(Word Count: 2740)

Printing and Women
The Gendered Impact of Printing Technology in China

Nina Liu[1]

January 20, 2025

Abstract

Economists have long argued that technologies can exhibit gender-biased impacts, often emphasizing gender-specific innovations. This study diverges from that norm by examining printing—a seemingly gender-neutral technology—and its gendered effects on human capital formation. Using a panel dataset of woodblock-printed books and poets from the Ming (1368-1644) and Qing (1644-1911) dynasties, this research reveals that book production significantly increased the density of female poets, with a less pronounced effect on male poets. An instrumental variable approach, leveraging river distance to bamboo sites (a crucial raw material for printer paper), supports these findings. Further analysis of 1982 census data indicates that printing maintained a female-biased impact on human capital and further improved gender equality in education during the early 20th century. The results imply that women, with limited access to external educational resources in pre-modern society, derived higher marginal returns in literacy from home-based book consumption than men. This research enhances our understanding of the potential biases inherent in various technologies.

[1] Nina, Ningxi Liu, PhD candidate at King's College London. Email: nina.liu@kcl.ac.uk

1. Introduction

Technologies can exhibit gender-biased impacts. Some breakthrough technologies such as male-biased plough (Alesina et al., 2013), female-biased cotton weaving (Xue, 2024) are widely discussed in economics, with less evidence showing that gender-neutral technologies can also have gender-biased impacts. However, such bias can be observed in one of the most influential innovations in human history: printing. When printing was invented and adopted in the pre-modern era, women's education was mainly restricted to the home and depended heavily on the availability of books. In contrast, men had greater access to resources such as schools and social networks. This disparity, therefore, led to a gender-biased use of printing.

This study investigates whether printing, a seemingly gender-neutral innovation, affected human capital formation differently for men and women. Specifically, it examines the short-run and long-run impacts of printing on gendered literacy and education outcomes in China. By analyzing data on woodblock-printed books and poets during the Ming-Qing period (1368-1911), as well as literacy rates in the twentieth century, this research provides a comprehensive perspective on the gendered effects of printing technology. The findings reveal that woman—historically constrained by limited educational opportunities—experienced greater benefits from the accessibility of printed materials, highlighting the broader social and economic implications of this technological development.

This analysis takes advantage of the enduring poetry culture in Imperial China to overcome a challenge faced by previous research, which struggled to obtain comparable estimates for male and female human capital due to the lack of relevant social statistics for women in the pre-modern era. In China, being a poet was not a commercial pursuit but a reflection of educational attainment, which makes counts of poets a valuable metric for assessing human capital, particularly among the men and women from the upper class.

This study contributes to the growing research on female-biased development, as detailed by Duflo (2012), and the role of social norms in hindering women's progress, summarized by Jayachandran (2015). Alesina et al. (2013) note that early agricultural societies using the plough established enduring male-favored gender norms. In Chinese economic history, Xue (2024) argues that the cotton revolution reduced sex selection and fostered gender-equitable beliefs, and Qian (2008) finds that rising tea prices, linked to women's agricultural income, improved

survival rates and education for both genders. This paper emphasizes that even gender-neutral technologies like printing can result in gender-biased development, revealing inherent biases in seemingly neutral technologies.

Additionally, this research contributes to the literature on female education by focusing on female writers as early self-made women (Nekoei and Sinn 2021a; Bühler et al. 2024). Due to limited social statistics on women's human capital prior to the 19th century, women's status was often tied to their male relatives leading to biased estimates. My dataset complements the Human Biographical Record (Nekoei and Sinn 2021b), which overlooks women, particularly in the non-Western contexts. By including data on both male and female poets in Imperial China, this analysis offers new insights into early-modern human capital (Goldin 2024) with a gendered perspective.

Moreover, this paper builds on extensive studies regarding the impact of printing on human capital, a key factor in economic growth (Mokyr 2005). Existing economics research has mostly focused on movable type printing (Dittmar 2011; Dittmar and Seabold 2019; Rubin 2014; Cagé and Rueda 2016). While historians have often downplayed the significance of woodblock printing (Febvre and Martin, 1997, p. 71), this study argues that it had a substantial positive impact on human capital formation in China, particularly for women who had limited access to educational resources.

2. Data and Identification Strategy

2.1. Data Sources of Primary Variables

The primary historical dataset comprises data on woodblock-printed books and poets from the Ming and Qing dynasties, gathered from multiple sources:

1. **National Census of Ancient Books Database**: Records of extant ancient books in registered libraries, documenting each book's information regarding book title, publication place, printer's name.
2. ***Ming Shi Zong*** and ***Wanqing Yishi Hui***: Poetry collections compiled in Ming and Qing dynasty that documenting biographies and works of male poets, considered the largest collection from Ming-Qing period.

3. **Ming Qing Women's Writings (MQWW) Database**: A comprehensive database of female poets' biographies and works who were born during Ming-Qing period, representing the largest collection of female writers.

The data were coded based on the 1820 CHGIS prefecture-level (second level) administrative divisions, counting the number of books and poets in each prefecture during the Ming and Qing periods. This allows for the construction of a two-period panel dataset across 268 prefectures spanning the Ming and Qing dynasties.

To explore long-run impacts, district-level literacy rates across five-year birth cohorts (1898–1972) were constructed using the **1982 National Population Census,** which includes a 1% sample of the total population, totaling over 10 million individual observations. Historical variables were mapped onto the 1982 district-level (second level) administrative divisions to analyze the persistence of printing's gendered effects.

2.2. Empirical Strategy

2.2.1. Pooled Ordinary Least Squares (OLS)

The benchmark analysis employs a pooled OLS regression to examine the relationship between log book density and log poet density using the specification below. Log density represents raw number (plus one) normalized by the population and takes a logarithmic transformation.

$$ln(poet\ density_{it}) = \delta_t + \theta_p + \beta ln(book\ density_{it}) + \gamma X_{it} + \epsilon_{it}$$

Where i denotes a prefecture ($i = 1, 2, \ldots, 268$), t denotes a dynasty in either Ming or Qing ($t = 1, 2$), p denotes a province that a prefecture belongs to ($p = 1, 2, \ldots, 18$). The dependent variables are the logarithm of normalized densities of both female and male poets, and the independent variable is the logarithmic normalized density of books. X_{it} are vectors of time-varying baseline controls (population density, *jinshi* (degree holder) density, and school density), time-invariant geographical controls (suitability, terrain ruggedness index, distance to coastal line and river, prefecture area), and time-invariant political controls (distance to national capital and dummy variable indicating provincial capital cities), all measured at prefecture level.

2.2.2. Two-Way Fixed Effects (TWFE)

To control for unobserved time-invariant heterogeneity across all prefectures, I adopt TWFE regression to examine the relationship between book production and the density of poets.

$$ln(poet\ density_{it}) = \delta_t + \theta_i + \beta ln(book\ density_{it}) + \Gamma X_{it} + \Lambda D_t X_i + \epsilon_{it}$$

Where i denotes a prefecture ($i = 1, 2, \ldots, 268$), t denotes a dynasty in either Ming or Qing ($t = 1, 2$). The dependent variables are the logarithm of normalized densities of both female and male poets, and the independent variable is the logarithmic normalized density of books. X_{it} are vectors of time-varying baseline controls. X_i are vectors of time-invariant geographical and political controls, and D_t is a dummy variable with a value of 1 indicating the Qing dynasty and 0 indicating the Ming dynasty.

2.2.3. Instrument Variable (IV)

To address potential endogeneity issues—such as the possibility that higher book production might be driven by pre-existing demand—an IV approach is used. The instrument leverages river distances to **predicted** bamboo sites, as bamboo became a critical raw material for printer paper during the Ming-Qing period. This IV is motivated by Chen et al. (2020), which utilizes the average shortest river distance to recorded bamboo and pine habitats to represent degree holder density in Ming-Qing China. They reasoned that bamboo and pine, being primary materials for paper and ink used in printing reference books for civil exams, implied that civil examinees were more likely to succeed when located in a prefecture with greater availability of these raw materials. This study enhances their approach by predicting bamboo sites based on ecological factors associated with bamboo growth (i.e., more rainfall, higher organic carbon, suitable soil pH, and lower altitude). Predicted bamboo improves the exogeneity of recorded bamboo associated in relation to book demand, satisfying the exclusion restriction by showing no direct effects on alternative economic factors (see Table 1).

Table 1: Exclusion Restriction:
Log River Distance to Bamboo and Initial Economic Conditions

	(1) Log density (population 1393)	(2) Caloric suitability index	(3) Log density (school before 1368)
Log (river distance to predicted bamboo)	-0.216	-0.035	-0.055
	(0.153)	(0.020)	(0.082)
Observations	268	268	268
Adjusted R^2	0.685	0.497	0.264
Mean	4.802	0.720	3.268
Geographical controls	Y	Y	Y
Political controls	Y	Y	Y

Note: Standard errors are reported in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.

3. Results

3.1. Short-Run Impacts

As shown in Table 2, the benchmark results using pooled OLS indicate that a 10% increase in woodblock-printed book density is associated with a $1.1^{0.368} - 1 = 3.57\%$ (see column 3) increase in female poet density, compared to a $1.1^{0.231} - 1 = 2.22\%$ (see column 5) increase in male poet density. The IV results corroborate these findings, demonstrating that proximity to **predicted** bamboo significantly influenced book production and, consequently, the density of female poets. The 2SLS estimates show a pronounced impact on women (0.539, see column 2) but an insignificant effect on men (0.162, see column 4). The first-stage F-statistic of 22.67 supports the validity of river distance to predicted bamboo as an instrumental variable.

These findings are statistically significant and robust via TWFE regression, supporting the conclusion that book production had a stronger correlation with the increase of female poet density compared to male poet density over time, as identified in Table 3.

The gendered impact of printing stems from the distinct educational opportunities available to men and women in Imperial China. Women's education was largely confined to the home, with limited access to education resources and restricted mobility due to foot-binding, which began at age five (Yao, 1934, p. 4-5). This made the availability of books essential for their literacy and intellectual growth. In contrast, men had access to a wider range of resources, reducing their reliance on printed materials.

Table 2: Log Woodblock-printed Books Density and Log Poet Density: First-stage and Second -stage Results using Pooled OLS

	(1)	(2)	(3)	(4)	(5)
	Log density (book)	Log density (female poets)		Log density (male poets)	
	1st-stage	2nd-stage	Pooled OLS	2nd-stage	Pooled OLS
Log (river distance to predicted bamboo)	-0.493***				
	(0.101)				
Log density (book)		0.539***	0.368***	0.162	0.231***
		(0.185)	(0.044)	(0.156)	(0.034)
Log density (*jinshi*)	0.435***	-0.133	-0.044	0.400***	0.364***
	(0.081)	(0.107)	(0.040)	(0.092)	(0.050)
Log density (school)	0.395***	0.287***	0.344***	-0.010	-0.033
	(0.082)	(0.111)	(0.094)	(0.089)	(0.073)
Log density (population)	-0.084	-0.236***	-0.248***	-0.183***	-0.178***
	(0.073)	(0.075)	(0.071)	(0.048)	(0.044)
Observations	536	536	536	536	536
R^2	0.590	0.611	0.639	0.576	0.582
Mean	3.337	1.431	1.431	2.221	2.221
First-stage F-Statistics		22.670		22.670	
Time FE	Y	Y	Y	Y	Y
Province FE	Y	Y	Y	Y	Y
All controls	Y	Y	Y	Y	Y

Note: All columns include the control variables mentioned in the text, as well as province and time fixed effects. Standard errors are clustered by prefecture, accounting for those within a radius of 180 kilometers, and are simultaneously corrected for autocorrelation over time for each prefecture. Standard errors are reported in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 3: Log Woodblock-printed Books Density and Log Poet Density: First-stage and Second -stage Results using TWFE

	(1)	(2)	(3)	(4)	(5)
	Log density (book)	Log density (female poets)		Log density (male poets)	
	1st-stage	2nd-stage	TWFE	2nd-stage	TWFE
Log (river distance to predicted bamboo)	-0.374***				
	(0.094)				
Log density (book)		1.002***	0.316***	0.140	0.228***
		(0.254)	(0.035)	(0.173)	(0.035)
Log density (*jinshi*)	0.318***	-0.160	0.021	0.526***	0.503***
	(0.083)	(0.101)	(0.050)	(0.079)	(0.058)
Log density (school)	0.541***	0.237	0.678***	0.056	0.000
	(0.114)	(0.199)	(0.084)	(0.141)	(0.092)
Log density (population)	-0.204***	0.086	-0.082	-0.116	-0.094*
	(0.071)	(0.087)	(0.063)	(0.076)	(0.054)
Observations	536	536	536	536	536
R^2	0.882	0.749	0.884	0.844	0.847
Mean	3.337	1.431	1.431	2.221	2.221
First-stage F-Statistics		14.923		14.923	
Time FE	Y	Y	Y	Y	Y
Prefecture FE	Y	Y	Y	Y	Y
All controls	Y	Y	Y	Y	Y

Note: All columns include the control variables mentioned in the text, as well as prefecture and time fixed effects. Standard errors are clustered by prefecture, accounting for those within a radius of 180 kilometers, and are simultaneously corrected for autocorrelation over time for each prefecture. Standard errors are reported in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.

3.2. Long-Run Impacts

As depicted in Figure 1, OLS analysis of the 1982 census data reveals that the gendered impact of printing persists into the 20th century. Districts with higher historical book production exhibited higher female literacy rates compared to male literacy rates (see Figure 1a) and improved gender equality in education (see Figure 1b), as measured by the ratio of female to male literacy rates.

Using the same IV—river distance to **predicted** bamboo—Figure 2 demonstrates that the gender-biased impact remains significant only for cohorts born before the mass education movement, which began in 1949 for children aged 7-12, allowing for a causal interpretation. This finding holds after controlling for historical economic conditions, geographical factors, and political influences. These results suggest that woodblock printing played a crucial role in promoting educational equality prior to the mass education movement, thereby reducing the gender gap in literacy rates.

Overall, the findings underscore the pivotal role of printing in shaping educational landscapes and advancing gender equality, serving as a foundational element in the broader narrative of social change.

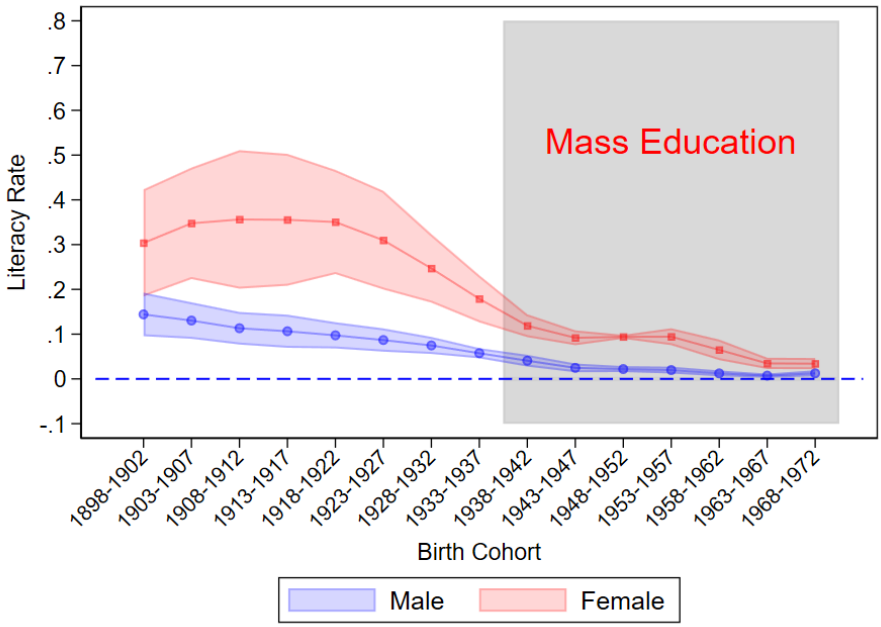
4. Robustness Checks

Several robustness checks are conducted to support my argument that printing is gender-biased:

1) **Alternative Independent Variable**: the analysis is repeated using non-poetry publications to ensure the results are not driven solely by literary works.
2) **Alternative Model**: Probit and Poisson models are employed to test the robustness of the gendered effects in scale-invariant parameters.
3) **Western Printing Influence**: the impact of woodblock printing was isolated from Western printing by controlling for proximity to Western printing presses established in the 19th century.

Figure 1. The OLS Estimates of Printing in the Twentieth Century

(a) Outcome: Literacy Rate by Male and Female



(b) Outcome: The Ratio of Female to Male Literacy Rate

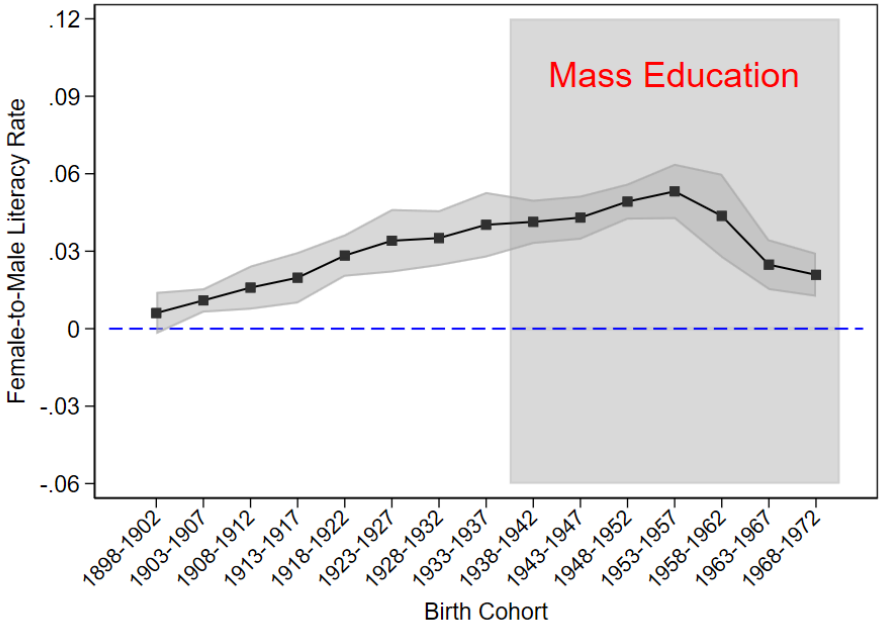
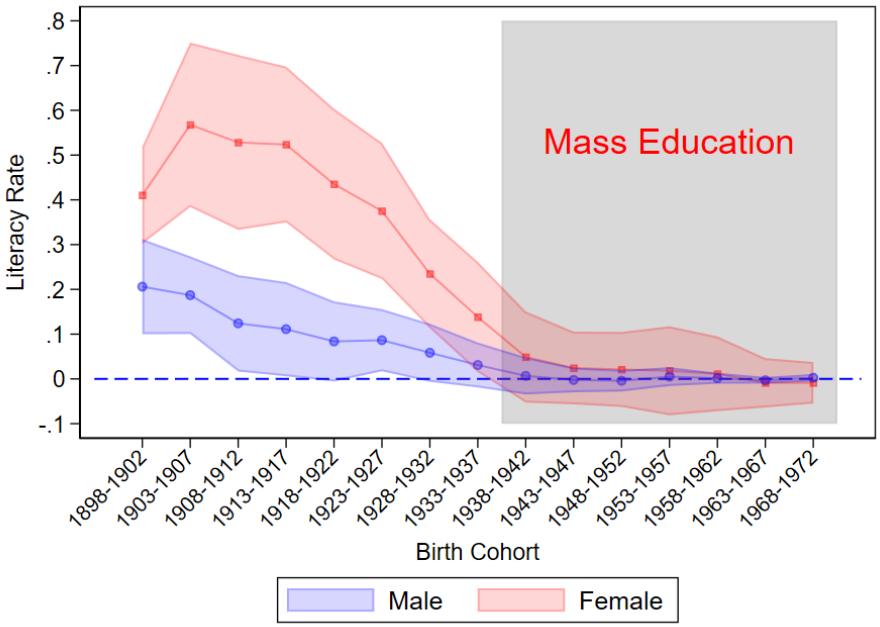
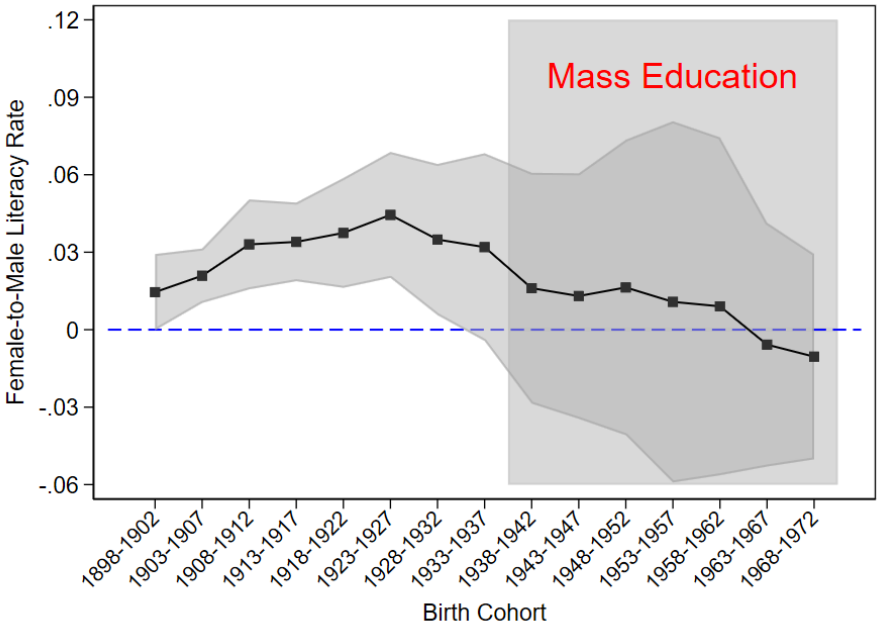


Figure 2. The IV Estimates of Printing in the Twentieth Century

(a) Outcome: Literacy Rate by Male and Female



(b) Outcome: The Ratio of Female to Male Literacy Rate



5. Conclusion

This study highlights how seemingly neutral technologies (i.e., printing) can have gendered impacts due to historical and social contexts. In pre-modern China, the proliferation of woodblock printing significantly enhanced women's human capital formation by increasing access to books, which were critical for their education. This effect persisted into the modern era, contributing to improved gender equality in education.

By shedding light on the gendered implications of printing, this research underscores the broader societal and economic consequences of technological advancements. It also contributes to a growing body of literature on gender-biased development, offering new perspectives on the historical roots of human capital formation and the role of technology in shaping social dynamics.

References

Alesina, A., P. Giuliano, and N. Nunn. On The Origins of Gender Roles: Women and The Plough. Quarterly Journal of Economics, 128(2):469–530, 2013.

Bühler, M., L. Vollmer, and J. Wimmer. Female Education and Social Change. Journal Of Economic Growth, 29(1):79–119, 2024.

Cagé, J. and V. Rueda. The Long-Term Effects of The Printing Press in Sub-Saharan Africa. American Economic Journal: Applied Economics, 8(3):69–99, 2016.

Chen, T., J. K.-S. Kung, and C. Ma. Long Live Keju! The Persistent Effects of China's Civil Examination System. Economic Journal, 130(631):2030–2064, 2020.

Dittmar, J., Information Technology and Economic Change: The Impact of The Printing Press. Quarterly Journal of Economics, 126(3):1133–1172, 2011.

Dittmar, J. and S. Seabold. New Media and Competition: Printing and Europe's Transformation After Gutenberg. 2019.

Duflo, E., Women Empowerment and Economic Development. Journal of Economic Literature, 50(4):1051–79, 2012.

Febvre, L. and H.-J. Martin. The Coming of The Book: The Impact of Printing 1450-1800, Volume 10. Verso, 1997.

Goldin, C., Human Capital. In Handbook of Cliometrics, Pages 353–383. Springer, 2024.

Jayachandran, S., The Roots of Gender Inequality in Developing Countries. Economics, 7(1): 63–88, 2015.

Mokyr, J.. The Intellectual Origins of Modern Economic Growth. Journal Of Economic History, 65(2):285–351, 2005.

Nekoei, A. and F. Sinn. Herstory: The Rise of Self-Made Women. 2021a.

Nekoei, A. And F. Sinn. Human Biographical Record. 2021b.

Qian, N. Missing Women and The Price of Tea In China: The Effect Of Sex-Specific Earnings On Sex Imbalance. Quarterly Journal of Economics, 123(3):1251–1285, 2008.50(4):1051–79, 2012.

Rubin, J., Printing and Protestants: An Empirical Test of The Role of Printing in The Reformation. Review of Economics and Statistics, 96(2):270–286, 2014.

Xue, M. M. High-Value Work and The Rise of Women: The Cotton Revolution and Gender Equality In China. Available At SSRN 2389218, 2024.

Yao, L. A Record of Gathering Radishes: The First Edition, Volume 4. Tianjin: Shidai Company, 1934.