector in the early 20th century. Because economic and political institutions were decentralized, laws and policies were made locally and reflected local preferences. My prediction is that the cotton revolution could shape a wide range of decisions made by individuals, businesses and politicians during this period, including women's participation in the industrial workforce. I find that a greater share of the industrial workforce was female in places with cotton weaving (1300-1840).

Multiple channels can underlie the long-term effect of the cotton revolution. After 1949, the new regime shut down important channels such as participation in paid employment or locally determined institutions. The long-run effect of the cotton revolution then more exclusively hinged upon the cultural channel. This makes the cohort growing up after 1949 the best group for examining the effect of the cotton revolution through culture. I examine the effect of cotton weaving (1300-1840) on the gender of the head of the household. Additionally, the cotton revolution should have a larger effect on the cohorts whose education and marriage decisions were made during the pre-socialist period, as a much larger number of mediating channels were present then. I find that the cotton revolution increased the probability of married women heading the household in both pre-socialist and socialist China, reaffirming the cultural channel, but this effect is still larger in pre-socialist China.

Related Literature Sociologists have long been interested in the consequences of primary-earner wives (Nock, 1995; Heckert, Nowak, and Snyder, 1998). Hitsch, Hortaçsu, and Ariely (2010) find that men have a strong desire to outearn their wives. Because families with primary-earner wives remain atypical statistically (Heckert, Nowak, and Snyder, 1998), and individuals tended to self select into highly unusual marriages of this kind, it is difficult to estimate the effect of having primary-earner wives.[7]

There is a small and growing literature in economics on the effect of married women assuming major earner status Bertrand, Kamenica, and Pan (2015) show that when the wife outearns the husband marital dissolution is more likely, indicating a strong norm against having primary-earner wives.

The cotton revolution provides an unusual opportunity to empirically examine the effect of the prevalence of female breadwinning at the population level and in the long run. The shock took place in a setting with conditions that are hard to come by in the historical and modern world and hard to replicate in field experiments. Notably, an unusually high share of the peasant households engaged in the production of textiles because the state demanded textiles through the universal in-kind taxation system (Bray, 1997).[8] This mitigated the usual concern of selection into treatment. Because those homogeneous peasant households comprised over 90% of the population, the shock had a similar impact on nearly all of an affected region. Also, in contrast to being a transitory phenomenon, such as women entering into the labor force during economic recessions, the pattern of female breadwinning lasted for

[7] In 2013, mothers in the United States were providing more than half of the income in 15 percent of married households with children under 18. See https://www.pewsocialtrends.org/2013/05/29/breadwinner-moms/

[8] Appendix L.2 includes further details on universal taxation and taxes in kind. The universal in-kind taxation can be seen as a state purchase program. The imperial state was the largest buyer of textiles.

several centuries. I show that a sustained prevalence of female breadwinning can transform beliefs about women's ability and worth.

The finding that the prevalence of female breadwinning transforms beliefs about women's ability and worth contributes to the scholar inquiry into the capacity for core beliefs about women to change. A puzzle in the literature has been that despite the increasing participation of women in the workforce, traits seen as typical of men and women have remained essentially unchanged from the 1970s to the 2000s (Prentice and Erica Carranza, 2002; Cotter, Hermsen, and Vanneman, 2011). This begs the question whether core aspects of beliefs about women, such as the perception that they are less agentic, would have the capacity for change.[9]

The lack of responsiveness to small increases in relative female income might have roots in gender being conceived as binary.[10] Because individuals put men and women in opposing categories, they may not update beliefs until the difference between categories seems to be small. This paper shows that if relative female income reaches a high enough threshold, it can become a relevant force for changing beliefs about women' ability and worth. When women in affected regions switched from producing a meager amount of hemp textiles and working alongside their husbands to providing the main income of the household, there was a fundamental change in beliefs about their ability and worth.

This paper adds to the literature on cultural norms and cultural beliefs in a historical perspective and is closest to the line of research using historical shocks as a source of variation in culture (Nunn and Wantchekon, 2011; Alesina, Giuliano, and Nunn, 2013; Galor and Özak, 2016; Grosjean and Khattar, 2019). Nunn and Wantchekon's (2011) work examines the trans-Atlantic slave trade as a shock to prosocial norms and studies its long-term effect on corruption and trust today. Testing Boserup's (1970) hypothesis, Alesina, Giuliano, and Nunn (2013) posit that the use of the plough in advanced agriculture has led to conservative gender norms by establishing the image of men as working outside the home.

This study has the advantage of exploiting a highly specific shock. The cotton revolution increased women's income in relation to their husbands, but was not accompanied by widespread urbanization, industrialization or modernization. Due to centralized rule in imperial China, it did not have the capacity to cause changes in local institutions or laws in affected regions. This makes the process of identifying the long-run effect of the cotton revolution through culture more tractable.

[9] A number of gender norms and gender-role attitudes have changed. For example, there has been a shift in attitudes towards working mothers (Fernández, Fogli, and Olivetti, 2004) and attitudes towards premarital sex (Fernández, 2014).

[10] Katchadourian (1979) refers to the idea of inflexible generic types, a Universal Man and a Universal Woman—a sexual symmetry derived from dualism in biology and psychology.

A usual challenge in this literature is to distinguish the effects through the cultural channel from those through other channels of transmission. Culture and institutions co-evolve (Alesina and Giuliano, 2015) and the channels through which culture can affect economic outcomes are ubiquitous (Guiso, Sapienza, and Zingales, 2006). Moreover, the economic effects of the initial shock might remain and serve as the main channel of transmission.

The period after 1949 has important features which assist in isolating the role of culture.[11] The socialist state mandated employment for women and men. This temporarily disabled the usual U-shaped relationship between per capita income and female labor force participation (Goldin, 1995), lowering the impact of economic forces on gender-related outcomes. Besides, the socialist state provided a fixed institutional environment that also promoted gender equality. The centralized system weakened the relationship between local preference and local institutions and meanwhile the national-level laws and policies supported gender equality. This muted the indirect effect of culture on individual behavior through political and legal rights, or gender-biased policies in education or labor opportunities. The setting of post-1949 China allows me to precisely identify a cultural channel at a population level and to provide population-level estimates of the effect of culture that are predictive of macro-level outcomes.

This study is relevant for the broader literature on the effect of an increase in women's earnings. In existing studies, higher earnings for women are associated with both female empowerment (S. Anderson and Eswaran, 2009; Aizer, 2010) and male backlash (K. L. Anderson, 1997; Macmillan and Gartner, 1999). The cotton revolution led to a large-scale, sustained increase in women's earnings. As a treatment, it differs from cash transfer programs which are typically on a smaller scale and more transitory. I show that a sustained, large-scale increase in women's earnings can have positive and lasting effects in the long run.

The main focus of this paper is on the emergence of gender-equitable beliefs and I use sex ratio imbalances as a key indicator of the presence of gender-inequitable beliefs. Scholars have identified economic factors such as relative adult female earnings (Rosenzweig and Schultz, 1982; Duflo, 2003; Qian, 2008; Eliana Carranza, 2014) as a direct cause of sex ratio imbalances. Qian (2008) shows that a short-term shock to female earnings had an immediate impact on the share of surviving girls. I examine sex ratio imbalances in the absence of major economic differences between men and women in order to separate the effects of economic

[11] Others have examined how state socialism shapes gender norms (Campa and Serafinelli, 2019; Lippmann, Georgieff, and Senik, 2020). In those studies, state socialism is the treatment itself. In this study, the socialist state provides a fixed institutional environment that also promotes gender equality that eases identification. To be specific, I "use" state socialism to take away economic differences between men and women such as differences in paid employment or inheritance. Also, because the socialist state centralized law- and policy-making, local differences in those domains cease to be confounding channels.

and non-economic factors. My main finding is that the emergence of gender-equitable beliefs is a proximate cause of a reduction in sex ratio imbalances.

I argue that the birth sex ratio is an ideal measure of gender-inequitable beliefs but with strict conditions specified. The absence of religious prohibitions on sex-selective abortion in China funnels a preference for male offspring into the actual practice of sex selection. In the United States, as ultrasound technology became widely available, fears emerged that sex selection might take place on a large scale—the 1970 National Fertility Study shows that the sex preference ratio is as high as 124 boys for every 100 girls for all women who intend to have more children (Westoff and Rindfuss, 1974)—but sex ratio imbalances on that scale never actually occurred. Almond, Edlund, and Milligan (2013) find that among Chinese and Indian immigrants in Canada, those who were converted to Christianity or Islam stopped resorting to sex-selective abortion, even though they still equally discriminated against women. This suggests that there is usually a disconnect between gender-inequitable beliefs and the actual practice of sex selection. In the case of China, the majority of the population are Buddhists or not irreligious, for whom sex-selective abortion is not prohibited. In a cross-cultural setting, a much higher level of sex ratio imbalances in China relative to other countries (except for India) would reflect the very different religious composition rather than people holding extreme beliefs about women. Indeed, two thirds of the richest self-made women in the world are from China.[12] Chinese women who go to top business schools demonstrate more competitive inclinations than their US counterparts.[13]

This remainder of the paper is organized as follows. Section II explains the historical context. Section III discusses data sources and variable constructions. Section IV links the cotton revolution to beliefs about women's ability and worth. Section V lays out the main analysis using the 2000 census. Section VI elaborates on the mechanisms underlying the long-term impact of the cotton revolution. In Section VII, I discuss the plausibility of my results, policy implications and a few caveats. Section VIII concludes the paper.

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II Cotton Textile Industry, 1300 - 1840

Below I provide a quick snapshot of the cotton textile industry in China during the cotton revolution (1300-1840). During this period, the main industries in the economy were grain

[12] http://qz.com/529508/china-is-home-to-two-thirds-of-the-worlds-self-made-female-billionaires/.

[13] Among MBAs or undergraduates at top programs, 65 percent of the women consider themselves "very ambitious", compared with 36 percent of their U.S. counterparts; 76 percent aspire to a top job versus 52 percent of Americans. Female candidates are found to be as competitive, if not more so, than their male counterparts. http://iveybusinessjournal.com/publication/ambitious-educated-women-and-their-key-role-in-solving-chinas-talent-crunch/.

and textile production. The production of cotton textiles was pre-factory and home-based, with the majority of textile-producing households being in rural areas. During this period, the cotton textile industry was associated with a high level of regional specialization, a vibrant long-distance trade, and Smithian growth.

The production of cotton textiles involved cotton cultivation, spinning and weaving. Among those tasks, weaving was the most skill intensive. Through various stages of weaving, such as preparation of weft and warp threads (winding yarn onto spools, warping, rolling onto warp beam, threading yarn onto reed-comb and framing string-heddle), setting design (patterning and warp lifting) and loom-weaving, warping is a skilled task, and a high level of concentration is needed to do the job properly. Patterning and warp lifting requires the highest level of skill.

Women played a central role in weaving; handloom weaving demanded adroitness and persistence, and physical strength was not important. With smaller hands and greater dexterity on average, women had a clear advantage in acquiring weaving skills and perfecting the technique. They worked as year-round, full-time weavers; this gave consistency to the texture of finished cloth. Weaving skills were typically transmitted intergenerationally, from mother to daughter, and through apprenticeship, older women passed on techniques to younger women. The belief that women are weavers is reflected in the gender of weaving deities in many societies (Appendix L.5).

The production of cotton textiles was highly decentralized and organized by peasant proprietors. The machinery, both the spinning wheel and the handloom, was simple enough for individual households to afford. Weavers bought raw cotton and sold finished cloth. There are several implications to this: firstly, it was natural for a woman to work in her own home since the practice was family owned. Secondly, because of the extended family system, a woman would work with other members of her family. They achieved a degree of economic efficiency through intrafamily cooperation. Thirdly, peasant proprietors were paid the average product of labor rather than marginal product of labor. Appendix B.1 details the causes and consequences of decentralized production during that period.

The cotton textile industry was situated in well-functioning markets and a developed trade network. Being able to obtain raw cotton from counties hundreds of miles away alleviated land constraints and allowed the industry to expand. This represents considerably different conditions from those in a natural economy, in which both production and consumption took place locally.[14] The state was a major buyer of cotton textiles and transported them using the Grand Canal (Figure A.X). After 1840, under political pressure, China began to

[14]Outside of China and parts of India, until the 19th century, the overwhelming bulk of raw cotton was spun and woven within a few miles from where it was grown (Beckert, 2015).

import mechanized cotton textiles from the British Empire. Over time, mechanized cotton textiles gradually replaced cotton textiles produced by peasant proprietors.

Because of regional specialization and long-distance trade, the cotton textile industry kept expanding. But there was little further technological innovation beyond the initial adoption of technologies introduced by Huang Dao Po in the 14th century (Elvin, 1972). These conditions ensured that the cotton revolution was associated with high relative female income during this period. For a discussion of the macroeconomic impacts of the cotton revolution, see Appendix B.3.

II.A Technological Improvements in 1300

Before 1300, hemp was the main fabric used for ordinary clothes. Hemp has low yields per unit of land and is not very durable or warm. High-quality silk was an expensive fabric and afforded by a small elite.[15] Due to climate constraints, wool was not produced in China proper.[16]

Around 1300, Huang Dao Po, a Shanghai native (1245-1330 CE), learned new technologies for cotton textile production from a remote ethnic group, the Li people.[17] Later she introduced those technologies to people in her hometown, Songjiang. The new technologies first began to spread from there. Due to the use of new technologies, cotton textile production became economically viable for the first time (Bray, 1997; Zhao, 1977).

Huang Dao Po introduced a new spinning wheel that had three spindles. Prior spinning wheels had only one spindle. The new spinning wheel increased productivity by allowing women to use both their hands and their feet to keep the wheel spinning. This device roughly doubled or tripled the productivity of spinning operatives. Workers using the new device could produce between 500 and 1500 grams of yarn per day. Joseph Needham notes that until the British Industrial Revolution, "the technological standard of Chinese cotton manufacture had no parallel anywhere else in the world" (Needham and Kuhn, 1988, p. 223). This resolved a bottleneck that had stopped the cotton textile industry from being more productive–before the new spinning wheel appeared, every weaver had to be matched with three to four spinners given the rate at which cotton fiber was spun into yarn.

In addition, Huang Dao Po created a two-roller cotton gin. It had two rollers rotating

[15]The value of traded silk accounted for 3% of the domestic trade, based on Table I. Only 7% of the Chinese population in Ming China was urban.

[16]China proper includes the 18 provinces south of the Great Wall, settled predominantly by the Han Chinese.

[17]The Li people live on the Hainan Island, south of the mainland. The Li people are still using similar technologies to those borrowed by Huang. More details about the ethnic group Li and the techniques they use can be found in Appendix L.4.

opposite to each other and efficiently separated cotton fibers from seeds. She also introduced new techniques for cotton fluffing and crushing, methods of weaving mixed cotton fabrics, colored fabrics and fabrics with mixed warp and weft fibers. To express gratitude for her contribution, a memorial was erected for her in 1337. To this day, the late 13th century folk song "Granny Huang, Granny Huang. Teach me spinning, teach me weaving. Two spools of yarn into two bolts of cloth." can still be heard in Songjiang.

Following this technological breakthrough, cotton textile production expanded rapidly in the following centuries. Raw cotton had higher yields per unit of land than hemp. Cotton gradually replaced hemp and low-to-medium grade silk to become the dominant fiber for day-to-day clothes.[18] Attractive features of cotton cloth include being durable, soft, light and being effective in the cold weather. Expanding urban markets also promoted the consumption of cotton cloth (Myers, 1965). According to Pomeranz (2000, p. 338), China's cotton textile production in 1750 was only slightly below that of Britain's in 1800.

II.B Gains from Long Distance Trade

Cotton is a bulky but lightweight commodity and travels easily. Transportation costs play little role in textiles geography (Wright, 2020). China had relatively well-integrated national and regional markets (Carol H. Shiue and Keller, 2007). In the mid-17th century, an estimated 20 million cotton cloth bales were produced annually (Beckert, 2015). By 1840, cotton textiles account for 25% of the long distance trade in China. I show a breakdown of goods circulated through long distance trade just before 1840 in Table I.

A portion of cotton cloth was transported by the state through the Grand Canal. The imperial state was the largest buyer of textiles. R. Huang (1964) estimates that in the early 17th century, at least one million bolts of cotton cloth were transported through the Grand Canal as tax payments to the central government.[19] In imperial China, universal in-kind taxation dates back to 220 AD. During the period under study, cotton textiles accounted for a large portion of taxes in kind.

Weaving yarn into cloth is subject to different climatic constraints than growing raw cotton. A relatively dry climate is preferred for cotton cultivation, with low precipitation during the growing season. Cotton spinning and weaving is more suitable in a relatively humid climate. Regional specialization and the interregional trade of raw cotton and finished cloth emerged in response to differential endowments. Places with different climates specialized in

[18] See Appendix B.2 for a discussion of the impact of the cotton revolution on non-cotton textile producing regions.

[19] One bolt of cotton cloth is 33.33 meters long. One million bolts of cotton cloth were worth half a million *taels* at the time. The Grand Canal and the Yangtze River formed the major trade network in early modern China.

different stages of cotton textile production, including the cultivation, spinning and weaving of cotton.

Table I: Domestic Long-Distance Trade in 1840

Categories	Quantity	Value	
		Silver (10,000 taels)	Percent (%)
Grain	24,500,000,000 *jin*	16,333.30	42.14
Cotton	2,555,000 *dan*	1,277.50	3.3
Cotton textiles	31,451,770,000 bolts	9,455.30	24.39
Raw silk	71,000 *dan*	1,202.30	3.1
Silk textiles	49,000 *dan*	1,455.00	3.75
Tea	26,050,000 *dan*	3,186.10	8.22
Salt	3,220,000,000 *jin*	5,820.90	15.1
Total		38,762.40	100

The table is taken from B. Li (2010). The original estimates are made by Wu (1983). The figures exclude goods exchanged on local markets.

A relatively small number of regions had both a suitable climate for cotton weaving and close location to the trade network. Cotton textile producers in cotton-weaving regions faced high demand from the rest of China which kept the prices of cotton cloth high for an extended period. Meanwhile, in contrast to expanded markets for goods, the labor market remained heavily restricted. This constrained the reallocation of labor to areas suitable for cotton textile production (See Appendix B.2 for details on labor mobility in imperial China). This was an important factor in weavers receiving high earnings for several centuries.

III Data

I combine several gazetteer-based sources to construct my main variable, cotton weaving (1300-1840). For other historical variables, I use China Historical GIS (CHGIS), the digital map collection of Harvard University, the database of Chinese Gazetteers (*Zhongguo fangzhi ku*), the 1916 economic census and surveys conducted by Christian missionaries in the early twentieth century. For modern outcomes and controls, I use modern censuses and surveys, including the 1990 and 2000 population census from the IPUMS International, and the Chinese City Statistical Yearbooks and the Chinese General Social Surveys (2005, 2010). For climatic and geographic variables, I rely on data from the Climate Research Unit of University of East Anglia, FAO (GAEZ v3.0), NASA and NOAA.

China comprises 56 different ethnic groups. I focus on the Han Chinese in this study. The main benefit of maintaining the focus on the Han Chinese is to use within-ethnicity variation

so that counties in the treatment and control groups are subject to similar laws and customs prior to 1300. Focusing on the Han Chinese is also a response to data constraints. Historical gazetteers, as a data source, are not common among most ethnic groups.

III.A Sample Construction

To construct my sample I take the following steps: (a.) Restrict the sample to 18 provinces within China proper. China proper refers to the "Eighteen Provinces" system used by the Qing dynasty. The five autonomous ethnic regions, Guangxi, Neimenggu (Inner Mongolia), Ningxia, Xizang (Tibet) and Xinjiang, are not included. (b.) Exclude frontier provinces (Gansu, Guizhou, Shaanxi and Yunnan), where Han settlements were discontinuous and uneven. (c.) Exclude autonomous prefectures and counties. Ethnic populations form the majority in those areas, and there are substantial differences in laws, traditions and customs governing ethnic populations and the Han Chinese. (d.) Exclude Beijing, the capital city of Ming, Qing and contemporary China. For about 300 years the Manchu royal family and Manchu and Mongolian troops were the main residents in the city. This leaves me with a sample of 13 provinces plus Shanghai. It includes 193 prefectures, or 1,622 counties. The baseline regression uses a sample of 1,474 counties after leaving out observations with missing values in control variables.

III.B Cotton Weaving (1300-1840)

To obtain an estimate of the distribution of counties and prefectures where cotton textiles were produced between 1300 and 1840 across China today, I map historical locations of cotton textile production into modern counties.

Historical gazetteers provide qualitative information on cotton weaving. Information on cotton spinning and weaving, as well as cotton cultivation, can be inferred from a section on local production (*shihuo zhi*). I code *cotton weaving (1300-1840)* as one, if finished cotton cloth is mentioned in the gazetteer of a specific county or prefecture (*jibei bu* or *mian bu*). Both *mian* and *jibei* translate as "cotton". *bu* translates as "cloth".

I draw on two studies that are complementary to each other, both based on historical gazetteers. A key source I rely on is Wang (2006). The author compiled data sources on the production of various types of cotton, silk and hemp textiles for 1368-1644. A second source I use is Deng (1999). She compiled information on cotton textile production for 1644-1840.[20]

To account for administrative boundary changes, I use time-series maps to determine the

[20]Deng (1999) surveyed locations of cotton textile production in early Qing. In the historical literature on regional and national markets in the Qing Dynasty, early Qing refers to period before the Opium War (1644-1840).

historical locations of cotton weaving. There are two types of historical gazetteers, county and prefecture gazetteers. When information is extracted from a prefecture gazetteer that was compiled in 1503, it is geocoded to be within the 1503 administrative boundary of this prefecture. Information on county boundaries prior to 1911 is not available. If information is extracted from a county gazetteer compiled in 1503, I geocode the source using the location of the county seat in 1503, since its administrative boundary in 1503 is unknown.

Next I map historical locations of cotton weaving into modern counties. If a record on cotton weaving is found in a historical county gazetteer, a value of one is assigned to the modern county that contains the administrative county seat of that historical county. This rule is adopted because information on county boundaries prior to 1911 is not available. Meanwhile, if a record on cotton weaving is found in a historical prefecture gazetteer, a value of one is assigned to all modern counties with at least half of their land areas overlapping with the historical prefecture.[21] If a county is not assigned a value of one in either case, it receives a value of zero. Together this yields a dummy variable of cotton weaving (1300-1840) for a modern county.[22]

Figure I shows the distribution of counties and prefectures in 2000 with cotton weaving (1300-1840) based on the main method. In Appendix C.1, I provide full details on how historical records are linked to modern counties.

Historical Gazetteer Data Historical gazetteers provide valuable information on cotton weaving between 1300 and 1840. For an average prefecture, a gazetteer is compiled every few decades. Before 1300, very few gazetteers were compiled. The majority of gazetteers have been found in counties and prefectures with a Han Chinese majority.

The approach of using historical gazetteers to acquire region level statistics has the following limitations: (a.) Some places began to compile gazetteers much later than did others; (b.) Some places preserved gazetteers better. Both can lead to incomplete data coverage.

Historically more developed counties began to compile gazetteers at an earlier date, compiled more gazetteers and preserved a larger fraction of them. To mitigate bias, I refrain from using gazetteer records to determine the onset of the cotton revolution at a county level. For instance, if the first gazetteer was compiled in 1700, but cotton weaving appeared far before

[21] Information on prefecture boundaries prior to 1911 is available.

[22] Modifying the main method, I geocode a historical county based on its 1911 boundary—this is the earliest point for which county boundaries became precisely defined. I then calculate the percentage of a modern county's land area overlapping with this historical county based on its 1911 boundary. This method yields a continuous measure of cotton weaving (1300-1840). Estimates based on this measure are very similar to those based on the main method. Another modification is to calculate the percentage of a county's land area that overlaps with a historical prefecture. This method also leads to a continuous treatment. It yields estimates comparable to those obtained with the main method.

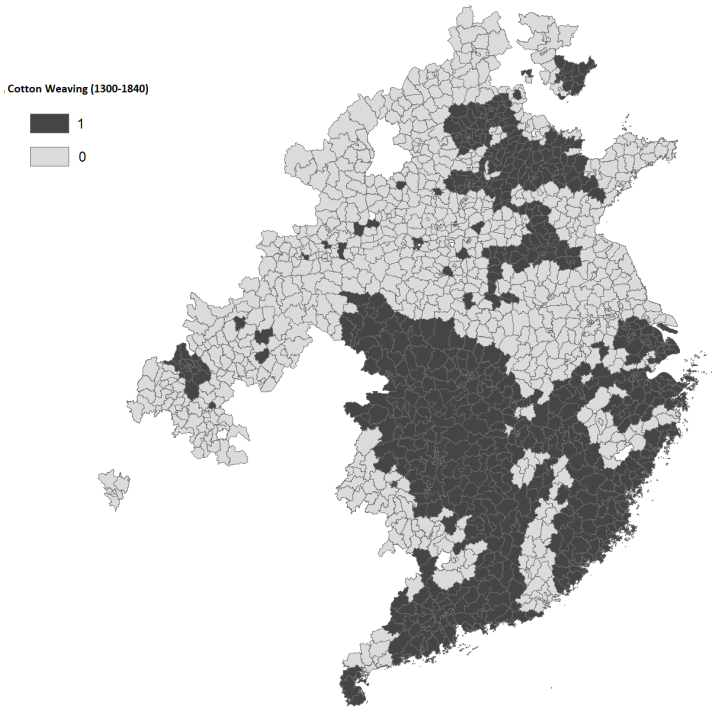

Figure I: Cotton Weaving (1300-1840)

1700, attempting to exploit the timing dimension will make the mistake of treating cotton weaving as starting in 1700.[23] In Appendix G.3, I further investigate the impact of gazetteer availability on my estimation and show that my results are robust to restricting the sample to counties with a similar number of gazetteers.

III.C Control Variables

In this section, I list data sources for the set of control variables used in the long run analysis. I control for factors that can be correlated with both cotton weaving (1300-1840) and gender-equitable beliefs in modern China.

My baseline controls include contemporary controls such as a county's GDP per capita, share of urban population, share of agriculture workforce, share of service workforce, share of urban *hukou* (household registration), years of schooling - men only, share of ethnic population, governance status and provincial capital status; historical controls such as population density in 1300, agricultural suitability, proximity to the Grand Canal or the Yangtze River and treaty port status; and geographic controls, such as ruggedness, distance to coast, soil

[23]When using a binary variable, the county will take on the value of one as long as any gazetteer compiled before 1840 contains a record of cotton weaving.

texture, latitude and longitude.

I obtain most of contemporary controls from the population censuses. I use GDP per capita, share of agriculture workforce and share of service workforce to control for the stage of development and sectoral composition. Sectoral composition affects demand for female labor. I use years of schooling - men only to proxy for modernization and secularization. I also control for the share of ethnic populations, who may have had different customs and traditions in the past and in the present. Additionally, I control for governance status and provincial capital status to account for differences in enforcement of government policies.

A variety of sources are used to construct historical controls. Historical population density is a proxy for economic development and can shape the ancestral traits of modern populations (Putterman and Weil, 2010). I use population estimates from Goldewijk, Beusen, and Janssen (2010) and Klein Goldewijk et al. (2011). Agricultural suitability is obtained from the FAO website. For an agrarian economy, agricultural productivity is strongly correlated with population density. Proximity to the Grand Canal or Yangtze is obtained from the China Historical GIS (CHGIS). The location of cotton weaving (1300-1840) depended on the trade network. Controlling for whether the county was on the Grand Canal or on the Yangtze River helps to account for the long-run impact of differential market access. Treaty ports established in the 19th century promoted industrialization and modernization (Jia, 2014). I control for treaty port status to account for its possible impact on economic growth, institutions and culture.

Data on ruggedness and distance to the coast are obtained from the National Aeronautics and Space Administration (NASA) website. I include them to account for economic geography. Those living in rugged terrain tended to be net consumers of cotton textiles (Deng, 1999). Soil texture data are obtained from the Harmonized World Soil Database (Nachtergaele et al., 2008). Soil texture is a factor in demand for female labor in an agarian economy (Eliana Carranza, 2014).

To account for deep-rooted differences across regions, I include Skinner socioeconomic macroregion fixed effects, in addition to province fixed effects. There is important regional variation in pre-existing (pre-1300) customs and traditions such as patrilocality, residence of the newly married couple with the husband's family or tribe. Socioeconomic macroregion fixed effects absorb part of the variation in pre-existing conditions. Skinner socioeconomic macroregion data are available at the G.W. Skinner Data Archive (Skinner, M. Henderson, and Berman, 2013). Appendix Figure A.IX depicts the nine socioeconomic macroregions in China.

Summary statistics of those variables are provided in Table A.VI. Appendix C.2 pro-

vides further details of those variables. Additional controls are used in the analysis of other historical episodes and will be discussed separately.

IV The Capable Woman: Historical and Modern Evidence

At the core of gender stereotypes, communal and agentic personal characteristics tend to be ascribed to different sexes (Bakan, 1966). Task-oriented, instrumental qualities are labeled as agentic. Research show that men's occupancy of the breadwinner role and women's occupancy of the homemaker role underlie those gender stereotypes (Eagly, Wood, and Diekman, 2000). If women occupy the breadwinner role, will female breadwinning help to revise those stereotypes?

A large share of married women became breadwinners during the cotton revolution. Some provided the main income for the household. Historians provide various estimates of the actual incomes women received for producing cotton textiles. Allen's (2011) wage regressions indicate that textile workers earned a wage premium compared with workers in construction or agriculture. Allen (2009) shows that one day's work by a weaver in the late 17th century produced 7,684 calories, which was adequate to support a family. B. Li (1997) shows that a woman's year-round textile work was enough to feed 2.7 people. Pomeranz (2002) provides a more optimistic estimate suggesting that an ordinary female weaver could earn 4 times as much as an unskilled male laborer. Artisan weavers could earn a still higher income. Greater skills and longer hours were required to produce artisan cloth.

An important cause of high relative female earnings over an extended period is that women had an advantage over men in home-based proto-industrial weaving due to having smaller hands and greater dexterity on average. The socialization process and intergenerational transfer of weaving skills mattered as well. Appendix B.2 elaborates on the causes of a lack of wage equalization across regions and genders over time. A comparison with the proto-industry in England also sheds light on the determinants of high earnings for women during this period (Appendix B.4).

The oral tradition in *Qibao*, a suburb of Shanghai, depicts that men ask their wives's permission for discretionary spending ("*niangniang shouli tao zhenxian*"). In Man (2011), Zheng paints a vivid image of unwavering female breadwinners: a woman boasted about having single-handedly supported the family and been a "strong woman," a "she-husband." She did not hesitate to point out that her husband was only capable of literary writing and painting rather than of making money and helping to make ends meet.[24]

[24]Man (2011) is a survey article. Zheng compiles a list of historical sources: J. Chen et al. (1991), Gu (1995), and Xu (1987). The story above is mentioned in Xu (1987).

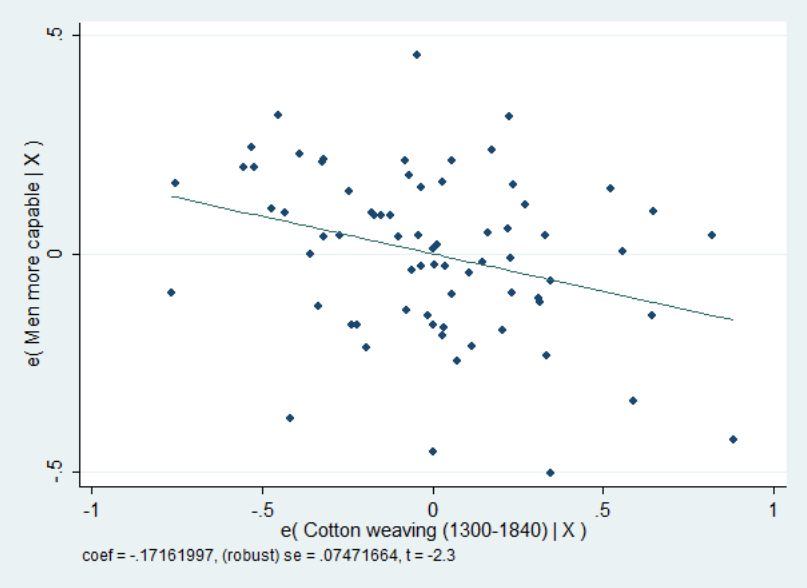

Figure II: "Men are naturally more capable than women." (a422)

Married women supported the family with incomes derived from weaving. In many instances, their earnings exceeded those of their husbands. Many young Chinese men spent 15-20 years of their life taking civil exams (Elman et al., 2000; Carol H Shiue, 2016; Carol H Shiue, 2017; T. Chen, Kung, and Ma, 2020). Many of those young men came from a commoner's background and had no other source of income. Their wives' incomes were then crucial to their success.

For widows, the cotton revolution greatly improved their standard of living. With these new incomes, widows supported themselves, their children, and their in-laws (Mann, 1987). They also contributed to communities and became famous donors to local charities (Elvin, 1984; Zurndorfer, 1998; Sommer, 2000). The positive impact of the cotton revolution on widows can be felt as early as the 1600s. An empirical analysis of widow survival is available in Appendix D.

In summary, although married women already did productive work before the cotton revolution, they were supplemental income earners. During the cotton revolution, married women produced a much larger quantity of goods for the state and for the market. This allowed married women to earn enough to support a family independently.

Chinese General Social Survey I provide direct evidence on the emergence of gender-equitable beliefs by examining the relationship between cotton weaving (1300-1840) and beliefs about women in the Chinese General Social Survey. Figure II illustrates the negative effect of cotton weaving (1300-1840) on the belief that men are naturally more capable than

women holding constant all other predictor variables. Contemporary, historical and geographical controls are added as described in Section III. The Y-axis is the county average of responses to the question: do you agree with the statement "men are naturally more capable than women"? A higher value means that a respondent is in more agreement with the statement. I interpret this result as evidence for a revision of the gender stereotype that men are more agentic and have more task-oriented, instrumental qualities.

Appendix E summarizes the main results. Besides being less likely to think men are naturally more capable, respondents in affected regions are less likely to think women are less suited for a career. I include these results in Table A.IV and show that the results hold for male respondents (Table A.V).

There are no noticeable differences in a range of other attitudes and beliefs, such as acceptance of premarital sex or same-sex marriage, or the belief that the benefit of modern science outweighs its cost or that most people can be trusted. This suggests that there are few differences in ideology between individuals in regions affected by the cotton revolution and those in other regions, besides the difference in their beliefs about women's ability and worth (Table A.VI).

V The Cotton Revolution and Beliefs About Women: Evidence from the 2000 Census

Having demonstrated the relationship between the cotton revolution and core beliefs about women in CGSS, I turn to the 2000 census to obtain a sample with more complete geographical coverage and measures related to individual decisions and behavior.

Because outcome variables were measured in 2000—160 years after cotton production was last associated with high relative female income and long after the discontinuation of handicraft cotton weaving—it is unlikely that the effect found is driven by the economic effect of cotton weaving itself.

Individual decision-making towards different genders is affected by economic, institutional and cultural factors (Fernández and Fogli, 2009). After 1949, the state mandated full-time employment for both women and men (Yang, 1999; Entwisle and G. Henderson, 2000), which reduced economic differences between them. There is a usual U-shaped relationship between per capita income and female labor force participation (Goldin, 1995). This relationship is temporarily disabled in socialist China, further reducing the impact of economic factors and economic channels. By 2000 female labor participation rate had remained at a very high level; the female-to-male ratio in the rate of labor force participation was at 85% in 2000, one

of the highest in the world.[25] The state also standardized institutions making it convenient to examine the cultural component.

V.A Birth Sex Ratio as a Key Outcome

A highly skewed sex ratio at birth provides an opportunity to infer gender-inequitable beliefs. The decision to have a daughter versus a son can be seen as a revealed preference measure of gender-inequitable beliefs. If an individual regards girls and women as inferior, they are less likely to choose to have a daughter.

The link between a male-to-female birth sex ratio and gender-inequitable beliefs can be described as follows. Suppose that an individual holds gender-inequitable beliefs (I) or gender-equitable beliefs (E). When an individual deliberately selects a boy through sex-selective abortion, it reveals that they hold gender-inequitable beliefs. When the birth sex ratio in the aggregate exceeds the normal range, which is 103 to 107 boys per 100 girls, it is an indication that at least a portion of the individuals hold gender-inequitable beliefs.[26]

Gender-inequitable beliefs, reflected in a preference for male offspring, can be realized in the use of the stopping rule or in sex-selective abortion. Outside of East Asia and South Asia, there has been little in the aggregate data to suggest that sex preferences for offspring influence sex ratios. This is at least partly due to religious prohibitions (Almond, Edlund, and Milligan, 2013). The United States represents a case where there is a preference for male offspring but its birth sex ratio has never deviated from the normal range (Appendix F). Because religious prohibitions do not apply to the general population of the Han Chinese, demand for male offspring is freely translated into the birth sex ratio through sex selection. This makes the birth sex ratio a feasible measure to capture gender-inequitable beliefs in the particular setting of China in 2000.

The low fertility regime present in 2000 represented a tight and binding constraint. Under the one-child policy, birth quota was an extremely scarce resource, and parents had to allocate this scarce resource to either a son or a daughter but not both. In the extreme case, when constraints on sex selection barely exist, individuals would *always* choose a son if they regard girls and women as inferior.[27] The low fertility regime also widens the variation in the birth

[25] http://hdr.undp.org/en/content/labour-force-participation-rate-female-male-ratio. The female-to-male labor force participation was 74.8% in the United States and 62.4% in Germany.

[26] All else equal, if fewer individuals holds gender-inequitable beliefs in County A than in County B, I's distribution in County A is to the left of that in County B. For the same county, if over time individuals abandon their gender-inequitable beliefs, I's distribution shifts to the left. Hence if cotton weaving (1300-1840) undermined gender-inequitable beliefs, the birth sex ratio should be less biased in those counties.

[27] This is very different from making other choices such as engaging in gender-biased human capital investment, where no necessary choice has to be made if educational resources are plentiful (as is the case in a high income country).

sex ratio and increases the precision of measurement.

Next I discuss a number of correlates of the birth sex ratio that can affect the link between the birth sex ratio and gender-inequitable beliefs and how regional variation in those correlates is much reduced in the context of China in 2000. A more detailed discussion of the determinants of the birth sex ratio, including economic and non-economic factors, is provided in Appendix F.1.

There exists a negative correlation between expected fertility and the birth sex ratio (Jayachandran, 2017). If an individual simultaneously prefers low fertility and holds gender-inequitable beliefs, the resulting distortion in the sex ratio among their children will be the most extreme. The one-child policy, starting in the 1980s, set fertility to be exogenous to individuals' choices and gave son preference a more exclusive role in determining the birth sex ratio. Previous work has similarly relied on the setting of the one-child policy for exogeneity in fertility or family size (H. Li, J. Zhang, and Zhu, 2008; Rosenzweig and J. Zhang, 2009).

When individuals resort to sex-selective abortion to have sons, access to abortion plays a role in determining the birth sex ratio. By the late 1990s, sex-selective abortion was accessible across the country (Appendix F). Another factor is individual attitudes towards abortion. Appendix Table A.VII suggests that attitudes towards abortion are very similar in counties with cotton weaving (1300-1840) and those without.

I begin to test my hypothesis by estimating the following equation:

$$\text{Birth sex ratio in } 2000_c = \alpha + \beta \text{Cotton weaving (1300-1840)}_c + \mathbf{X}_c^H \mathbf{\Omega} + \mathbf{X}_c^G \mathbf{\Lambda} + \mathbf{X}_c^C \mathbf{\Pi} + \epsilon_c \ , \quad (1)$$

where c denotes a county. Cotton weaving $(1300\text{-}1840)_c$ is cotton weaving during the period of 1300 to 1840 at County c. Birth sex ratio in 2000_c is the number of boys per hundred girls born.[28] $\mathbf{X}_c^H$ is a vector of historical controls, and $\mathbf{X}_c^G$ and $\mathbf{X}_c^C$ are vectors of geographical and contemporary controls respectively, each measured at the county level.

Historical, geographical and contemporary controls are as described in Section III.C. I include these controls to account for regional differences in pre-existing customs and beliefs, historical and modern development, modernization and secularization, sectoral composition, economic geography, market access and variation in the enforcement of the one-child policy. These factors are potentially correlated with both cotton weaving (1300-1840) and the birth sex ratio in 2000. The purpose of these control variables is explained in greater details in Section III.C and Appendix C.2. Sources of variation in the enforcement of the one-child

[28] I can derive an alternative measure of sex ratio imbalances by taking the natural log of the deviation of the birth sex ratio from the normal range (103-107 boys per 100 girls). Results are very similar when this alternative measure is used.

Table II: Cotton Revolution and Sex Selection: OLS Results

	Dependent variable: birth sex ratio in 2000					
	(1)	(2)	(3)	(4)	(5)	(6)
Mean of Dep. Var.	118.3	118.3	118.6	118.6	118.6	118.6
Cotton weaving (1300-1840)	-3.008***	-3.225***	-3.514***	-3.748***	-3.625***	-3.754***
	(0.668)	(0.713)	(0.740)	(0.782)	(0.784)	(0.780)
Log per capita GDP			-2.923***			
			(0.495)			
% in agriculture			0.0700			
			(0.393)			
% in service			-0.269			
			(1.314)			
Male Schooling			-0.269			
			(1.314)			
% ethnic population			-0.735***	-1.073***		
			(0.250)	(0.254)		
Historical controls	No	No	Yes	Yes	Yes	Yes
Geographical controls	No	No	Yes	Yes	Yes	Yes
Political controls	No	No	Yes	Yes	Yes	No
Province FE	No	Yes	Yes	Yes	Yes	Yes
Socioeconomic macroregion FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.150	0.231	0.371	0.324	0.316	0.300
Observations	1622	1622	1474	1474	1474	1474

The table reports the relationship between cotton weaving (1300-1840) and sex ratio imbalances in the 2000 census. The unit of observation is a county. The dependent variable is the birth sex ratio. Column 1 reports estimates with only socioeconomic macroregion effects. Column 2 reports estimates with both socioeconomic macroregion and province effects. Column 3 includes all controls. "Historical controls" are treaty port status, agriculture suitability, and whether a county was on the Grand Canal or the Yangtze River which were the major trade network. "Geographic controls" ar the natural log of one plus ruggedness, the natural log of distance to coast, latitude, longitude and their interaction. Column 4-6 sequentially drops potentially endogenous modern controls. The omitted category for governance status is a county being governed by the prefecture-level city. Robust standard errors are used in all specifications. Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

policy are discussed in Appendix F.

The OLS estimates show that in counties with cotton weaving between 1300 and 1840, fewer girls are missing today. The coefficient estimates are both statistically significant and economically meaningful. I begin my analysis with socioeconomic region fixed effects only (column 1), and then include both socioeconomic region fixed effects and province fixed effects (column 2). When I include the full set of controls in column 3, the size of the coefficient increases from -3.008 to -3.753. The cotton revolution is associated with a decrease of the birth sex ratio by 3.753 boys per 100 girls, which is 27% of the standard deviation of the

birth sex ratio.[29] Column 3 contains the baseline specification for the rest of this study. Appendix Figure A.II shows the partial regression plot based on column 3. It indicates that the coefficient estimate of cotton weaving (1300-1840) is not influenced by a small number of counties.

In column 4, the coefficient estimate remains similar when I omit log GDP per capita, log share of urban *hukou*, log share of agricultural workforce and log share of service workforce and average education of men.[30] In column 5, I further exclude the share of ethnic population.[31] In the last column, I drop all contemporary controls, and the coefficient estimate remains similar.

These results can be replicated using the individual-level 2000 census data (1% sample). Figure A.III examines the relationship between the cotton revolution and the average probability of an individual being female for earlier cohorts. A positive relationship between the two only became apparent into the late 1990s. This coincides with the timing of ultrasound access becoming widely available.

Alesina, Giuliano, and Nunn (2013) posit that the use of the plough in advanced agriculture has led to conservative gender norms. Following their approach, I use a 200km radius to identify the territory of each ethnic group in the Ethnographic Atlas. The interaction term between the plough and cotton weaving (1300-1840) is negative and significant (Appendix Table A.VIII). Cotton weaving (1300-1840) led to the most significant change in core beliefs about women in places that had the plough technology, suggesting that home-based proto-industrial production of cotton textiles helped women overcome the disadvantage formed in a plough-based agricultural society and led to the rise of women despite conservative gender norms.

Historically Relevant Economic Activities Performed by Women I examine the effect of other historically relevant economic activities performed by women that generated lower earnings (Appendix G.7). The range of activities being examined here include the

[29]The specification is robust to the inclusion of the squared term of log GDP per capita. Fertility is a "bad" control, as decisions are made simultaneously on fertility and sex selection [pp.64-68](Angrist and Pischke, 2008), but results are robust to controlling for fertility.

[30]Though large sex ratio imbalances were relatively recent, the underlying gender-inequitable beliefs had been around for longer. GDP per capita could have been impacted by pre-2000 gender discrimination. Sex ratio imbalances can also affect GDP through increasing saving rates, according to the "competitive saving" thesis laid out in (Wei and X. Zhang, 2011). In both cases, controlling for log GDP per capita will lead to "overcontrolling".

[31]The share of ethnic population might have become endogenous to the dependent variable due to the one-child policy. Under the one-child policy, ethnic populations were subject to a less restrictive birth quota. W. Huang and Zhou (2016) has documented that inter-ethnic marriages happened more under the one-child policy.

production of hemp and silk textiles, tea production and farming activites on clayey versus loamy soil. The difference between those economic activities and cotton weaving is that while these activities also demanded female labor, they typically did not generate a high enough income for women to be major income earners. When a woman worked as a hemp textile producer or a tea picker, she contributed to economic production of the household but her income remained as supplemental.

Table A.XV summarizes the results. It does not appear that the presence of the lower-earning economic activities bears much of a relationship with the birth sex ratio in 2000. The relationship between relative female income and beliefs about women seems non-linear. For it to be relevant for the emergence of gender-equitable beliefs, relative female income has to reach a certain threshold. Differences in relative female income do not necessarily map into differences in the prevalence of gender-equitable beliefs.

Further Robustness To further ensure the robustness of the results, I conduct the following tests: (i.) I cluster at different geographic units to address heterogeneity in data sources (Table A.IX). The number of clusters ranges from 8 to 1295 depending on the geographic level standard errors are clustered. My results are not sensitive to the level of geographic clustering for standard errors. (ii.) I address potential biases caused by gazetteer availability (Table A.X). I restrict my sample to counties with a similar number of gazetteers. My estimates remain stable as the sample size varies from 320 to 1474. (iii.) I account for spatial correlations using both Conley standard errors and a spatial-autoregressive model (Tables A.XIII and A.XIV). (iv.) I exclude the economically advanced Yangtze Delta region and counties with a net in-flow of migrants (Table A.XI). The cotton textile industry was particularly developed in the Yangtze Delta. The exclusion of this region from the sample does not change the estimates. (v.) I include two historical correlates of cotton weaving (1300-1840), commercial networks and state capacity, in the baseline regression. In-kind taxation played a major role in state demand for cotton textiles and was positively related to state capacity. Appendix G summarizes the results of the above tests.

Intervening Shocks A series of political and economic shocks have occurred since 1840. I account for these intervening events and their interactions with cotton weaving (1300-1840). Reassuringly, neither early industrialization, missionary activities, nor recent economic liberalization can explain away the effects of the cotton revolution. In the counterfactual where thesfe events did not take place, the cotton revolution would have led to a reduction of the birth sex ratio by 5.5 boys per 100 girls. The full analysis is available in Appendix H.

V.B Related Outcomes

I examine the effect of the cotton revolution on a range of outcomes commonly examined in labor economics. Compared to the birth sex ratio under the one-child policy in late 1990s, these outcomes are more easily influenced by modern economic and political conditions. Some of those economic and political conditions might serve as mediating channels to transmit the effect of the cotton revolution on gender-equitable beliefs (Baron and Kenny, 1986), so it is significantly more difficult to clearly identify the mechanism underlying the long-term impact of the cotton revolution on these variables than on the birth sex ratio.

In columns 1-3 of Table III, I examine choices easily influenced by private individuals, such as women's educational attainment, marital status and representation in leadership positions. Cotton weaving (1300-1840) predicts women getting more education, staying unmarried more often and/or for longer and assuming more leadership roles. This is consistent with results in Section IV on the impact of the cotton revolution on the belief that men are naturally more capable and that only men should focus on having a career.

In columns 4-8, I examine the effect of the cotton revolution on outcomes controlled by the centralized government. The socialist state mandated full-time employment for both genders across China. Therefore, the cotton revolution should have little impact on female employment. This is supported by the results in columns 4-8 of Table III.

Taken together, I find evidence that cotton weaving (1300-1840) affected behavior and decisions with respect to education, marriage and hierarchy in the workplace, at a time there was neither formal restriction on female employment nor a gender gap in actual employment (columns 4-8). Because the differences in economic payoffs to educating women versus men are small, beliefs about women should have a more significant role in the gender education gap. In other words, mandated labor force participation mitigated the indirect effect of the cotton weaving (1300-1840) on educational and marriage decisions via female employment, allowing me to focus on its direct effect on parental investment in education, entry into marriage and acceptance of women in positions of power.

V.C Accounting for Selection

A potential concern is selectivity into the adoption of new cotton spinning and weaving technologies. If individuals in counties with cotton weaving (1300-1840) perceived women differently before 1300, or were going to develop systematically different beliefs about women anyways, estimates will be biased away from zero.

Table III: Cotton Revolution and Sex Selection: Related Outcomes

	Private decisions			Centralized (state) decisions				
	Years of schooling	% Unmarried	Company CEOs	Female labor force participation			Female unemployment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Mean of Dep. Var.	0.864	0.119	0.137	0.500	0.818	0.920	3.491	1.270
Cotton weaving (1300-1840)	0.0102***	0.00645***	0.0111***	0.000209	0.000733	0.00407	-0.0852	-0.0567
	(0.00252)	(0.00172)	(0.00425)	(0.00262)	(0.00530)	(0.00634)	(0.128)	(0.123)
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Socioeconomic macroregion FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.581	0.645	0.292	0.817	0.594	0.779	0.717	0.0247
Observations	1474	1474	1474	1474	1474	1474	1474	1474

The table reports the relationship between cotton weaving (1300-1840) and women's education and marriage, the gender composition of company CEOs, as well as a null relationship between cotton weaving (1300-1840) and women's employment and labor force participation in the 2000 census. The unit of observation is a county. Column 1 examines the female-to-male ratio of years of schooling. Column 2 examines the percentage of unmarried women. Column 3 examines the female-to-male ratio of company CEOs. Column 4 examines the ratio of women in the labor force to the size of female population. Column 5 examines the female-to-male ratio of labor force participation. Column 6 examines the ratio of women in the labor force to the population of women aged 15-50. Column 7 examines the percentage of women who are unemployed. Column 8 examines share of women unemployed/ share of men unemployed +0.1%. Baseline controls are the same as in column 3 of Table II. Robust standard errors are used in all specifications. Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The population under study are predominantly Han Chinese, who were governed by Confucian laws both before and after 1300. Part of the remaining differences within the Han Chinese population were at the socioeconomic macroregion level. Those differences are accounted for in the baseline estimation using socioeconomic macroregion fixed effects.

I add Han subgroup fixed effects to filter out remaining differences in pre-existing customs and norms (Appendix I.1). Each subgroup has a distinct language. By including Han subgroup fixed effects, I use only variation within subgroups.

To address the remaining concerns, I adopt a number of strategies and summarize results. I first check the degree of selection on unobservables based on selection on observables (Appendix I.2). The result of this analysis suggests that the ratio of selection on unobservables relative to selection on observables has to be 4 to 13 times larger to explain away my results.

To ensure that my sample comprises treated and untreated units that are as similar to each other as possible, I restrict my sample to matched units (Appendix I.3). Individuals in those units are more likely to hold similar beliefs about women before 1300, as well as to have had a similar trajectory regarding the development of gender-equitable beliefs (Kahn-Lang and Lang, 2018; Athey and Imbens, 2018). Table A.XIX provides more details on this exercise. The main results stay the same across samples constructed using different matching criteria.

Lastly, I directly account for pre-1300 beliefs about women and include it both as a control and use it to build a naive difference-in-differences model. In addition, I use an instrumental variable strategy to circumvent omitted variable bias. My instrument is the interaction term between a humidity-based weaving suitability measure and proximity to the location from which new technologies first began to spread (Songjiang). The results of these two tests are described below.

V.C.1 Pre-1300 Beliefs About Women and Difference-in-Differences Estimates

Counties with cotton weaving (1300-1840) and those without might differ in their core beliefs about women before 1300. Socioeconomic macroregion and Han subgroup fixed effects account for a great deal of variation in norms and customs, of which beliefs about women are an important component. The ideal control variable will be a direct measure of core beliefs about women before 1300. Unfortunately, there is a paucity of data available at a county level for the pre-1300 period, and as noted in previous sections, a direct measure of beliefs about women before 1300 does not exist.

I examine poetry written in the Song Dynasty to build a measure of visibility of women in society. The Complete Song Dynasty Poems (*quan song shi*) comprises over 250,000 poems. The Song Dynasty lasted from 960 until 1279 AD. I use topic modeling to classify

poetry, which is the most common method of unsupervised learning in machine learning. It automatically clusters word groups that best characterize a set of documents. It turns out that the entirety of the poems can be represented by just ten topics. Among those, Topics 9 and 10 contain cluster words that are mostly about women or common metaphors for them. The content of a total of 75,188 poems is tagged as "women-visible" because of the presence of these two topics.

I compute the share of "women-visible" poems by author and aggregate author-level data to the county level. Counties without any author featured in *quan song shi* are not included. This yields a measure of visibility, *women in pre-1300 poetry*, for 733 counties. In an average county, 23% of the poems by an average author are "women-visible". I include this measure in the baseline regression (Equation 3). My baseline estimates are robust to the inclusion of this control. As expected, counties in which women were more visible in pre-1300 poetry saw less sex selection in 2000. The predictive power of this measure disappears once I restrict my sample to counties matched on pre-1300 characteristics. Results are summarized in Appendix Table A.XX.

I estimate the effect of cotton weaving (1300-1840) using a naive difference-in-differences model. In this setup, the period prior to 1300 is the *pre* period, and year 2000 is the *post* period. The outcome variable is beliefs about women. *Women in pre-1300 poetry* is used as a proxy for beliefs about women for the *pre* period; the female-to-male ratio of the birth cohort is used as a proxy for the *post* period. In the baseline OLS regressions, I use the male-to-female ratio as the main outcome variable. Here I use the female-to-male ratio so an increase (decrease) in the female-to-male ratio has the same correspondence with the distribution of beliefs about women as an increase (decrease) in *women in pre-1300 poetry*.[32] For comparability, I use z scores of both *women in pre-1300 poetry* and the female-to-male ratio of the cohort born in 2000.

Table IV: Pre- and Post- 1300: From Supplemental to Major Income Earners

	Before 1300	1300-1840
Cotton weaving (1300-1840)=1	Women as supplemental income earners	Women as major income earners
Cotton weaving (1300-1840)=0	Women as supplemental income earners	Women as supplemental income earners

[32]The female-to-male ratio of the birth cohort has also been used in columns 4-6 of Table A.XX where I add *women in pre-1300 poetry* as a control variable.

Below I estimate the following:

$$\gamma = [\text{Beliefs}_i|(CW_i = 1, Post = 1) - \text{Beliefs}_i|(CW_i = 1, Post = 0)] - [\text{Beliefs}_i|(CW_i = 0, Post = 1) - \text{Beliefs}_i|(CW_i = 0, Post = 0)]$$

$CW_i = 1$ and $CW_i = 0$ stand for counties with cotton weaving (1300-1840) and counties without, respectively. Essentially, I estimate the difference between beliefs about women in environments where women are major income earners and where they are supplemental income earners, differencing out their differences in the *pre* period (Appendix Table IV). For both types of counties, $CW_i = 0$ and $CW_i = 1$, before 1300, women were supplemental income earners. They wove hemp for home use or to be "purchased" by the state. When the cotton revolution happened, women produced cotton cloth both for the state and for the market. Women became major income earners in cotton weaving regions, $CW_i = 1$. In the rest of China, $CW_i = 0$, women continued to carry on pre-1300 activities or began to cultivate cotton (but not to weave it), and remained as supplemental income earners. If beliefs about women in environments where women are supplemental income earners are close equivalents, that is to say, $\text{Beliefs}_i|(CW_i = 1, Post = 0)$ equals $\text{Beliefs}_i|(CW_i = 0, Post = 0)$, the difference-in-differences estimator decays to the OLS estimator in Equation 3, $\text{Beliefs}_i|(CW_i = 1, Post = 1)$ - $\text{Beliefs}_i|(CW_i = 0, Post = 1)$. In other words, under the assumption that beliefs about women are similar where women are supplemental income earners, an OLS estimation strategy is equivalent to a difference-in-differences estimation strategy.

Table V summarizes the results. The coefficient estimate of the difference-in-difference estimator is positive and statistically significant throughout the columns. This suggests that cotton weaving (1300-1840) moved the distribution of gender-equitable beliefs. In other words, gender-equitable beliefs became more prevalent following the cotton revolution. The coefficient estimates are between 0.3 and 0.4 standard deviation of the outcome variable. These estimates are slightly larger than OLS estimates in Table II. According to the baseline OLS estimate, cotton weaving (1300-1840) is associated with a 0.27-standard-deviation decrease in the male-biased birth sex ratio.

V.C.2 Instrumental Variable Strategy

I use the interaction term between the humidity-for-weaving index and proximity to the location from which new technologies first began to spread (Songjiang) as my instrument. Both the humidity-for-weaving index and proximity to Songjiang are predictors of technology adoption. The details of the humidity-for-weaving index are provided in Appendix J. f

In the premodern world, the diffusion of technology was a slow process. When Huang

Table V: Cotton Revolution and Beliefs About Women: A Difference-in-Differences Estimation Strategy

p5cm p3.5cm p3.5cm p3.5cm—

	Dependent variable: beliefs about women		
Z-Score			
(1)	(2)	(3)	
Cotton weaving$^{1300\text{-}1840}$ × Post	0.308*	0.356*	0.403**
	(0.166)	(0.182)	(0.157)
County FE	Yes	Yes	Yes
Post dummies	Yes	Yes	Yes
Observations	474	362	494

The table reports difference-in-differences estimates of the impact of cotton weaving (1300-1840) on beliefs about women. The unit of observation is a county. The dependent variable is the birth sex ratio. Baseline controls are those used in column 3 of II. Columns 1 restricts the sample to a matched sample with a caliper size of 0.005 ; columns 2 and 3, a caliper size of 0.001 and 0.01 (see Table A.XIX). For the *pre* period, the outcome variable is the Z-Score of *women in pre-1300 poetry*; for the *post* period, the outcome variable is the z score of the female-to-male ratio of the cohort born in 2000. Robust standard errors are included in all specifications. Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Dao Po first introduced the new technologies to her hometown, Songjiang, it was the only place with highly productive cotton textile production. The rationale behind using proximity to Songjiang is that the further away from Songjiang, the less likely new technologies would have been adopted before 1840.[33]

Relative humidity (%) played a key role in the production of cotton textiles.[34] For the successful manufacture of cotton textiles, the fibers must contain a suitable amount of moisture. [35] The relationship between weaving suitability and relative humidity is non-linear. The range of relative humidity suitable for cotton weaving is between 60% and 85%. Within this range, tensile strength increases in relative humidity (Lewis, 1913; Iqbal et al., 2012). Once below 60% RH, cotton weaving is no longer viable. Above 85%, there is little gain in weaving productivity in increasing relative humidity. I take this non-linear relationship into account when building my humidity-for-weaving index.

Taking into account both intrayear and intraday variation in relative humidity, the index

[33]The value of *proximity to Songjiang* decreases in a county's distance to Songjiang. To construct this variable, I take the negation of a county's distance to Songjiang and add it to the distance to Songjiang from the farthest away county.

[34]Crafts and Wolf (2014) discuss factors in locational choice faced by cotton textile manufacturers in 19th c. England. In their analysis, they distinguish between "original advantages" and "acquired advantages". "Original advantages" include the availability of water power, the quality of farm land, local levels of humidity and etc.

[35]Humidity makes cotton fibers more pliable, lowers the chance of breakages in the yarn and reduces dust in the air (Lewis, 1913; Lander, 1914; Farnie, 1979; Ananthanarayanan, 2013).

captures both the number of months a year, and the number of hours a day, that are suitable for cotton weaving. This yields a measure that is highly specific to cotton weaving. In addition, the spinning and weaving of cotton, silk, hemp, wool and synthetics vary greatly in their humidity requirements. Scientists and engineers have studied optimal humidity for each fabric (Stamper and Koral, 1979; Ananthanarayanan, 2013; Kut, 2014). Silk should be weaved at a relative humidity of 60 to 70%; 50 to 55% RH for weaving woolens and 55 to 70% RH for weaving worsteds. Fiber-dependent humidity requirements ensure that the humidity-based index built on the technical specifications of weaving cotton is specific to its purpose.

Both the humidity-for-weaving index and proximity to Songjiang can be correlated with geographic determinants of beliefs about women. I take the interaction term between the two to create a more exogenous source of variation. According to Pearl (2000), the interaction term between non-instrumental variables can be a valid instrument.

I begin my IV estimation by testing the relationship between my instrument and cotton weaving (1300-1840). Because my treatment variable is binary, I use Probit-2SLS as my main estimation strategy. Probit-2SLS is a three-stage procedure recommended in Wooldridge (2002, pp.623-626). It uses a Probit model for the first stage.[36] The purpose of using this estimation strategy is to properly model the relationship between the instrument and cotton weaving (1300-1840) in order to best mitigate the problem of weak instruments due to omitted nonlinearity (D. J. Henderson and Parmeter, 2015).[37]

The results are summarized in Table VI. County outliers are excluded. These excluded counties have a birth sex ratio higher than 165.7, which exceeds that of 99% of the counties. Column 1 contains the OLS estimates. Column 2 reports the Probit-2SLS estimate. This is my preferred specification. In this procedure, the second stage is to calculate the predicted probability of cotton weaving (1300-1840), and the third stage is to regress the birth sex ratio on the predicted probability of cotton weaving (1300-1840). Third-stage results are reported in Panel A. A one-standard-deviation increase in cotton weaving (1300-1840) leads to a reduction of the birth sex ratio by 2.768 boys per 100 girls (2.768=5.648*0.49). In column

[36]The full procedure is as follows: first, use Probit to regress the treatment on the instrument and exogenous variables; second, take predicted values from the first step and include them in the first stage of a regular 2SLS procedure, together with the exogenous predictors of the birth sex ratio; third, run the second stage as in a regular 2SLS procedure.

[37]D. J. Henderson and Parmeter (2015) shows that instruments that may be strong in a nonlinear relationship with the treatment could be weak when a linear relationship is imposed upon. An alternative method to address nonlinearities is to use a nonparametric instrument. However, Newey (2013) shows that nonparametric IV estimation only behaves when the instrument is very strong. When the reduced form R^2 is low, and a linear IV slope can be estimated, the variance of the coefficients of nonlinear terms will be very high.

Table VI: Cotton Revolution and Sex Selection: An Instrumental Variable Analysis

	(1) OLS	(2) Probit-2SLS	(3) 2SLS
	Panel A Dependent variable: birth sex ratio in 2000		
Mean of Dep. Var.	117.9	118.0	117.9
Cotton weaving (1300-1840)	-2.856***	-5.648**	-7.780*
	(0.698)	(2.860)	(4.729)
	Panel B Dependent variable: cotton weaving (1300-1840)		
Humidity-for-weaving index × Proximity to Songjiang		0.0432***	0.0120***
		(0.0098)	(0.002)
Humidity-for-weaving index	Yes	Yes	Yes
Proximity to Songjiang	Yes	Yes	Yes
Baseline controls	Yes	Yes	Yes
Province FE	Yes	Yes	Yes
Socioeconomic macroregion FE	Yes	Yes	Yes
Observations	1454	1430	1444

The table reports OLS, Probit-2SLS and regular 2SLS estimates of the relationship between cotton weaving (1300-1840) and sex ratio imbalances in the 2000 census. The unit of observation is a county. The dependent variable is the birth sex ratio. First-stage results are displayed in Panel B. For Probit-2SLS, the full procedure has three stages; Panel A displays third-stage estimates. For regular 2SLS, the procedure has two stages; Panel A displays second-stage estimates. Counties in which the birth sex ratio is within the top 99 percentile (> 165.7) are excluded. Baseline controls are the same as in column 3 of Table II. Robust standard errors are included in all specifications. Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4, I use regular 2SLS as opposed to Probit-2SLS. This yields a slightly larger coefficient estimate which is less precisely estimated. First-stage estimates in Panel B confirm that the instrument is positively correlated with cotton weaving (1300-1840).

My IV estimate in column 2 is 5.6 boys per hundred girls, or 0.4 standard deviation of the birth sex ratio. This is slightly larger than the baseline OLS estimate (Table II). The two causal estimates, the IV estimate and the difference-in-differences estimate, are close to each other. Together these suggest that the baseline OLS estimate might be an underestimate of the true effect.

VI Understanding the Mechanisms

I have documented the long-term effect of the cotton revolution and shown evidence in favor of culture being the underlying channel. In this section, I aim to better understand the channels underlying the long-term effect of the cotton revolution. First, I shed light on

the treatment—the prevalence of female breadwinning—and show how female breadwinning would affect gender relations within the household and how this can lead to population-wide cultural change. Second, I provide further evidence on cultural change by showing that the cotton revolution was associated with a decline in the practice of dowry. Third, I test my hypothesis under various institutional arrangements, of which different predictions are produced about the effect of the cotton revolution.

VI.A The Prevalence of Female Breadwinning as a Treatment

Regarding the cotton revolution, I have presented historians' calculation of women's relative earnings (Section IV). Below I discuss the change women's major income earner status introduces to married households and how the prevalence of this economic change induces cultural change.

When women's relative contributions are close to or more than 50% of the household income, they are financially *indifferent* between being married and unmarried. The financial consequences of being divorced by their husbands or being deserted were much reduced. Divorce laws in imperial China allowed men to unilaterally divorce their wives on many grounds, as long as the divorce fits in one of the categories under "seven codes for divorcing wives." Divorced women would face severe economic hardships as men did not have financial obligations for their ex-wives and remarriage was stigmatized for women. In a class of bargaining models, an increase in relative female income shifts women's bargaining position by improving her welfare at the threat point (see Lundberg and Pollak (1996) for a summary of Nash cooperative and non-cooperative models.) If abused, it was credible for a woman who earned a high income as a weaver to retreat into her natal family, since it would not lower her standard of living; this increased her bargaining power within the marriage and gave her more decision-making authority. Her mental health and self-esteem might also improve.

From the perspective of parents, as women became productive members of the economy in their own right, it became less financially costly and mentally stressful to raise a daughter (Bossler, 2000). This would have a direct impact on their willingness to have daughters.

The evolution of culture is a slow-moving process (Boyd and Richerson, 1985; Boyd and Richerson, 2005).[38] The time span of the cotton revolution allowed for those slow moving processes to unfold. Nunn (2012) remarked that historical events could have persistent impacts if they alter the relative costs and benefits of different cultural traits, changing the prevalence of those traits in a population, and are transmitted vertically from parents to children.

In the context of imperial China, the universal in-kind taxation system required all house-

[38]Giuliano and Nunn (2017) shows that culture evolves at a faster rate when the weather is variable between generations.

holds to produce textiles. This meant that large increases in relative female income were prevalent in affected regions and new beliefs about women would be formed in a large share of the population. A high percentage of population being exposed to the shock could also contribute to the malleability of core aspects of beliefs about women by reducing coordination problems in changing cultural customs.

Because marriage was early and universal, women were breadwinners in many married households, rather than in a selected sample of households or only among unmarried women.[39] Hence the impact of the shock was mainly on the adoption of new roles within the marriage rather than on selection into marriage or on marital sorting. In Bisin and Verdier (2001)'s model on intergenerational cultural transmission, cultural values are transmitted vertically from parents to children. Changing norms in married households - presumably with children present - was a favorable avenue for intergenerational transmission of these beliefs.[40]

VI.A.1 Absolute versus Comparative Advantage: No Relationship Between Cotton Cultivation and Sex Ratio Imbalances

Below I contrast the effect of cotton weaving with that of cotton cultivation. The goal is to further establish the prevalence of female breadwinning as the relevant treatment.

The cotton revolution led to an increasing demand for labor in cotton weaving, but also in the cultivation of cotton. Female labor was heavily used in cotton cultivation but likely only because women were less productive than men in cultivating wheat and rice. That is to say, women only had a *comparative* advantage in cotton cultivation.[41] Relative female income could still rise but very unlikely it would reach the same threshold reached in the households of cotton weavers. Due to different climatic constraints and regional specialization, the locations of cotton cultivation differed significantly from those of cotton weaving (Appendix Figure III and A.XVI). This allows me to estimate their respective effects.

I find no evidence that an increasing demand for female labor in cotton cultivation has had the same impact as cotton weaving. Counties that specialized in cotton cultivation did not have a more balanced birth sex ratio in 2000. In Table VII, there is no significant relationship between cotton cultivation and the birth sex ratio (column 1). The coefficient estimate is precisely estimated at zero. The main results remain when I use an indicator variable that takes the value of one when raw cotton suitability is above the median and zero

[39] In premodern China, only 1% of Chinese females were unmarried at age 30, whereas more than 15% of European women were unmarried at age 40 (Lee and Feng, 1999).

[40] Fernández, Fogli, and Olivetti (2004) shows that growing up with a working mother might have influenced a man's preferences for a working wife.

[41] In contrast to weaving, which demanded adroitness and was performed at home, women had no particular advantage in cultivating cotton. Cotton cultivation was unskilled work and thus there was no skill premium in earnings from cotton cultivation. Women trained themselves for years to develop weaving skills.

Table VII: No Relationship Between the Cultivation of Raw Cotton and Sex Ratio Imbalances

	Dependent variable: birth sex ratio in 2000			
	(1)	(2)	(3)	(4)
	Continuous	Median	Continuous	Median
Mean of Dep. Var.	118.6	118.6	118.6	118.6
Raw cotton	-0.00234	0.172	-0.00119	0.208
	(0.00329)	(1.382)	(0.00329)	(1.377)
Cotton weaving (1300-1840)			-3.471***	-3.497***
			(0.747)	(0.742)
Baseline controls	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Socioeconomic macroregion FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.363	0.363	0.371	0.371
Observations	1470	1470	1470	1470

The table reports the relationship between the cultivation of raw cotton and sex ratio imbalances in the 2000 census. The unit of observation is a county. The dependent variable is the birth sex ratio. Baseline controls are those used in Column 3 of Table II. Columns 1 and 3 use continuous measures of suitability for growing raw cotton. Columns 2 and 4 take the median of the suitability measure. Robust standard errors are used in all specifications. Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

otherwise. In columns 3-4, I include both cotton weaving (1300-1840) and raw cotton. The coefficient estimate of cotton weaving (1300-1840) does not deviate much from the baseline estimate.

I consider this as clarifying evidence that the effect of the cotton revolution on gender-equitable beliefs hinges upon cotton weaving and that the treatment of women becoming major income earners is relevant. There was also an increase in demand for female labor in the case of cotton cultivation, but no long-term cultural change associated with it.

VI.B A Decline in the Practice of Dowry

I have provided modern evidence to support the hypothesis is that there has been long-term cultural change tied to the cotton revolution, and below I use historical data to trace that change back to its temporal origin.

There is not sufficient data for creating a direct measure of beliefs about women for the centuries following the cotton revolution. The poetry data, available for the pre-1300 period, have no close equivalent for later periods. I instead look into data on cultural customs, such as the practice of dowry.

Using all pre-1949 county gazetteers available on the Chinese Gazetteer Database, Series I

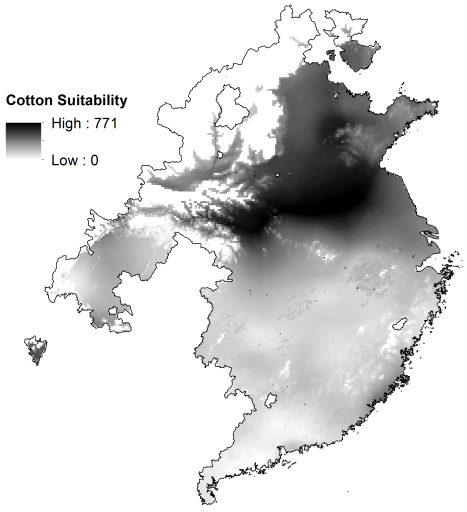

Figure III: Agro-Climatically Attainable Yield (kg DW/ha) for Immediate-Input-Level, Rain-Fed Cotton

(*zhongguo fangzhi ku*), I construct a historical measure of the practice of dowry. The measure is at the county level. The database has over 2,000 county gazetteers for over 700 counties. I restrict the sample to all counties with at least one county gazetteer. This yields a sample of 754 counties. The unit of analysis is a county in the administrative year of 1911.

I regress cotton weaving (1300-1840) on the practice of dowry (Table VIII). I find the presence of cotton weaving to be negatively associated with the practice of dowry. Controls for initial conditions such as population density and agricultural suitability are insignificant. Province fixed effects are included in all columns.

The practice of dowry is not an ideal measure of beliefs and values. The cotton revolution was a shock to women's earnings profile. Because the economic effect of the cotton revolution was still in place, women in affected regions contributed more to the marital household, a decline in dowry could be driven by economic factors only. Existing research has indicated a relationship between the earnings profile of women and the size of dowry payments (Becker, 1991; S. Anderson, 2003; S. Anderson and Bidner, 2015). According to anecdotes in De Moor and Van Zanden (2010) in fifteenth-century Tuscany, if the bride is seen as capable of contributing to the marital household, her parents would only need to pay a smaller dowry to get the groom to accept their daughter.

While a decline in the practice of dowry does not necessarily suggest a shift in cultural beliefs, simultaneous results on the effect of the cotton revolution on both outcomes that are closely related to culture and belong to two different points in time, are strong evidence in

Table VIII: Cotton Revolution and the Practice of Dowry: Pre-1949 Historical Gazetteers

	Dependent variable: the practice of dowry				
	(1)	(2)	(3)	(4)	(5)
Mean of Dep. Var.	0.109	0.109	0.109	0.109	0.109
Cotton weaving (1300-1840)	-0.0709**	-0.138**	-0.130**	-0.126**	-0.141**
	(0.0351)	(0.0605)	(0.0617)	(0.0605)	(0.0658)
Log(pop. density in 1300)		0.00373	-0.0120	0.00558	0.00226
		(0.0254)	(0.0271)	(0.0232)	(0.0238)
Agriculture suitability			0.0166	0.0254	0.0256
			(0.0122)	(0.0156)	(0.0162)
Ruggedness				0.0126	0.0130
				(0.0128)	(0.0154)
Latitude	No	No	No	No	Yes
Longitude	No	No	No	No	Yes
Latitude × Longitude	No	No	No	No	Yes
Province FE	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.00278	0.0234	0.0238	0.0245	0.0220
Observations	754	753	751	751	751

This table reports the relationship between cotton weaving(1300-1840) and the practice of dowry as noted in historical gazetteers. The unit of observation is a county. The dependent variable is the number of mention of dowry. Robust standard errors are used in all specifications. Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

favor of cultural change. I find no relationship between cotton weaving and the practice of bride price.

VI.C Female Employment in the Modern Industrial Sector

Next I examine the effect of the cotton revolution in a different institutional setting: the effect on female employment in the modern industrial sector in the early 20th century. During this period, the heyday of the cotton revolution has long passed. There was no longer a positive association between relative female income and hand weaving. Industrial jobs have emerged. Meanwhile, because economic and political institutions were decentralized, laws and policies were made locally and reflected local preferences. If the cotton revolution has the hypothesized effect on beliefs about women, my prediction is that in the early 20th century it shaped a wide range of decisions made by individuals, businesses and politicians through their beliefs about women. This includes female participation in the industrial workforce.

There is no systematic data on the composition of the workforce for the entire country prior to the Republican Era (1911-1949). The 1916 Economic Census has the number of male and female workers working in modern factories by province and industry. There was

Table IX: Share of Female Workers in the Industrial Sector: Evidence from the 1916 Economic Census

	Dependent variable: % female workers			
	(1)	(2)	(3)	(4)
Mean of Dep. Var.	0.197	0.197	0.197	0.197
Cotton weaving (1300-1840)	0.137**	0.110*	0.110*	0.110*
Log total population	No	No	No	Yes
Industry dummies	No	No	Yes	Yes
#clusters	14	14	14	14
Adjusted R^2	0.0244	0.267	0.262	0.340
Observations	170	170	170	170

The table reports the relationship between cotton weaving (1300-1840) and the share of female workers in the 1916 Economic Census. The unit of observation is an province-industry pair. The dependent variable is the share of female workers. Column 4 accounts for the number of clusters and report p-value (0.068) based on the empirical distribution of t-statistics using a wild cluster bootstrap-t procedure. Standard errors are clustered at the province level and in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

a lot of regional variation in women's participation in the industrial workforce. Table A.II provides summary statistics. At the province-industry pair level, on average, roughly 19% of the workers were female. Women made up a sizable portion of the industrial workforce in Jiangsu, Zhejiang and Shanghai, where women outnumbered men; women barely worked in factories in Zhili, Shanxi and Shaanxi.

I regress cotton weaving (1300-1840) on the share of female workers in the industrial workforce. Table IX suggests that in provinces with a greater share of the population exposed to the cotton revolution, a higher share of the factory workers were female. The results are not affected by the inclusion of industry dummies or population size as controls. It is possible that women who spun and wove at home had skills applicable to the industrial production of textiles. However, I find that the share of female workers was not only higher in textile manufacturing but also higher in other industries. Cotton weaving (1300-1840) is positively correlated with the share of female workers in the majority of industries, with the exception of fur making.

A likely explanation is that in affected regions, it was already accepted that women would produce for the market and provide an income, and a woman at work was less likely to be seen as a threat to domestic order or a deviant from the norm. This result is consistent with the hypothesis that there was a permanent change in beliefs about women following the cotton revolution.

VI.D Head of the Household: Pre- and Post-1949

In this section, I use the 1990 census to estimate the effect of the cotton revolution. The outcome I focus on is the gender of the head of the household in the 1990 census. If the cotton revolution led to a permanent change in beliefs about women, my prediction is that the gender composition of the heads of the household in 1990 should reflect updated beliefs about women.

I then compare the effects of the cotton revolution on individuals with a varying degree of exposure to socialist policies and now facing the same economic and institutional environment in 1990. The socialist state shut down important channels such as participation in paid employment (See Section VI.C). The effect of the cotton revolution would more exclusively hinge upon the cultural channel after 1949. Because the long-term impact of the cotton revolution should be larger when multiple channels were in effect, my prediction is that the effect of the cotton revolution on the gender composition of the heads of the household in 1990 is larger for cohorts growing up before the socialist period.

In the year when the 1990 census was launched, because property remained nationalized, neither men nor women privately owned or traded property. Housing was allocated to newly-wed couples by the government or the state-owned enterprise that employed them. In addition, the head of the household status entailed few, if any, financial and legal consequences. These conditions help to rule out purely economic explanations for the effect I might find. Having a female householder should mainly indicate that families are comfortable with having women in positions of power. Because the treatment, cotton weaving (1300-1840), is measured at the prefecture level, my estimates would speak to prefecture-level differences in customs and norms supportive of women assuming authority within a family.

The 1990 Population Census has a variable "Head of household" and a second variable "Relationship to head of household".[42] I code "Head of household" as one when"Relationship to head of household" is listed as "self", zero when"Relationship to head of household" is listed as "spouse". There is substantial variation in the gender of the householders: across prefectures, from 1.3% to 21.2% of the householders were female.

Table A.VII describes the main sample based on the 1990 Census. Each observation is an individual who is the head of the household. The sample is restricted to Han Chinese individuals. I use the same geographic coverage as in the main sample in Section V.[43] Approximately

[42]In the United States, the census switched to "Person 1" and "Relationship to first person listed on the questionnaire" just before 1980. https://www.census.gov/history/www/through_the_decades/index_of_questions/1980_population.html

[43]To be included, the territory of a prefecture has to be entirely contained in the geographic coverage of the main sample.

Table X: Who Became the Head of the Household? Evidence From the 1990 Census

	Dependent variable: female			
	(1)	(2)	(3)	(4)
Mean of Dep. Var.	0.0723	0.0604	0.0614	0.0614
Cotton weaving (1300-1840)	0.225*	0.250*	0.366**	0.356**
	(0.134)	(0.147)	(0.159)	(0.149)
Marginal effects	0.013*	0.014*	0.020**	0.018**
	(0.008)	(0.008)	(0.009)	(0.007)
Education	No	No	No	Yes
Occupation	No	No	No	Yes
Migration status	No	No	No	Yes
Age 30-50	No	No	Yes	Yes
Married	No	Yes	Yes	Yes
Age bracket	Yes	Yes	Yes	Yes
Family size	Yes	Yes	Yes	Yes
Baseline controls	Yes	Yes	Yes	Yes
Socioeconomic macroregion FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Pseudo R^2	0.127	0.063	0.061	0.177
Observations	808535	783132	426974	426974

The table reports the relationship between cotton weaving (1300-1840) and the probability of women heading the household in the 1990 census. The unit of observation is an individual who is a householder. The dependent variable is a binary variable that equals one if the householder is female. The sample is restricted to all Han Chinese (column 1), further restricted to married individuals (column 2), and additionally restricted to individuals aged 30 to 50 (columns 3 and 4). Column 3 is my preferred specification. I include controls for education, occupation and migrant status in column 4. All estimates are based on Logit regressions. Baseline controls are the same as in column 3 of Table II, among which variables from the 1990 census are used as contemporary controls. Robust standard errors are clustered at the prefecture level. There are 97 clusters. Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

47% of the total population lived in a prefecture with cotton weaving (1300-1840). Due to historical and modern restriction on migration, migration remained rare by the time of 1990; many individuals lived in the same town as their ancestors.

I first estimate the effect of the cotton revolution on the gender of the householders as recorded in the 1990 census. My estimation equation is

$$\text{Female}_{i,p} = \alpha + \beta \text{Cotton weaving (1300-1840)}_p + \mathbf{X}_p^H \mathbf{\Omega} + \mathbf{X}_p^G \mathbf{\Lambda} + \mathbf{X}_p^C \mathbf{\Pi} + \mathbf{X}_i^I \mathbf{\Gamma} + \epsilon_{i,p} \,, \quad (2)$$

where p denotes a prefecture. In the IPUMS 1990 census data, individual residence is only

recorded at the prefecture level. The outcome variable is whether the head of the household is female. Cotton weaving $(1300\text{-}1840)_p$ is cotton weaving taking place between 1300 and 1840 in Prefecture p.[44] If the cotton revolution had been effective in transforming beliefs about women, β should be positive and significant. $\mathbf{X}_p^H$, $\mathbf{X}_p^G$ and $\mathbf{X}_p^C$ are the same controls as in the county-level analysis.[45] $\mathrm{X}_i^I\mathbf{\Gamma}$ denotes individual-level controls: age group and family size.

Estimates based on Logit regressions are reported in Table X.[46] Column 1 includes all baseline controls as shown in column 3 in Table II, in addition to controls for age group and family size. In column 2, I restrict the sample to married individuals. This allows me to distinguish the effect of the cotton revolution on married households from its effect on the composition of household types. In column 3, I further restrict the sample to prime-aged individuals who were between 30 and 50 in 1990. At 30, the vast majority of the population became married; before age 50, labor force participation was near universal for both sexes. This selection criterion further mitigates heterogeneity in economic determinants of the householder status. It also minimizes the effect of age-specific mortality differences between men and women.[47] Another strength of this sample is that it comprises mainly individuals who grew up in socialist China.

In column 4, I include additional individual-level controls, such as educational attainment, occupation and migration status. These controls could be endogenous to gender-equitable beliefs. In this specification, I can partial out any indirect effect of gender-equitable beliefs on the gender composition of the householders via women's education attainment and occupational choice.

The coefficient estimates are quantitatively similar across the columns. In my preferred specification (column 3), the probability of a householder being female increases by two percentage points in prefectures positively impacted by the cotton revolution, which is 32.6% of the average probability of a householder being female (6.14%). This lends more confidence to the main hypothesis that the cotton revolution led to the emergence of gender-equitable beliefs and has affected subsequent outcomes through that channel.

[44] See Appendix C.1 for more details as to how this variable is constructed. Small boundary changes occurred over time. To reduce measurement error, I construct a binary variable such that prefectures with more than 90% of the territory with cotton weaving between 1300 and 1840 are coded as one; prefectures with less than 10% of the territory with cotton weaving are coded as zero. The difference in the means of the dummy and the continuous variable is small (See Table A.VII).

[45] $\mathbf{X}_p^C$ are county-level census data aggregated to the prefecture level weighted by county population. For $\mathbf{X}_p^C$ most controls from the census year 2000 are superseded by controls from the census year 1990. GDP per capita 2000 is superseded by GDP per capita 1989.

[46] For cotton weaving (1300-1840), a binary variable is used in all regressions. Estimates based on the continuous variable yield similar results.

[47] Fernández and Fogli (2009) takes a similar approach in examining the effect of culture on female labor force participation and fertility among second-generation immigrants.

The above analysis shows the impact of the cotton revolution persists under centralized socialist rule. In the absence of centralized socialism, it would have been possible for the cotton revolution to shape local policy outcomes in favor of women through aggregated preferences. Examples of such local policies are labor market laws that regulate gender segregation. These local policies can affect women's earning power today which might in turn affect their probability of being the householder. The magnitude of those estimates in an environment without centralized socialism could then be larger.

Examining younger cohorts provides a more accurate estimate of the effect of the cotton revolution purely through the mechanism of culture shaping individual behavior. Those cohorts of individuals grew up at a time where variation in local institutions was minimized, which partials out any indirect effect of gender-equitable beliefs on the gender composition of the householders via local institutions.

When older, presocialist cohorts are examined, a wider ranger of mechanisms underlies the estimated effect of the cotton revolution. Local culture can affect local institutions which in turn affects individual behavior. A cohort analysis in Appendix Table A.III suggests that the relationship between the cotton revolution and the householder status is weakened for cohorts whose education, marriage and career decisions were formed under state socialism. Individuals included in the sample were married and at least 30 years old in 1990. I first compare individuals who were at least 14 years old by 1949 (born before 1935) and those who were younger (column 1). I find a larger effect of the cotton revolution on individuals who were over 14 by 1949. In column 2 I interact my treatment with all age groups and find the effect to be larger for older cohorts. In columns 3 and 4, I repeat the analysis with additional individual-level controls. The coefficient estimate of the interaction term decreases slightly after adding individual-level controls.

VII Discussion

This paper examines the causes and consequences of a change in the perception that women are less able. Below I discuss the plausibility of results in a comparative perspective, highlighting some of the key insights and policy implications.

Why did the cotton revolution have these effects? Due to a combination of market and state forces, women enjoyed high incomes from making cotton cloth and these high incomes lasted for a sustained period. Women's advantage in home-based proto-industrial production of cotton cloth incentivized them to accumulate crucial skills and to produce for the market over the course of their lifecycle. The vast majority of households were small peasant proprietors. Men kept working in family owned fields and their labor productivity

stagnated. The universal in-kind taxation system also had a role in slowing down wage convergence across the genders and regions.

The Black Death in Western Europe is a useful comparison point to how the cotton revolution affected Chinese women. After the Black Death, real wages went up due to labor scarcity. More women were drawn into the labor force. This led to a compression of wage levels. However, after the Black Death, women continued to work on low-paying, unskilled jobs. Women's income rose but the ratio of female to male wages remained relatively low. During the cotton revolution, women worked on high-paying, skilled jobs. In the Western European context, though marriage was delayed, most women chose marriage over work at some point in their life (Voigtländer and Voth, 2013). Their earnings from work remained low; they might have helped them provide a dowry but had little impact on their intra-household bargaining position. During the cotton revolution, by contrast, women enjoyed the economic gains from cotton weaving throughout the life cycle. This also allowed women to accumulate human capital and to take on more demanding tasks as they grew older.[48]

A related case is industrialization in the United States (Appendix K.2). At the beginning of American Industrialization, women were drawn into the labor force and their relative income rose. From 1820 to 1850, in the industrialization of the American Northeast, female labor force participation was substantial, and the wages of women increased relative to that of men (Goldin and Sokoloff, 1982). However, these were predominantly unmarried women as "there was a stigma against married women working as manual laborers in factory-type work", because manufacturing jobs at that stage were dirty, noisy and often physically demanding (Goldin et al., 1990).

"For about nine hundred years, from 1000 to 1900 CE, cotton was the world's most important manufacturing industry" (Beckert, 2015). Compared to self-sufficient household production in most parts of the world during this period, proto-industrial weaving in China was highly productive due to the use of better technologies, an ample supply of raw cotton, a substantial market demand and the presence of good transportation infrastructure. Compared to centralized factory production becoming common after the 19th c., proto-industrial weaving in China was organized within households and convenient for women to access. The combination of gains from trade and an accessible workplace created the conditions for high relative female income.

So why was there a lack of organized response to women's increasing earning power in China? Economic change associated with the cotton revolution was specific to local regions; under centralized imperial rule, there was little room for local forces to develop formal in-

[48] Appendix K.1 includes more details on the effect of the Black Death on women's labor force participation, marriage and fertility.

stitutions specific to the local region or to organize local collective action.[49] Despite vastly different economic conditions faced by women after the cotton revolution, local initiatives were not formed to drive women out of high-earning work. For example, in parts of Europe, weaving became a male profession, organized within weaving guilds in local areas (See Epstein et al. (1998), Wallis (2008), Ogilvie (2011), and Ogilvie (2014) for urban craftsmen in medieval and early modern Europe and European guilds). In China, the development of guilds was slow and did not take place until the 19th century.

The main findings provide a few additional insights: first, it is surprising that the practice of sex selection, mainly seen in China and India, might share the same cultural component as the barrier to women entering into positions of authority. Secondly, this cultural component can be shaped by material forces but has implications going beyond the original context of those forces. Thirdly, the domains of cultural change are quite specific, and are most concentrated in domains pertaining to the relative position of women to men. Beliefs about women's ability and worth relative to men's have been updated, but there is no correspondent change in attitudes towards premarital sex or attitudes on same-sex marriage. Additionally, my findings suggest that core aspects of beliefs about women seem sticky in the short run, but malleable in the long run. This challenges the view that gender differences are intrinsic, or that male dominance is inevitable (Goldberg, 1977).

In societies historically lacking high-value work opportunities for women, ingrained cultural beliefs, notably the belief that women are less agentic and capable, can continue to hinder the progress of women today. Gneezy, Leonard, and List (2009) find that the social environment, particularly whether a society is patriarchal or matrilineal, is key to women's competitive inclinations. Gender-inequitable beliefs can result in both discrimination against women and negative self-evaluation or self-stereotyping by women and potentially, in gender differences in terms of both preferences and psychological traits. Attitudes towards risk-taking, competition, negotiation and other psychological traits have been shown to be different for men and women, and scholars have shown that this difference can be at least partly explained by nurture. It is possible that areas exposed to the cotton revolution switched from an equilibrium in which women were seen as less capable than men—in part because they contributed less to economic production—to one in which they could achieve value and esteem.

The perception that women are less able is deeply entrenched in human societies. Rousseau commented "One should be strong and active, the other weak and passive; one must necessarily have both the power and the will, it is sufficient for the other to offer little resistance"

[49]There was also no equivalent of a "marriage bar" or coverture in China. Their presence would have significantly reduced the incentive for women to earn an income.

(Rousseau, 1762: 1979). These views parallel the social psychology literature on gender stereotypes, agency and communion (Bakan, 1966). The cotton revolution can be viewed as a successful intervention to beliefs about women's ability. From the viewpoint of belief updating, one favorable condition was that the productivity of women in cotton weaving was easy to ascertain. In contrast to modern firms, which often have a multi-layer managerial structure, the monitoring of output in home production for cotton textiles was straightforward. Cotton cloth was produced at home and the value of work was instantly revealed when these textiles were sold in the market. Output was easily measured and not subject to ambiguous standards of interpretation. This reduced opportunities to exercise discrimination, which tends to arise when evaluation is more difficult (Deaux, 1985; McArther, 1985). Policy interventions are more effective in areas where output is well defined.

In drawing parallels to modern policy interventions, the paper suggests that it is possible for women to become more equal to men even in traditional agrarian societies. Small businesses and home-based production in rural areas can have surprisingly positive effects on the status of women.

A caveat to bear in mind is that modern policies are situated in environments where education and employment for women are often competing goals. Women's involvement in cotton textile production, often as early as in their pre-teen and teen years, did not have an effect on their educational attainment, as women were universally illiterate. Due to competing claims on time by workforce participation and human capital investments, interventions to increase economic opportunities for women would need to be more carefully executed if the goal is higher life-time incomes.

On the flip side, with advances in technology, there are a richer variety of ways for women to earn high incomes today. In the cotton revolution experiment, it might have taken hundreds of years of high relative female income for the perception of women to change. It might not take as long to see such changes in a modern context.

VIII Concluding Remarks

Following a technological shock, a vibrant commercial trade in cotton textiles produced by peasant households arose in China. This created the conditions for Smithian economic growth over several centuries. Based on their advantage in cotton weaving, many women became major income earners—women contributed close to or more than 50% of the household income. Studying this transition, I find that it led to a permanent change in beliefs about women's ability and worth.

To substantiate this claim, I provide a wide range of evidence on the transformative

impacts of the cotton revolution on core beliefs about women. There is a negative correlation between cotton weaving (1300-1840) and the belief that men are naturally more capable than women. These newly formed gender-equitable beliefs have implications for individual decisions and behavior. A sizable portion of the variation in the birth sex ratio in 2000 can be linked to cotton weaving (1300-1840). The cotton revolution is also associated with more women in positions of power.

I generate casual estimates in a variety of ways including using a naive difference-in-difference model and an instrumental variable strategy. In order to better understand the mechanisms underlying the long-term effect, I document cultural change at an earlier point relative to the main analysis by linking the cotton revolution to a decline in the practice of dowry. I then estimate the effect of the cotton revolution under various institutional arrangements, and find further evidence in line with the cultural channel.

My findings also suggest that as women's relative contributions increased to close to or more than 50% of the household income, beliefs about women's ability were updated. Whereas when women contributed to economic production of the household but her income remained as supplemental, beliefs about women remained unchanged. This might provide a partial explanation to the persistence of gender stereotypes—women are less agentic and able—despite the increasing participation of women in the workforce in the US from the 1970s to the 2000s.

The epidemiological approach has been widely used to isolate the role of culture. In Fernández (2007) and Fernández and Fogli (2009), past fertility rates in the country of ancestry of second-generation American women have significant explanatory power for labor force participation and fertility behavior of these women. The post-1949 period of China provides a rare opportunity to generate well-identified population-level estimates of the effect of culture that are predictive of macro-level outcomes.

The literature on gender equality has so far focused on reforming institutions as a way to promote gender equality (Doepke and Tertilt, 2009; Doepke, Tertilt, and Voena, 2012; Fernández, 2014). Deeply rooted cultural beliefs has been slow to change despite fast-changing formal institutions, stalling women's empowerment. I explore the alternative but complementary path to the rise of women via cultural change. This path is particularly relevant for developing societies with low state capacity and weak institutions.

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