Review of Economic Studies (2019) **86**, 723–754 doi:10.1093/restud/rdy025

Advance access publication 25 May 2018

It's Raining Men! Hallelujah? The Long-Run Consequences of Male-Biased Sex Ratios

PAULINE GROSJEAN
University of New South Wales
and
ROSE KHATTAR
Parliament of the Commonwealth of Australia

First version received December 2015*; Editorial decision December* 2017*; Accepted May* 2018 (*Eds.*)

We document the short- and long-run effects of male-biased sex ratios. We exploit a natural historical experiment where large numbers of male convicts and far fewer female convicts were sent to Australia in the 18th and 19th centuries. In areas with more male-biased sex ratios, women were historically more likely to get married and less likely to work outside the home. In these areas today, both men and women continue to have more conservative attitudes towards women working, and women work fewer hours outside the home. While these women enjoy more leisure, they are also less likely to work in high-ranking occupations. We demonstrate that the consequences of uneven sex ratios on cultural attitudes, labour supply decisions, and occupational choices can persist in the long run, well after sex ratios are back to the natural rate. We document the roles of vertical cultural transmission and marriage homogamy in sustaining this cultural persistence.

Key words: Culture, Gender roles, Sex ratio, Natural experiment, Australia.

JEL Codes: I31, N37, J16, Z13

1. INTRODUCTION

Variation in sex ratios alters the relative value of women and men on the marriage market and can exert a variety of effects on intra-household decision-making and labour supply decisions. While several studies document immediate consequences of changes in sex ratios,[1] an important question is whether these effects are transitory — lasting only until sex ratios return to normal — or persist over time. This question is particularly important given the large distortions in sex ratios currently observed in many regions of the world. There are an estimated 100 million

1. See, among others: Grossbard-Shechtman and Neideffer (1997), Angrist (2002), Chiappori *et al*. (2002), and Francis (2011) which study the effects of male-biased sex ratios, or Abramitzky *et al*. (2011), and Boehnke and Gay (2017), which study the effects of female-biased sex ratios.

The editor in charge of this paper was Michele Tertilt.

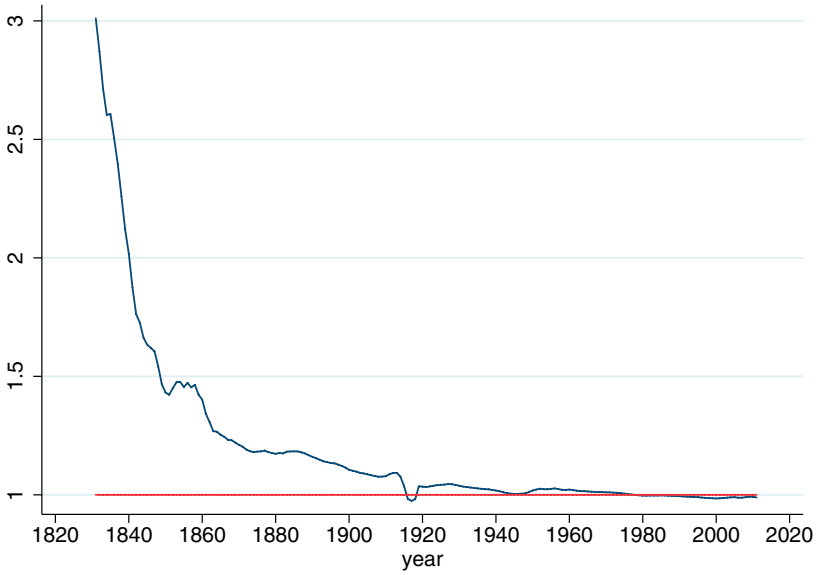

FIGURE 1

Sex ratio in Australia: number of men to every woman, 1830–2011.

Source: Australian Bureau of Statistics.

"missing women" around the world today, of whom 80 million are in China and India. However, answering this question is very difficult as male-biased sex ratios often endogenously result from less economic opportunities for women (Qian, 2008; Carranza, 2014; Xue, 2016) or a lower value placed on women by society (Almond *et al*., 2013).

An ideal natural experiment would consist of placing more men than women on an isolated island, with these men and women being of a similar cultural background and operating within the same institutional environment, and then observe outcomes over time. We exploit just such a natural experiment and study the long-run consequences of a male-biased sex ratio on female employment, occupational choice, leisure, and attitudes towards gender roles.

In the late 18th and 19th centuries, the British policy of sending convicts to Australia resulted in heavily male-biased sex ratios (the number of males over the number of females). Male convicts far outnumbered female convicts, by a ratio of almost 6 to 1 (Oxley, 1996) and the majority of the white Australian population initially consisted of convicts.[2] Among free migrants, men also vastly outnumbered women well into the 20th century, as it was mostly men who chose to come to Australia to seek economic opportunities in mining and agriculture. As can be seen in Figure 1, a male-biased sex ratio endured in Australia for more than a century.

We study the short- and long-term effects of male-biased sex ratios on female outcomes in the labour force and at home. We rely on spatial and, in some specifications, time variation in the historical sex ratio. We find that in the short-term (*i.e.* historically), male-biased sex ratios were associated with women being more likely to marry and participate less in the labour force. They were also less likely to be employed in high-ranking occupations. We study the long-term implications of male-biased sex ratios by matching ninety one historical counties from the first Australian colonial censuses to postal areas in a nationally representative household survey and

2. There continues to be uncertainty and controversy over the number of Indigenous Australians at the start of European settlement, but the latter certainly constituted a very different economy.

in the 2011 Census. In areas that were historically more male-biased, we find that today both men and women have more conservative attitudes towards women working. Women also participate less in the labour market and enjoy more leisure. Moreover, likely a consequence of the reduction in their labour market supply and conservative attitudes held, women are also less likely to obtain high-ranking occupations in areas that were more male-biased in the past.

The effect of the historical sex ratio on current gender roles is notable. In shaping attitudes towards gender roles at home and in the workplace, the effect of a one standard deviation increase in the historical sex ratio (which, incidentally, is close to the shift from the natural sex ratio at birth (1.04) to the historical sex ratio mean (3.10)) is associated with a negative change in progressive attitudes by 0.06 standard deviations, which is comparable to 45% of the effect of identifying as a female versus a male respondent. A one standard deviation increase in the historical sex ratio is associated with a 6% reduction in working hours supplied by females in the labour market, a 0.13 standard deviation decrease in the share of women employed in high-raking occupations, and a 2.3 hours per week increase in leisure for women, which is more than half the average (negative) gap in leisure time between women and men.

There are a few potential identification concerns, which we address in several ways. One concern is that the spatial variation in historical sex ratios may have been determined by characteristics that also influence the outcomes of interest. Our historical results are robust to specifications that control for time and county fixed effects, which remove the influence of any time invariant county characteristics that could be associated both with local sex ratios and with female work and marital outcomes. Our long-run results rely on the initial spatial variation in the sex ratio, measured in the first census. We analyse the historical circumstances that determined such variation and control for these factors. In particular, we flexibly control for geographic and land characteristics, for the presence of minerals, as well as for the initial conditions in terms of economic specialization.

Although our results are robust to controlling for the influence of a large number of geographic and historical characteristics and to propensity score matching, it remains possible that local sex ratios in the past could have been influenced by unobservable characteristics that, in the present, still underlie female opportunities and attitudes. Endogeneity in this sense might arise, for instance, from the systematic selection of women with stronger preferences for leisure, or of men with particularly conservative views about gender roles, to historically biased sex ratio areas. Statistical tests based on Oster (2018) suggest that the presence of such unobservable characteristics is unlikely to drive the results. Still, to deal with this issue, we employ an instrumental variable strategy based on a unique feature of Australia's history. Convicts were not free to move, so we instrument the population sex ratio by the sex ratio among convicts only. Since the majority of the population consisted of convicts at the time we measure the historical sex ratio the instrument is highly relevant. We control for the number of convicts to account for the potential long-run effect of convict presence, independent of the effect of sex ratios, which would violate the exclusion restriction. All the results are robust to this instrumental variable strategy.

To explain how historical sex ratios can have such enduring consequences on present-day outcomes, we discuss several potential channels of persistence. Our results rely on within-state variation, ruling out formal institutions as a persistence mechanism.[3] Initial sex ratios

3. The legal framework operative in Australia with respect to gender discrimination has been constant across all states since the *Sex Discrimination Act 1984* (Commonwealth), which operates at a federal level. This is a direct consequence of Australia's Constitution; any state law inconsistent with this act is invalid to the extent of the inconsistency (Constitution, Section 109). The *Family Law Act 1975* (Commonwealth) unifies family law in Australia at the federal level.

could have distorted industrial specialization towards male-intensive economic activities. The empirical evidence and historical literature do not strongly support this channel of persistence. We also find no evidence that past conditions of the marriage market influenced the relative education levels of men and women. Moreover, none of these mechanisms could explain the *positive* influence of sex ratios on women's leisure. Instead, we argue that — at least part of — the persistence is explained by the emergence of cultural norms about the appropriate role of women and the relative bargaining power of men and women in relationships as a response to skewed imbalanced sex ratios. We shed light on some of the channels behind this cultural persistence.

Cultural norms are inherently sticky because they are generally transmitted from parents to children (Bisin and Verdier, 2001; Doepke and Zilibotti, 2008; Fernández, 2013; Fernández *et al*., 2014). Accordingly, we find that historical sex ratios are only associated with conservative views about gender roles among people born of Australian parents. Moreover, the specific circumstances of the marriage market generate feedback mechanisms that underlie cultural persistence. As people prefer to marry those with similar views, gender norms are strategic complements among potential spouses, which in itself implies that such norms can become evolutionarily stable (Young, 1998). Accordingly, we find that historical sex ratios are only associated with conservative gender views in areas where homogamy is high.

The main contributions of this article are 2-fold. This is the first study to document the long-term effects of male-biased sex ratios. We show that the effects of sex ratios on social norms and on female occupation have persisted for more than a hundred years, long after sex ratios reverted to normal. This suggests that the nearly one hundred million missing women in the world today may deeply affect labour markets and gender norms not only in the years to come, but also in the long run, even if the imbalance itself is corrected.

We also contribute to the literature on the influence of culture on economic outcomes and how culture emerges and persists. Until recently, the rise in female labour force participation, the expansion of women's economic and political rights, as well as the reduction in fertility rates that has been observed in developed countries has been explained by technological change and the rise in returns to female labour.[4] However, several studies have also demonstrated how slow-changing cultural beliefs influence real work choices, family formation, and welfare.[5] Regarding the origins of such beliefs, the literature has suggested that technological conditions that prevailed in the past can shape gender specialization in the long run (Alesina *et al*. 2013; Hansen *et al*. 2015; Xue 2016). Our contribution is to document similar long-run effects of past conditions in the marriage market.

2. CONCEPTUAL BACKGROUND

In this section, we discuss how male-biased sex ratios may affect gender roles and cultural norms about gender roles in the short- and long-run.

4. See Goldin and Katz (2002), Greenwood *et al*. (2005), Doepke and Tertilt (2009), Doepke *et al*. (2012), Olivetti (2014).

5. Fortin (2005) shows how gender role attitudes influence labour market outcomes. Alesina *et al*. (2013) establish a relationship between beliefs and participation of women in the economy and in politics. Bertrand *et al*. (2015) find that households in which women earn more than men are less likely to form and, once formed, are more likely to end in divorce. Fernández (2008, 2013) and Fernández and Fogli (2009) show that fertility and female labour force participation preferences change slowly.

2.1. *Short-run effects of sex ratios on female labour supply, leisure, and marriage*

Bargaining models of intra-household decision-making since Becker (1973, 1974) argue that marriage market conditions are an important determinant of intra-household utility distribution. Simple supply and demand models inform us that the bargaining position of one gender is proportional to its scarcity — the scarcer sex will benefit from being in shorter supply. A male-biased sex ratio, which implies a lower supply of women on the marriage market, will increase female bargaining power, shifting resources and family structures in a way that could benefit women. As a result, under such conditions, the Becker marriage market (à la Grossbard-Shechtman, 1984) or collective labour supply models (Chiappori *et al*., 2002) predict that women are less likely to participate in the labour force and will enjoy more leisure.

Empirical studies of the effect of sex ratios are, however, rendered difficult by the lack of variation in human sex ratios at birth (normally around 1.04). Variations in sex ratios at birth are generally the outcome of sex-selective abortion or sex-skewed mortality, themselves endogenous outcomes of economic opportunities for women (Qian, 2008; Carranza, 2014) and of cultural attitudes towards women (Almond *et al*., 2013). Through exploiting migration-induced variation in sex ratios, several studies find that male-biased sex ratios are associated with higher marriage rates and a decline in labour force participation and in hours worked by women (Grossbard-Shechtman and Neideffer, 1997; Angrist, 2002; Chiappori *et al*., 2002). Causal identification in these studies is made difficult by potential self-selection bias in migration decisions, which could be driven by local labour market or marriage market conditions. Francis (2011) exploits a natural experiment when the Chinese Nationalist Army fled to Taiwan in 1949. He shows that a shortage of women led to women marrying more,[6] but does not explore the effect on female labour supply, occupational choice, or leisure, as we do.[7]

2.2. *Long-run effects — cultural persistence*

Gender specialization that is the outcome of short-run economic forces can imprint onto cultural norms concerning gender roles (Alesina *et al*., 2013; Hansen *et al*., 2015) or the relative status of men and women (Xue, 2016). Such cultural norms can durably influence female outcomes at work and at home, even long after the circumstances that originally gave rise to them have changed.[8] Several factors may explain such persistence. Cultural beliefs can, for example, affect the design of formal laws and policies, which can be difficult to change. Economic specialization can also be shaped by gender roles, either directly or indirectly through cultural beliefs.

Another explanation, which we focus on, is that cultural norms are inherently sticky. Cultural norms can be passed on from parents to children (Bisin and Verdier, 2001; Doepke and Zilibotti, 2008, Fernández, 2013; Fernández *et al*., 2014), which generates a strong hysteresis in the evolution of cultural norms.

Moreover, the specific circumstances of the marriage market generate feedback mechanisms that reinforce cultural persistence. Individuals with similar views are more likely to marry

6. Abramitzky *et al*. (2011) and Boehnke and Gay (2017) exploit another natural experiment: variation in World War I related deaths in France. They find that, conversely, a shortage of men is associated with men marrying more and marrying up and with an increase in female labour force participation. However, these papers study the effects of *female*-biased sex ratios and are hence less externally relevant to providing a deeper understanding of the long-term consequences of today's 100 million "missing women".

7. More recently, Wei and Zhang (2011) suggest that male-biased sex ratios have increased the price of brides in China.

8. See *e.g.* Fortin (2005), Fernández (2008, 2013), Fernández and Fogli (2009), Alesina *et al*. (2013), Hansen *et al*. (2015), Xue (2016).

one another and more likely to stay married (Becker *et al*., 1977; Lehrer and Chiswick, 1993). Marriage homogamy of this kind implies that views about gender roles are strategic complements among potential spouses, which will imply persistence in the long run (Young, 1998; Bisin and Verdier, 2001; Belloc and Bowles, 2013). Given such potential feedback mechanisms, cultural change has the characteristics of a collective action problem. The greater the cost of deviating from a given set of cultural traits, the less likely it is that any cultural change will occur. Deviation and experimentation may be particularly costly in the marriage market, where time is of the essence, uncertainty substantial, and search costs relatively high. If experimenting with attitudes towards gender roles leads to a delay, or even failure, to find a partner, people will conserve traditional views. Homogamy in the marriage market should thus be associated with stronger persistence of cultural norms. To the contrary, immigration should make experimentation easier and may accelerate transition towards gender views more adapted to current economic conditions rather than those of the past (Belloc and Bowles, 2013).

3. HISTORICAL BACKGROUND AND DATA

3.1. *Historical background*

European settlement in Australia commenced after the independence of the U.S., when it became the new destination of choice for the U.K.'s overflowing jail population. Between 1787 and 1868, 132, 308 and 24, 960 male and female convicts were transferred to Australia, mostly to Tasmania and New South Wales (hereafter NSW), which initially also included Queensland, the Australian Capital Territory, and Victoria. These convicts were not "hardened and professional criminals" (Nicholas, 1988, p. 3) but "ordinary working class men and women" (Nicholas, 1988, p. 7). The majority were transported for minor property offences, such as petty theft (Oxley, 1996).

The extent of free migration to Australia was rather limited until the 1830s. The male-biased sex ratio was sustained by nearly a century of ongoing convict transportation. Male convicts made up more than 80% of the adult male population of NSW in 1833. Even among free migrants, men vastly outnumbered women. It was mainly men who were attracted to the economic opportunities offered in Australia, which consisted of agriculture (McLean, 2012) and later mining, after the discovery of gold in the early 1850s. As can be seen in Figure 1, a male-biased sex ratio endured in Australia for more than a century.

The European settler population of Australia was ethnically homogenous. The vast majority of convicts and free migrants came from England and Ireland. According to the 1846 NSW Census, 90% of people born outside Australia came from either England or Ireland, with very little heterogeneity across different localities within Australia.[9]

Essential to our identification strategy is to understand what determined the variation in sex ratios within Australia. Upon arrival, convicts were not confined to prison cells. Initially, they were assigned to work under government supervision. Later, as the cost of caring for large numbers of convicts became too high, convicts were assigned to a master for private employment. Employers, or masters, were government officials, free settlers, or even ex-convicts, as convicts were released after the term of their sentence, generally 7 years. The placement of convicts was dictated by labour requirements and decided in a highly centralized way, as described by Governor Bligh of NSW in 1812:

> They (the convicts) were arranged in our book […] in order to enable *me* to distribute them according (cited in Nicholas, 1988, p. 15, emphasis added).

9. A total of 50% came from England and 40% from Ireland. The standard deviation of the two distributions is only 0.05.

Women were in the minority and female labour force participation in the Australian economy was low (Nicholas, 1988). One explanation is that only men had the physical strength necessary for agricultural work and building the country (Nicholas, 1988). Yet the demand for female labour should have been high as the colonial economy was "desperate for labour" (Meredith and Oxley, 2005, p. 45) and transported women had many valuable skills, particularly in domestic service[10] (Oxley, 1994). Moreover, institutional wage discrimination should have further boosted the demand for female labour. In 1816, Governor Macquarie of NSW announced that male and female convicts respectively be paid £10 and £7 per annum (Nicholas, 1988, p. 131). Meredith and Oxley (2005, p. 56) document an even larger gender pay gap of 46% within the non-convict population. Alford (1984, p. 243) instead suggests that the cultural norm which saw a "woman's proper place" as within the home played a significant role in explaining low female labour force participation.

Some convict women were confined to female factories, which were "a combination of textile factory and female prison" (Salt, 1984, p. 142) for those who had committed a crime, bore a child out of wedlock, or displeased their assigned master.[11] Women working in female factories had little or no wage.[12] Governor Macquarie of NSW perhaps put it best when he stated that female convicts had three choices: become a domestic servant, live in a female factory, or marry (Alford, 1984, p. 29). In the circumstances described above, marriage may have seemed like the most attractive option. Moreover, given their scarcity, the demand for wives was high.

The authorities' concern that "the disproportion of the sexes" would have "evil effects" as men experienced "difficulty …in getting wives" (Select Committee on Transportation, 1837–1838, p. xxvii) was not unfounded. Women were more than twice as likely to be married compared with men. More than 70% of women in Australia were married in the 19th century, a much higher rate than in Britain during the same time period (60%) (Alford, 1984, p. 26).

In sum, 19th century Australia was an environment where women's economic opportunities outside marriage were limited and unattractive. As financial independence was difficult, if not impossible, one would expect that women found men who could fulfill the role of economic provider attractive. The high bargaining power of women, due to their scarcity, would further reduce their incentive to participate in the labour force.

3.2. *Historical data*

We collect data on the historical sex ratio and on the structure of the colonial economy from the early 19th century colonial censuses of six Australian states.[13] Other data sources, such as colonial musters that counted transported people, have high reporting error and are not representative of the entire population as participation was not compulsory (Camm, 1978, p. 112), and were thus not used.

Our measure of the historical sex ratio in present-day regressions comes from the first census in each state. We use the 1836 NSW Census (which also included the Australian Capital Territory at the time), the 1842 Tasmanian Census, the 1844 South Australian Census, the 1848 Western

10. Data from the first available Censuses used here reveal that domestic services employed 14% of the labour force making it the second largest employment sector at the time, following agriculture at 23%.

11. No analogous male factory existed. NSW had three female factories in the counties of Cumberland, Northumberland, and Macquarie. Queensland's county of Brisbane had one and Tasmania had five (two located in Hobart and the others in Launceston, George Town, and Campbell Town).

12. Third class women, those who committed a crime in the colony or misbehaved in the factory, received no wage (Salt, 1984, pp. 86, 105).

13. Online data from the Historical Census and Colonial Data Archive was supplemented by the actual census report due to errors in the 1881 Tasmanian Census. Only the census reports are consistently available throughout the period, as some of the individual records were destroyed in a fire in 1882.

Australian Census, the 1854 Victorian Census, and the 1861 Queensland Census. These dates vary because states were independent colonies until 1901. The Supplementary Data Appendix describes in more detail the data sources and variable definitions.

Descriptive statistics for the first available historical cross-section are displayed in Panel A of Table 1. Although the total population of Australia at the time was only about 255,000 people,[14] more than 60% of the current population of Australia now lives in the areas covered by the historical data. The unit of observation in the census is a county[15] and there are ninety one counties. The average county had 4,493 individuals, and the majority of counties (about 85%) had between 300 and 10,000 people. Although the average sex ratio was about three men for every woman, it was much higher among convicts, at nearly thirty men for every woman. As an extreme example, in the NSW county of Bligh the sex ratio was 11 for the whole population[16] and 219 among convicts. The historical census also contains information on the number of married males and females and on economic occupation by gender. Unfortunately, the available records do not provide any further break down of labour force status or occupation by age. For this reason, our measure of labour force participation consists of working individuals as a proportion of married individuals, which is taken as a proxy for individuals of working age.

Table 1 compares how well covariates are balanced between counties with historical sex ratios above or below the median (2.05). Agriculture was the largest employment sector in Australia at the time, accounting for 23% of the labour force. Domestic services followed at 14%, and then manufacturing and mining with a combined total of 12%. The shares of people employed in these different activities do not differ systematically across high and low sex ratio areas (see Panel A of Table 1), suggesting that labour demand factors should not play a significant role in explaining potential differences in female labour shares. Areas with high or low historical sex ratios are also broadly similar in terms of land characteristics and mineral endowments. Areas with high historical sex ratios are richer in major gold deposits, but poorer in major coal deposits (see Panel C of Table 1).

Figure 2 maps the sex ratio in the whole population and in the subset of the convict population in areas of Australia that were already settled at the time of the study. The concentration of sexes does not have a definite pattern: high and low sex ratios were found in the hinterland as well as along the coast.

In addition to the first census in each state, we also consider the full panel of 19th century censuses, from 1836 to 1881 (described in Supplementary Table A1). The panel is unbalanced across states because they were independent colonies until 1901 and county maps are not available for all the years. The panel ends in 1881 because substantive redistricting occurred after that date and maps are not available. Descriptive statistics for this panel dataset are included in Panel B of Table 1. Due to the balancing influence of natural births[17] and to the increasing number of free migrants relative to convicts over the 19th century, the sex ratio for the whole period is lower than the ratios observed in the first censuses, but still stands at 1.9 men for every woman. Female marriage rates were high throughout the period, particularly in more male-biased areas where women tended not only to marry more, but also to work less. Female labour force participation

14. These numbers do not include Aboriginal or Torres Strait Islanders, who were not counted in the census until the 1960s. Only very rough estimates are available for these populations.

15. "Counties" is used here to refer to historical administrative divisions within the different colonies of Australia, variously called "counties", "police districts", "towns", or "districts".

16. Henceforth, "whole population" includes convicts, emancipists (*i.e.* ex-convicts), free settlers, and all individuals born in the colony (including children as there is not a consistent age-group classification in the census). Hence, the historical sex ratio is inclusive of the convict sex ratio.

17. No demographic study has found any evidence of distorted or abnormal historical sex ratios at birth in Australia (Opeskin and Kippen, 2012).

TABLE 1
Summary statistics and balance of covariates

Variables	Obs.	Mean	SD	Min	Max	Above - below median (i)	t-stat of diff. (ii)
Panel A: First historical cross-section for use in present-day regressions							
Historical sex ratio	93	3.10	2.95	1.01	18.83	3.11	6.04***
Historical sex ratio among convicts	36	28.86	42.04	1.27	219.00	32.9	3.55***
Historical population (in thousands)	93	4,493	11,876	36	101,080	–4019	−1.63
Sectors — % of county employed in:							
Agriculture, pastoral, horticulture, wine	90	0.23	0.12	0.02	0.75	0.036	1.38
Domestic and personal service	90	0.14	0.14	0.03	0.81	−0.0094	−0.32
Manufacturing or mining	90	0.12	0.20	0.00	1.23	−0.042	−0.95
Government and learned professions	90	0.02	0.02	0.00	0.13	−0.0042	−0.97
Panel B: historical panel data (1836 – 1881)							
Historical sex ratio	446	1.88	1.57	0.93	18.83	1.23	8.63***
Prop. female married (% adult female pop.)	406	72.37	26.60	6.26	284.36	12.3	6.05***
Prop. male married (% adult male pop.)	406	39.53	12.93	5.34	138.58	−13.6	−8.75***
Female labour force participation (% married women)	205	43.93	28.03	0	100.00	−20.6	−4.13***
Women in high-ranking occupations (% working women)	247	24.45	23.17	0	77.97	−10.3	−3.67***
Panel C: HILDA data matched with the historical censuses and controls from 2011 Census and Geoscience Australia							
Progressive attitude: Female work	42,918	4.47	1.98	1	7	−0.37	−2.07**
Log hours worked (+1)	31,297	3.50	0.58	0	4.98	0.08	2.44*
Time spent with children	30,306	6.30	14.24	0	140	0.19	0.25
Time spent in housework and household errands	31,150	15.13	14.17	0	140	0.99	1.48
Feel rushed	43,556	2.23	0.93	0	4	−0.08	−1.29
Have spare time	43,663	1.17	0.88	0	4	0.04	0.79
Individual controls							
Married or de facto	48,991	0.62	0.49	0	1	−0.02	−0.50
Age	49,019	43.69	18.42	14	101	1.33	0.94
Beyond year 12 education	48,989	0.34	0.47	0	1	−0.03	−0.55
Australian born	49,006	0.76	0.43	0	1	0.03	0.64
Female	49,019	0.53	0.50	0	1	0.02	0.64
Postal area controls							
Urban	49,019	0.93	0.25	0	1	−0.20	−2.05**
Contemporary sex ratio	49,017	0.97	0.09	0.64	13.53	0.04	2.10**
Plains and plateaus	49,017	0.48	0.50	0	1	−0.13	−1.20
Hills and ridges	49,017	0.03	0.16	0	1	−0.11	−2.02**
Low plateaus and low hills	49,017	0.06	0.23	0	1	0.07	1.82*
Minor coal	49,017	0.04	0.20	0	1	−0.01	−0.87
Minor other	49,017	0.01	0.04	0	1	0	0.90
Major coal	49,017	0.27	0.44	0	1	−0.21	−2.86***
Major copper	49,017	0.01	0.05	0	1	0.05	1.68*
Major gold	49,017	0.32	0.47	0	1	0.21	2.04**
Major mineral sands	49,017	0.06	0.24	0	1	0.06	1.08
Major other	49,017	0.00	0.01	0	1	0.00	0.97
Panel D: 2011 Census matched to the historical censuses							
Female labour force participation rate (FLFP)	1900	56.00	9.47	0	100	−2.04	−2.27**
Women in high-ranking occupations	1890	21.31	8.48	0	46.50	−3.05	−3.29***
Additional Postal area controls							
Prop. with professional college education	1895	0.21	0.05	0	1	−0.004	−0.87

Notes: (i) is the difference between counties above or below the median historic sex ratio. (i) and (ii): differences and t-stat are from regressions at the county level with state fixed effects and robust standard errors. In Panels A and B, observations are historical counties. In Panel C, observations are individuals. In Panel D, observations are present-day postal areas. The excluded land category is "mountains". The excluded mineral category is "no traces or deposits". 'Prop.' refers to proportion.

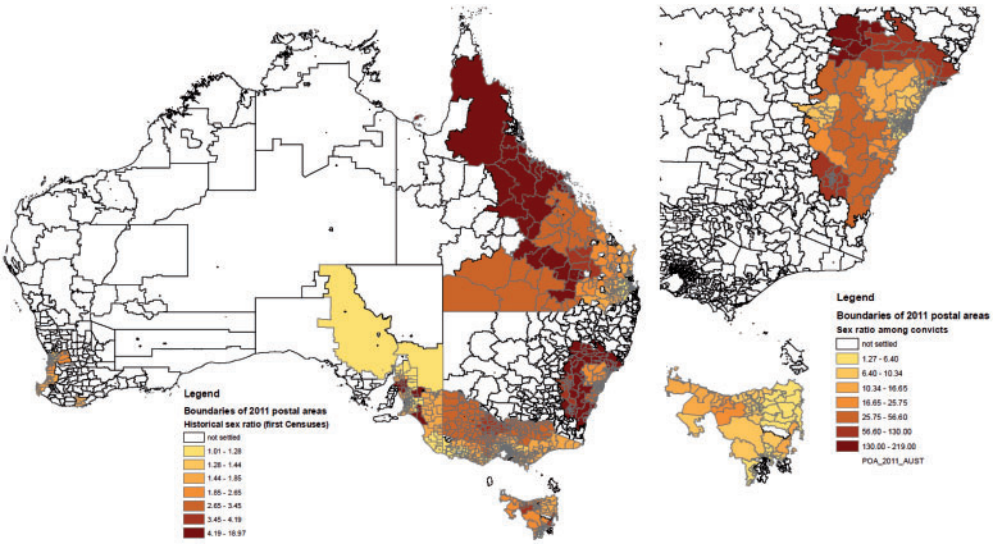

FIGURE 2

Sex ratios in mid-19th century Australia: whole population (left panel) and among convicts (right panel).

Notes: The maps only show the parts of Australia for which census data is available for the period of study. Left panel: Australian Capital Territory, New South Wales, Queensland, South Australia, Tasmania, Victoria, and Western Australia. Right panel: Australian Capital Territory, New South Wales, and Tasmania.
Source: Australian Historical Census.

and the proportion of employed women in high-ranking occupations, which includes teaching, clerical, legal, and medical professions, are statistically significantly lower in male-biased sex ratio areas.

3.3. *Present-day data*

Postal areas in modern-day datasets are not equivalent to historical counties and prior to this study, digitized shapefiles on Australian historical census boundaries did not exist. We collected and digitized hard copies of maps from the National Library of Australia and from state libraries to construct these boundaries and match historical counties to present-day boundaries.[18] The Supplementary appendix lists the maps used and provides further details on this matching process.

We explore the long-term effects of male-biased sex ratios with data from the Household, Income and Labour Dynamics in Australia survey (HILDA), a nationally representative survey available since 2001, and from the 2011 Australian Census.

Present-day data on cultural attitudes and on time allocation are from HILDA. The postal area identifies the location of respondents. After matching to historical data, we are left with a sample of between 30,000 and 50,000 individual observations, depending on the questions used, for more than 1,500 postcodes.

To capture views about gender roles, we rely on HILDA asking to what extent respondents agree that: "it is better for everyone involved if the man earns the money and the woman takes care of the home and children." Response categories range from 1 (strongly disagree) to 7 (strongly agree). We recoded this question so that a higher value indicates stronger disagreement with this statement, which we interpret as more progressive attitudes.

18. When a postal area covered multiple counties, we assigned it to the county where it was mostly located.

Data on time allocation are used to measure labour supplied in the labour market and at home, as well as total leisure time. To proxy individual hours worked in the labour market, we rely on the following question: "How many hours per week do you usually work in all jobs?" To measure leisure, we use time use data. The HILDA questionnaire asks how much time, in a week, each individual spends on a list of eight different elements of labour market work and housework (*e.g.* in paid employment, commuting to and from work, running household errands, doing housework, taking care of own children, taking care of other people's children, caring for disabled/elderly relatives, doing outdoor tasks). We are particularly interested in time spent each week taking care of one's own children and in housework (for which we combine running household errands and doing housework). As additional proxies of leisure, we use the following two questions: "How often to you feel rushed or pressed for time?" and "How often do you have spare time that you don't know what to do with?" Answers to these questions are coded from 1 (never) to 5 (almost always).

Data on female labour force participation and occupational choice are from the 2011 Census. The unit of observation is the postal area. In total, there are 2,515 postal areas. We match around 2,000 of these postal areas to historical counties, the remaining being areas that were not settled at the time of the historical censuses. We focus on women in high-ranking occupations: women employed as professionals as a proportion of employed women.

We retain several individual characteristics from HILDA and variables from the census, as well as data on mineral and land type from Geoscience Australia as controls. Descriptive statistics are provided in Panels C and D of Table 1. The balance of these covariates across areas below or above the median historical sex ratio is also presented in the last two columns of Table 1. We observe no statistically significant differences across high and low historical sex ratio areas in terms of present-day age, gender, ancestry composition, income, or education. As discussed, areas with high or low historic sex ratio have similar endowments and land types. Areas that historically had more men than women tend to be less urbanized today and, probably as a consequence, marginally still more male-biased. We retain urbanization and the present-day sex ratio as covariates.

4. SHORT-RUN EFFECTS: SEX RATIOS, MARRIAGE, AND FEMALE LABOUR SUPPLY IN 19TH CENTURY AUSTRALIA

In this section, we discuss panel and cross-sectional estimates of the contemporaneous relationship between sex ratios and female marriage rates and labour supply.

We estimate the following regressions in the panel of historical counties from 1836 to 1881 (1) and in the cross section provided by the first historical census in each state (2):

$$y_{cst} = \alpha_1 + \beta_1 SexRatio_{cst} + X_{cst}\theta + \delta_{cs} + \delta_t + \varepsilon_{cst}. \quad (1)$$

$$y_{cs} = \alpha_2 + \beta_2 SexRatio_{cs} + X^G_{cs}\varphi + X^H_{cs}\phi + \delta_s + \varepsilon_{cs}. \quad (2)$$

In (1), y_{cst} measures marital outcomes for men and women, female labour force participation, and female occupations in county c at time t. $SexRatio_{cst}$ is the historical sex ratio: the number of males over the number of females in county c at time t. X_{cst} may include additional time-varying characteristics of county c, namely male labour force participation or male occupations. δ_{cs} and δ_t are county and time fixed effects. As the panel is unbalanced, we have grouped years together and consider half decades as time fixed effects. In alternative specifications, we model a polynomial of time of degree 3 from the 1836 start date. Standard errors are clustered at the county level.

County fixed effects in (1) remove the influence of time invariant county characteristics that could be associated with sex ratios and marriage or female work outcomes. Time fixed

effects remove the influence of common time varying shocks, such as changes in overall economic specialization. Identification of the effect of the sex ratio requires either the absence of idiosyncratic shocks to the marriage market or to the female labour market, or at least that the sex ratio in a given county did not respond to such shocks systematically. While it is difficult to think of an exogenous and idiosyncratic shock to the marriage market *per se*, it is possible to imagine idiosyncratic shocks to the labour market, which may also affect the marriage market. Given the economy under study, the latter might consist of the discovery of minerals, which would attract male labour and drive up the male-biased sex ratio in a given county. It may also lead male incomes to increase, inducing an increase in female marriage rates and a decrease in female labour force participation due to an income effect. Cross sectional estimates in (2) enable us to address this issue in two ways: by controlling for mineral discoveries, and by restricting the estimation sample to periods preceding the first discovery of gold in Australia.

In (2), y_{cs} includes marital outcomes and female labour force participation or female occupations in county c, in state or colony s, as measured by the first census in each state or colony. $SexRatio_{cs}$ is the contemporaneous sex ratio. State fixed effects δ_s remove unobserved heterogeneity related to differences in the legal environment or in the treatment of convicts. X_{cs}^G and X_{cs}^H are intended to capture geographic and historic characteristics that may have been correlated with the sex ratio and with the outcomes of interest. In particular, as discussed, the 19th century Australian economy was specialized in the production of primary commodities in mining and agriculture. Such economic opportunities could have influenced the sex ratio as well as female outcomes, directly or through income effects in the marriage market. To flexibly account for geographic differences across counties that may be correlated with agricultural potential, we control for latitude and longitude in all specifications. To control more precisely for mining and agricultural opportunities, we control for nine detailed categories of mineral deposits[19] and land characteristics.[20] We also control for county historical economic specialization by including in X_{cs}^H the historical shares of the population employed in the main categories of employment discussed in Section 3: agriculture, domestic services, mining and manufacturing, government, and learned professions. Total historical population in the county is also included in X_{cs}^H.

Panel estimates of (1) are displayed in Table 2. For each dependent variable, specifications in the first column only include county fixed effects, and we add time fixed effects in the second column. More male-biased sex ratios are associated with women marrying more and reducing their labour supply and men marrying less. They are also associated with a lower proportion of women employed in high-ranking occupations. All the effects are statistically significant at the 1% level. Results are robust to controlling for the county's male labour force participation or for males employed in similar occupations when the dependent variable is, respectively, female labour force participation or the share of women in high-ranking occupations. The magnitude of the results is notable. An increase of one standard deviation in the sex ratio is associated with a reduction in female labour force participation and in the share of women in high-ranking occupations by 0.27 and 0.43 standard deviations, respectively.

Cross-sectional estimates of (2) are displayed in Panel A of Table 3 and confirm that male-biased sex ratios are associated with a statistically significant increase in female marriage rates and statistically significant decreases in male marriage rates, female labour force participation, and the share of women in high-ranking occupations. For each dependent variable, we first present the results of the regression controlling only for latitude and longitude and then add the full set of

19. Minor coal, minor other, major coal, major copper, major gold, major mineral sands, major oil and gas, major others. The excluded category is no deposits or traces only. *Source*: Geoscience Australia.

20. Plains, plateaus, and sand plains, hills and ridges, low plateaus and low hills, mountains. *Source*: Geoscience Australia.

TABLE 2
Short-run results: sex ratios, female labour supply, and marriage between 1836 and 1881

	1	2	3	4	5	6	7	8	9	10
	Married women (% women)		Married men (% men)		Female labour force participation (% married women)			Women in high-ranking occupations (% working women)		
Sex ratio	2.396***	2.481***	−2.135***	−1.515***	−21.136***	−12.961**	−13.205**	−19.663***	−13.832***	−14.100***
	(0.714)	(0.794)	(0.495)	(0.285)	(6.482)	(5.076)	(5.579)	(3.452)	(3.551)	(3.603)
Male labour force participation							0.088***			
							(0.026)			
Male high-ranking occupations										0.110
										(0.106)
Observations	412	412	412	412	205	205	205	247	247	247
R^2	0.026	0.234	0.055	0.120	0.077	0.335	0.377	0.101	0.617	0.619
Number of counties	94	94	94	94	70	70	70	77	77	77
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes	No	Yes	Yes	No	Yes	Yes

Notes: The table reports fixed effects regression estimates. All regressions are with a constant. The unit of observation is a historic county-year (see Table A1 for years in each state). "Sex ratio" is the number of men to the number of women. "Female (respectively, Male) labour force participation" is the proportion of females (respectively, male) employed, as a proportion of married females (respectively, males). "Women (respectively, Men) in high-ranking occupations" is the proportion of women (respectively, men) employed in "commerce and finance", as a percentage of employed females (respectively, males). See Table 1 for summary statistics. Robust standard errors clustered at the county level are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

TABLE 3

Short-run results: sex ratios, female labour supply and marriage in the first historical cross section in each state (panel A) and before the first discovery of gold (panel B)

	1 Female marriage rate (%, historic)	2	3 Male marriage rate (%, historic)	4	5 Female Labour Force Participation	6	7 Women in High-Ranking Occupations (%, historic)	8
Panel A: First census in each state								
Historical sex ratio	1.235***	1.029***	−2.382***	−1.759***	−0.343***	−0.274**	−0.255**	−0.160+
	(0.408)	(0.347)	(0.339)	(0.335)	(0.101)	(0.104)	(0.124)	(0.103)
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Minerals and land type	No	Yes	No	Yes	No	Yes	No	Yes
Historical controls	No	Yes	No	Yes	No	Yes	No	Yes
Observations	83	80	83	80	83	80	66	65
R^2	0.522	0.712	0.588	0.778	0.296	0.495	0.595	0.731
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Panel B: First census in each state before 1851 (New South Wales, Tasmania, South Australia, Western Australia)								
Historical sex ratio	0.954**	0.956***	−2.081***	−1.828***	−0.413***	−0.386+	−0.050	−0.224***
	(0.412)	(0.232)	(0.312)	(0.452)	(0.103)	(0.228)	(0.071)	(0.091)
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Minerals and land type	No	Yes	No	Yes	No	Yes	No	Yes
Historical controls	No	Yes	No	Yes	No	Yes	No	Yes
Observations	48	45	48	45	48	45	31	30
R^2	0.498	0.805	0.564	0.727	0.366	0.556	0.708	0.830
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

historic and geographic controls aimed at capturing circumstances that could lead to a spurious correlation between sex ratios and female marital and work outcomes. As discussed, the strongest contender consists of mineral discoveries, which could drive the sex ratio up and influence female labour force participation and female marriage rates through income effects. Another way to deal with this issue is to restrict the estimation to the period preceding the first discovery of gold in Australia in 1851. This is done in Panel B of Table 3. The results mostly carry through and the point estimates are very similar. For marriage rates and female labour force participation, a chi-squared test cannot reject the null hypothesis that the coefficients associated with sex ratio are identical across the two estimation samples.[21] The fact that the coefficients are close suggests that the residual bias is minimal after we control for our geographic and historic characteristics.

To sum up, panel and cross-section estimates indicate that male-biased sex ratios are conducive to higher female marriage rates and lower female labour force participation. Two mechanisms could explain the negative effect of sex ratios on female labour supply: (1) a compositional effect: women wedded more and married women generally work less in the labour market and more at home; or (2) a bargaining power effect: women have a better bargaining position in the marriage market, they work less, and enjoy more leisure. In the absence of historical data on leisure consumption or on the respective labour supply of married versus unmarried women, we are unable to distinguish between the two effects. However, we show in the next section that today, in areas that were more male-biased in the past, women consume more leisure.

The negative relationship between sex ratios and the share of women in high-ranking occupations could have several interpretations. It could result from women working less and

21. $P=0.83$ for female marriage rates, $P=0.99$ for male marriage rates, $P=0.56$ for FLP.

not accumulating the experience generally needed to attain such occupations. It is also possible that views about the appropriate role of women explain this result, as suggested by Alford (1984). The lack of historical data on attitudes prevents us from directly testing this channel. In the next section, we present evidence on present-day attitudes towards gender roles that gives credence to such a cultural explanation.

5. LONG-RUN EFFECTS: CULTURAL NORMS, WOMEN IN THE WORKPLACE, AND WOMEN'S LEISURE TODAY

In this section, we explore the long-term consequences of male-biased sex ratios on female outcomes at home and in the workplace and on cultural attitudes towards gender roles.

5.1. *Empirical strategy*

5.1.1. OLS. We examine the long-term effects of male-biased sex ratios on present-day outcomes by estimating the following equations:

$$y_{ipcs} = \alpha_1 + \beta_1 SexRatio_{cs} + X^G_{pcs}\Gamma_1 + X^H_{cs}\Pi_1 + T^C_{pcs}\Lambda_1 + X^C_{ipcs}\Theta_1 + \delta_s + \delta_t + \varepsilon_{ipcs}. \quad (3)$$

$$y_{pcs} = \alpha_2 + \beta_2 SexRatio_{cs} + X^G_{pcs}\Gamma_2 + X^H_{cs}\Pi_2 + T^C_{pcs}\Lambda_2 + \delta_s + \varepsilon_{pcs}. \quad (4)$$

y_{ipcs} is the survey-based measure of attitudes or time use of individual i in postal area p, part of historical county c in state s. y_{pcs} are the census-based measures of female labour force participation or occupations in postal area p, part of historical county c in state s. $SexRatio_{cs}$ is the historical sex ratio: the number of males over the number of females in historical county c, as per the first census in each state or colony s. δ_s is a vector of state dummies. δ_t is a vector of HILDA wave dummies when applicable. Since historical data at the level of the ninety one historical counties is less granular than present-day data at the postal area or individual level, all standard errors are clustered at the county level.

T^C_{pcs} and X^C_{ipcs} are vectors of postal area-level and individual-level present-day controls. In the models of individual attitudes and time allocation, individual controls are gender, marital status, age, income, education, and whether the respondent was born in Australia. Postal area-level controls include the sex ratio today and urbanization, taken from the census. In the models of female labour force participation and occupational choice, present-day controls include the sex ratio today, urbanization, and average education. Controlling for the proportion of married people or for the full range of industrial specialization is problematic, as these may be endogenous outcomes. However, to account for sectorial differences across counties that influence the share of women employed as professionals today, we check for the robustness of the results by controlling for the share of men employed in similar occupations.

X^G_{pcs} and X^H_{cs} are vectors of time-invariant geographic and historic characteristics that may have been correlated with the historical sex ratio and may still influence present-day outcomes. Economic opportunities in 19th century Australia influenced where convicts were assigned and where free settlers and emancipists located, and could bias our estimates if they are also related with our outcomes of interest. If, for example, economic specialization persisted over time, these initial conditions could directly influence present-day economic opportunities for women and ignoring them would bias our estimates. To account for differences across counties that may be due to initial economic specialization or that may be correlated with agricultural and mining potential, we include the controls already discussed in the historical cross-sectional analysis (latitude, longitude, detailed categories of mineral deposits and land characteristics, initial economic specialization and total historical population).

The assumption necessary for the identification of a causal effect of the historical sex ratio in (3) and (4) is that the spatial distribution of the relative number of men and women was random, conditionally on our proxies for economic opportunities and on total population at the time. While economic opportunities were an important dimension of the decision of where to settle, it is conceivable that the latter was also influenced by unobservable characteristics, such as a taste for leisure, which could subsequently have been transmitted to present-day populations and influence outcomes of interest. We therefore adopt an instrumental variable strategy based on a subpopulation that was not free to choose where to live: convicts.

5.1.2. Instrumental variable. We instrument the overall sex ratio by the sex ratio among the convict population only. This instrument is relevant because convicts constituted a large proportion of the population, so that the sex ratio among convicts is an important, relevant component of the overall sex ratio. The raw correlation between total population and convict population is 0.99, and the raw correlation coefficient between the convict and population sex ratios is 0.83. Since convicts were not free to move, using the sex ratio among them as an instrument alleviates the self-selection issue that historically men and women chose their location based on unobservable preferences. That said, as discussed in the historical background section, convict assignment was not purely random and was dictated by labour requirements. We remove this potential endogeneity bias by controlling for historical employment sectorial shares and for the full set of geographic factors, including the location of minerals and land type.

Causal identification requires that: (1) conditional on our proxies for labour needs, allocation of convicts was random, and (2) the convict sex ratio only influenced present-day outcomes through its effect on the historical population sex ratio (exclusion restriction). For assumption (1), the quote by Governor Bligh of NSW in 1812 (page 10) provides evidence. A potential source of violation of (2) resides in the possibility that the presence of convicts had a direct effect on attitudes, labour force participation, occupations, and time use today, independently of the effect on sex ratios. This could be the case, for example, if convicts systematically held different preferences for leisure or different views about gender roles from the rest of the population. This would, however, contradict the widely accepted view that convicts were representative of English and Irish societies at the time (Meredith and Oxley, 2005; Oxley, 1994). Nevertheless, we control for the number of convicts in our 2SLS procedure to alleviate this concern. We drop total population from the set of historical controls when we control for the number of convicts because of multicollinearity.

As only NSW and Tasmania were penal colonies, convicts are only present in about a third of the historical counties. To adjust for the small number of clusters, we provide two alternative corrections to the standard errors. The first is to bias-correct the cluster-robust variance matrix by inflating standard errors by a factor of $\sqrt{G/(G-1)}$ with G the number of clusters, as suggested by Cameron and Miller (2015). In our case, this amounts to multiplying standard errors by a factor of 1.018 in the regressions with HILDA data and by a factor of 1.016 in the regressions with census data. The second is to compute standard errors using the wild cluster bootstrap method based on 1, 000 replications, as recommended by Cameron *et al*. (2008) and Cameron and Miller (2015).

5.2. *OLS results*

For each dependent variable, Table 4 reports estimates of specifications in which we first include state fixed effects, the basic geographic controls, and individual and postal areas controls. We then add the full range of historical and geographic controls.

TABLE 4
Long-run effects: historical sex ratios, gender role attitudes and female labour supply — OLS

	1	2	3	4	5	6	7	8	9	10	11	12
	Progressive attitude: female work		Progressive attitude: women in politics		Female labour force participation			Log hours worked		Women in high-rank occupations		
Historical sex ratio	−0.024***	−0.036***	−0.001	−0.009	−0.577***	−0.349**	−0.109	0.011**	0.015***	−0.759***	−0.662***	−0.445***
	(0.005)	(0.009)	(0.009)	(0.007)	(0.212)	(0.171)	(0.075)	(0.004)	(0.003)	(0.142)	(0.149)	(0.135)
Female	0.467***	0.464***	0.932***	0.934***				−0.288***	−0.291***			
	(0.018)	(0.017)	(0.020)	(0.020)				(0.022)	(0.023)			
Female*historical sex ratio								−0.022***	−0.021***			
								(0.007)	(0.007)			
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes	–	–	–	Yes	Yes	–	–	–
Contemporary poa controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Historical controls	No	Yes	No	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes
Minerals and land type	No	Yes	No	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes
Male LFP	No	No	No	No	No	No	Yes	No	No	No	No	No
Men high-rank occup	No	No	No	No	No	No	No	No	No	No	No	Yes
Observations	42,866	42,284	32,017	31,589	1,889	1,862	1,862	31,264	30,894	1,888	1,861	1,861
Number of counties	81	78	81	78	91	88	88	81	78	91	88	88
R^2	0.166	0.168	0.094	0.094	0.137	0.185	0.730	0.144	0.148	0.236	0.277	0.573

Notes: The table reports OLS estimates. All regressions are with a constant and HILDA wave fixed effects when using HILDA data. Dataset used in Columns 1–4, 8, 9: HILDA. Dataset used in remaining columns: 2011 Census. The unit of observation is an individual in a postal area matched to a historic county in HILDA and a postal area matched to a historic county in the census. The dependent variable in Columns 1 and 2 is an individual's agreement with the statement "it is better for everyone involved if the man earns the money and the woman takes care of the home and children". Response categories range from 1 (strongly agree) to 7 (strongly disagree) (mean: 4.47). The dependent variable in Columns 3 and 4 is an individual's agreement with the statement "On the whole, men make better political leaders than women do". Response categories range from 1 (strongly agree) to 7 (strongly disagree) (mean: 5.13). "Geographic controls" are a postal area's centroid's latitude and longitude. "Minerals and land type" is the presence and type of mineral deposit (minor coal; minor other; major coal; major copper; major gold; major mineral sands; major others) and land formation (plains and plateaus; hills and ridges; low plateaus and low hills; mountains), which are provided by Geoscience Australia. "Historic controls" are: the historical county population, as well as the proportion of residents working historically in agriculture, domestic service, manufacturing, mining, government services and learned professions. "Individual controls" are: relationship status (married or de facto), age, whether one was born in Australia, and whether one has education beyond year 12. "Present-day postal area controls" in regressions using HILDA are the number of men to women in a postal area and whether a postal area is urban. "Present-day postal area controls" in regressions using the census include in addition the average vocational tertiary education of a postal area. "Male LFP" is the 2011 male labour force participation as reported in the 2011 Census. "Men high-ranking occup" is the proportion of employed men working as managers or professionals. Standard errors are reported in parentheses and have been corrected for heteroskedasticity and for clustering at the historical county level. ***, **, *, and + indicate statistical significance at the 1%, 5%, 10%, and 15% level, respectively.

5.2.1. Attitudes. The estimates displayed in Columns 1 and 2 of Table 4 show that today, people are more likely to hold the view that women should stay at home in areas where sex ratios were high, *i.e.* male-biased. The relationship between attitudes towards gender roles and historical sex ratios is statistically significant at the 1% level even when controlling for the full set of controls. A one standard deviation increase in the historical sex ratio (2.95[22], which is close to moving from the natural sex ratio at birth (1.04) to the mean of the historical sex ratio) is associated with a negative change in progressive attitudes towards gender roles by 0.06 standard deviations. This is comparable, at the mean, to 45% of the effect of being a female versus a male respondent. Moreover, the relationship between the historical sex ratio and attitudes today is specific to views about women working. For example, Columns 3 and 4 of Table 4 show that there is no statistically significant relationship between historical sex ratios and opinions about the quality of female compared to male political leaders.

5.2.2. Female labour force participation at the extensive and intensive margins. The relationship between female labour force participation and the historical sex ratio is negative but falls short of standard levels of statistical significance when we include all contemporary controls (Column 7 of Table 4). However, there is a negative and robust relationship between female labour force participation at the intensive margin (measured by the log of hours worked) and the historical sex ratio (Columns 8 and 9 of Table 4). The coefficient associated with the interaction between the historical sex ratio and a dummy variable for being a female respondent is negative and statistically significant at the 1% level, and robust to the inclusion of the battery of controls. In other words, women today work fewer hours in the labour market in areas where sex ratios were more male-biased in the past. A one standard deviation increase in the historical sex ratio is associated with a 6% decrease in hours worked by women. Accordingly, estimates based on census data show that women substitute full-time work for part-time work (see Supplementary Table A2). Meanwhile, the main effect of the historical sex ratio in Columns 8 and 9 of Table 4, which measures the relationship between historical sex ratios and male labour supply, is positive and statistically significant. Overall, our results indicate that where sex ratios were more male-biased in the past, women work significantly fewer hours today, while for men the opposite is true. The magnitude of the effect for men is about 70% of the magnitude of the effect for women.

5.2.3. Occupations. A likely consequence of women working fewer hours, being more likely to occupy part-time positions, and of society holding more conservative attitudes, is that women may not fill high-ranking occupations. This seems consistent with the evidence in Columns 10 to 12 of Table 4. The share of women in high-ranking occupations is negatively associated with historical sex ratios, even when controlling for the full set of controls. A one standard deviation increase in the historical sex ratio is associated with a decrease in the share of women employed as professionals by 0.13 standard deviations, which is about 1 percentage point. In terms of the share of the variation explained, adding historical characteristics to the full set of controls increases the R^2 by 2.5 percentage points. This is equivalent to more than 3% of the remaining unexplained variation in the share of women employed as professionals.[23]

5.2.4. Time Use. Table 5 reports estimates of equation (3) when the dependent variables measure leisure and time allocation. We add in equation (3) an interaction term between historical

22. Admittedly, this is a large variation compared to current sex ratio imbalances. For example, provinces with the most male-biased sex ratios in the 2000 China Population Census display sex ratios around 1.31 (Guangdong) to 1.37 (Hainan) (Wei and Zhang, 2011).

23. (0.573–0.559) / (1–0.559). 0.559 is the R^2 of a regression with all but historical controls.

TABLE 5
Long-run effects: historical sex ratios and time use — OLS

	1	2	3	4	5	6	7
	Leisure time	Time spent taking care of children		Time spent on housework and household errands		Feel rushed	Have spare time
		Extensive margin	Intensive margin	Extensive margin	Intensive margin		
Historical sex ratio	−0.266	0.027	−0.129	0.082	0.088	−0.000	−0.013
	(0.238)	(0.095)	(0.158)	(0.122)	(0.123)	(0.004)	(0.009)
Female	−4.807***	5.312***	11.774***	10.304***	10.182***	0.241***	−0.230***
	(0.694)	(0.204)	(0.492)	(0.428)	(0.409)	(0.011)	(0.014)
Female * Historical sex ratio	0.769**	−0.221***	−0.416*	0.083	0.072	−0.013***	0.011**
	(0.300)	(0.080)	(0.209)	(0.191)	(0.187)	(0.004)	(0.005)
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Contemporary poa controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Historical controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Minerals and land type	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	27,389	29,869	10,538	30,700	29,689	42,915	43,020
Number of counties	78	78	78	78	78	78	78
R^2	0.174	0.121	0.211	0.218	0.218	0.095	0.073
Mean dep. var.	115.81	6.303	17.866	15.128	15.643	2.234	1.173

Notes: The table reports OLS estimates. All regressions are with a constant and HILDA wave fixed effects. The level of observation is an individual in a postal area, matched to a historic county. "Geographic controls", "Individual controls", "Present-day postal area controls", "Historical controls", and "Minerals and land type"' controls are as in Table 4. Leisure time is 168 (all hours in a week) minus the sum of time spent in 8 tasks including paid employment, commuting, housework and taking care of children (see Section 2 for a precise definition). For regressions in Columns 2 to 5, the first column considers the whole sample and the second column considers only individuals with non-zero values for the task. "Time spent with children" includes: playing with children, helping them with personal care, teaching, coaching, or actively supervising them, and getting them to daycare, school, or other activities. "Housework and household errands" includes: preparing meals, washing dishes, cleaning house, washing clothes, ironing, sewing, shopping, banking, paying bills, and keeping financial records. "Feel rushed" are answers to the following question: "How often to you feel rushed or pressed for time?" Answers are coded from 1 (never) to 5 (almost always). "Have spare time" are answers to the following question: "How often do you have spare time that you don't know what to do with?" Answers are coded from 1 (never) to 5 (almost always). Standard errors are reported in parentheses and have been corrected for heteroskedasticity and for clustering at the historical county level. ***, **, *, and + indicate statistical significance at the 1%, 5%, 10%, and 15% level, respectively.

sex ratio and gender to measure the differential effect of historical sex ratios on men and women's time allocation. For economy of space, we only report the results with the full set of geographic, historical, and present-day controls. For time spent with children and time allocated to housework, we first present estimates for the whole sample and then estimates at the intensive margin.

Women, on average, consume less leisure than men: the coefficient associated with being female in Column 1 of Table 5 is negative, statistically significant at the 1% level, and large in magnitude. On average, women enjoy 4 hours less of weekly leisure compared with men. However, the coefficient associated with the interaction between the historical sex ratio and being female is positive and statistically significant at the 5% level. This suggests that women who live in areas that were more male-biased in the past enjoy more leisure compared to women who live in areas where the imbalance was not so severe. The magnitude of the effect is considerable. A one standard deviation increase in the sex ratio is associated with 2.3 additional hours of leisure time per week for women, closing more than half the average leisure gap between men and women.

The result that women in areas that were more male-biased in the past enjoy more leisure today is explained by the fact that they work fewer hours in the labour market, as already established, combined with the fact that they do not increase their labour at home, as shown by estimates in Columns 2 to 5 of Table 5. If anything, these women spend less time taking care of their children, and spend comparably no more time on housework and running household errands. A one standard deviation increase in the historical sex ratio is associated with a reduction in the time spent with children by 1.23 hours per week for women, at the intensive margin. It is worth noting that we do not find any statistically significant difference in fertility as a function of the historical sex ratio.[24] The positive enduring effects of male-biased sex ratios on leisure is further demonstrated in the last two Columns of Table 5, which present regression results for other proxies of leisure available in the HILDA survey. In areas where sex ratios were more male-biased in the past, women today are significantly less likely to "feel rushed" and significantly more likely to enjoy "spare time". The coefficients are statistically significant at the 1% level and robust to the inclusion of the full battery of controls.

5.3. *Robustness of OLS results*

All the results pertaining to attitudes, female labour supply at the intensive margin, the share of women in high-ranking occupations, leisure, and time use are robust to non-linear effects of the historical sex ratio, as well as to excluding metropolitan areas, outlying counties that had fewer than 300 or more than 40,000 people, or counties that historically had very few women (less than 100). They are also robust to controlling for a range of additional characteristics that could be correlated both with the historical sex ratio and with the outcomes of interest, such as: distance to major ports of entry and to the main metropolitan areas, population density today, shares of different religions within the population historically and today,[25] and average income in the county and its quadratic. Some of these additional robustness tests are presented in Supplementary Tables A3 and A5. We also check that the results are robust to propensity score matching. To do so, we predict the historical sex ratio as a flexible function of extended geographic characteristics

24. Estimating specification (3), *i.e.* regressing the number of children respondents have ever had (variable *tchad* in HILDA) on the historical sex ratio yields a statistically insignificant coefficient of 0.018 associated with the historical sex ratio (p: 0.219).

25. While information on ethnicity is very sparse in the historical census, religion seems to be an adequate proxy. For example, in the above mentioned 1846 NSW Census, 50% of the population was Church of England and 31% was Roman Catholic, percentages which correspond well to the respective 50% and 40% shares of the population of English or Irish ancestry.

(latitude, longitude, presence of minerals, land type) and historical employment shares in different sectors, as well as all interactions between geographic and historical characteristics and second order polynomials. We then condition on this predicted propensity score in the main specification. All the results described thus far carry through (see Columns 6, 20, and 27 of Supplementary Table A3 and Columns 6, 20, 27, and 34 of Supplementary Table A4). We also present in Supplementary Tables A3 and A4 the results of placebo specifications in which historical sex ratios are randomly re-allocated between historical counties, while keeping the overall average share of men relative to women constant. As expected, the results are never significant.

Placebo specifications in which male work outcomes, such as male labour force participation, the share of men employed as professionals, and the share of men working full- or part-time time, are regressed on the historical sex ratio bear no significant results. The results are presented in Supplementary Table A5.

We also implement a statistical test developed in Oster (2018). Based on the recommended assumption that the maximum R^2 is 1.3 times the R^2 obtained with the full set of controls, the influence of unobservable variables (the delta) would need to be more than 12 times as large as the influence of all controls included in Column 2 of Table 4 to explain away the influence of the historical sex ratio on progressive attitudes towards female work. For other outcomes, such as hours worked by women, the share of women in high-ranking occupations, leisure time, time spent on household chores or taking care of children, and other proxies of leisure, the delta is well above the recommended threshold of 1, and in many cases negative, indicating that the inclusion of controls actually increases the magnitude of the coefficient associated with historical sex ratios.

5.4. *Instrumental variable results*

Table 6 presents instrumental variable estimation results for attitudes, female labour force participation, and occupations. Table 7 presents instrumental variable estimation results for time allocation and leisure. In all specifications, we include the full set of geographic, historical, and present-day controls, which correspond to those in Tables 4 and 5 with the addition of convict population in place of total population. We only present the results of the instrumental variable strategy for the sample of females when relevant (hours worked, time use). We present 2SLS results only at the intensive margin for the two categories of time use, since results at the extensive margin are very similar. We also present the OLS specifications (3) and (4) and the reduced form in which we regress outcomes directly on the convict sex ratio.

First-stage regressions indicate that our instrumental variable is strong, with F-statistics displayed in Panels B of Tables 6 and 7 ranging between 11.78 and 57.15, well above conventional levels of weak instruments. Point estimates of the coefficient associated with the convict sex ratio are around 0.03, suggesting that a one standard deviation increase in the convict sex ratio resulted in an increase in the population sex ratio of nearly 1.3.

Most of the results discussed thus far are robust to the instrumental variable strategy. The instrumented sex ratio is associated with more conservative attitudes towards gender roles, fewer hours worked by females, and a lower proportion of women employed as professionals, and the relationships are statistically significant at the 1–5% level. 2SLS estimates suggest that a one standard deviation increase in the historical sex ratio is associated with a 12.4% decrease in hours worked by women and a decrease in the share of women professionals by 0.14 standard deviations, which is about 1.3%.[26] The relationship between the consumption of leisure by women

26. The standard deviation of the historical sex ratio in the subpopulation where convicts were present is 1.73. For the sample of female respondents only, it is 1.79.

TABLE 6
Long-run effects: historical sex ratios, gender role attitudes and female labour supply — 2SLS

	1	2	3	4
	Panel A: Second stage — 2 SLS			
	Progressive attitude: Female work	FLFP	Log hours worked by females	Women in high-rank occupations
Historical sex ratio	−0.137***	−0.052	−0.072***	−0.735***
	(0.041)	(0.349)	(0.024)	(0.195)
	[0.042]	[0.355]	[0.024]	[0.198]
State FE	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes
Individual controls	Yes	–	Yes	–
Contemporary poa controls	Yes	Yes	Yes	Yes
Historical controls	Yes	Yes	Yes	Yes
Minerals and land type	Yes	Yes	Yes	Yes
Number of convicts	Yes	Yes	Yes	Yes
Male LFP	No	Yes	No	No
Men high-rank occup	No	No	No	Yes
Wild cluster bootstrap *p*-value	0.002	0.888	0.002	0.002
Observations	14,415	510	5,105	510
R^2	0.165	0.812	0.056	0.791
	5	6	7	8
	Panel B: First stage — 2 SLS			
	Historical sex ratio			
Historical sex ratio among convicts	0.028***	0.032***	0.035***	0.032***
	(0.006)	(0.006)	(0.010)	(0.006)
	[0.006]	[0.006]	[0.010]	[0.006]
State FE	Yes	Yes	Yes	Yes
Geographic controls	Yes	–	Yes	–
Individual controls	Yes	Yes	Yes	Yes
Contemporary poa controls	Yes	Yes	Yes	Yes
Historical controls	Yes	Yes	Yes	Yes
Minerals and land type	Yes	Yes	Yes	Yes
Number of convicts	Yes	Yes	Yes	Yes
Men labour force participation	No	Yes	No	No
Men high-rank occup	No	No	No	Yes
F-stat	18.80	33.38	11.78	33.00
Wild cluster bootstrap *p*-value	0.000	0.000	0.028	0.000
Observations	14,415	510	5,105	510
R^2	0.843	0.819	0.854	0.819

(continued)

and the (instrumented) sex ratio is still positive and statistically significant at the 1% to 5% level, depending on whether we use objective (leisure time computed from time use) or subjective (responses to "feel rushed" or "have spare time") measures of leisure. The magnitude of the 2SLS estimates is slightly larger, but comparable to the OLS. For example, a one standard deviation increase in the historical sex ratio is associated with 3.69 additional hours of leisure time per week for women. As for more precise measure of time allocated by women to their children or to household work, the point estimates are still negative but no longer statistically significant. Our results suggest that even though they may not significantly reduce their supply of labour at home, women still reduce their labour supplied outside the home and, as a result, enjoy more leisure.

TABLE 6
(cont'd): Long-run effects: historical sex ratios, gender role attitudes and female labour supply — 2SLS

	9	10	11	12
	Panel C: OLS			
	Progressive attitude: female work	FLFP	Log hours worked by females	Women in high-rank occupations
Historical sex ratio	−0.082***	0.070	−0.027**	−0.651***
	(0.019)	(0.176)	(0.010)	(0.225)
	[0.019]	[0.179]	[0.010]	[0.228]
State FE	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes
Individual controls	Yes	–	Yes	–
Contemporary poa controls	Yes	Yes	Yes	Yes
Historical controls	Yes	Yes	Yes	Yes
Minerals and land type	Yes	Yes	Yes	Yes
Number of convicts	Yes	Yes	Yes	Yes
Men labour force participation	No	Yes	No	No
Men high-rank occup.	No	No	No	Yes
Wild cluster bootstrap P-value	0.004	0.728	0.002	0.040
Observations	14,415	510	5,105	510
R^2	0.165	0.812	0.059	0.793
	13	14	15	16
	Panel D: Reduced form			
	Progressive attitude: female work	FLFP	Log hours worked by females	Women in high-rank occupations
Historical sex ratio among convicts	−0.004***	−0.002	−0.002***	−0.024***
	(0.001)	(0.011)	(0.000)	(0.006)
	[0.001]	[0.011]	[0.000]	[0.006]
State FE	Yes	Yes	Yes	Yes
Geographic controls	Yes	–	Yes	–
Individual controls	Yes	Yes	Yes	Yes
Contemporary poa controls	Yes	Yes	Yes	Yes
Historical controls	Yes	Yes	Yes	Yes
Minerals and land type	Yes	Yes	Yes	Yes
Number of convicts	Yes	Yes	Yes	Yes
Male LFP	No	Yes	No	No
Men high-rank occup	No	No	No	Yes
Wild cluster bootstrap P-value	0.002	0.888	0.002	0.002
Observations	14,415	510	5,105	510
R^2	0.165	0.812	0.060	0.791

Notes: See Table 4 for the list of controls. "Individual controls" also include gender. The historical county population has been excluded from the set of "Historical controls" because of a multicollinearity issue with the total number of convicts in a county ("Number of convicts"). Standard errors in parentheses have been corrected for heteroskedasticity and for clustering at the historical county level. Number of clusters (historical counties): 28 for estimation with HILDA data (Progressive attitude and hours worked (log)) and 31 for estimation with the Census (FLFP and women in high-ranking occupations). Standard errors in square brackets are bias-corrected cluster-robust to adjust for the small number of clusters (see Cameron and Miller 2015). The reported *p*-values at the bottom of the table have been corrected by the wild cluster bootstrap method by Cameron *et al.* (2008) based on a 1,000 replications. ***, **, *, and + indicate statistical significance at the 1%, 5%, 10%, and 15% level, respectively.

TABLE 7
Long-run effects for females: historical sex ratios and time use — 2SLS

	1	2	3	4	5
	Panel A: Second stage — 2 SLS				
	Leisure time	Time spent taking care of children	Time spent on housework and household errands	Feel rushed	Have spare time
Historical sex ratio	2.231**	−0.396	−0.403	−0.054***	0.071**
	(0.963)	(1.219)	(0.869)	(0.017)	(0.029)
	[0.980]	[1.241]	[0.884]	[0.017]	[0.003]
State FE	Yes	Yes	Yes		Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes	Yes
Contemporary poa controls	Yes	Yes	Yes	Yes	Yes
Historical controls	Yes	Yes	Yes	Yes	Yes
Minerals and land type	Yes	Yes	Yes	Yes	Yes
Number of convicts	Yes	Yes	Yes	Yes	Yes
Wild cluster bootstrap P-value	0.190	0.790	0.742	0.002	0.120
Observations	5,041	1,915	5,530	7,887	7,902
R^2	0.179	0.182	0.159	0.093	0.056
	6	7	8	9	10
	Panel B: First stage - 2 SLS				
	Historical sex ratio				
Historical sex ratio among convicts	0.031***	0.040***	0.031***	0.029***	0.029***
	(0.008)	(0.012)	(0.008)	(0.007)	(0.007)
	[0.855]	[0.012]	[0.008]	[0.007]	[0.007]
State FE	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes	Yes
Contemporary poa controls	Yes	Yes	Yes	Yes	Yes
Historical controls	Yes	Yes	Yes	Yes	Yes
Minerals and land type	Yes	Yes	Yes	Yes	Yes
Number of convicts	Yes	Yes	Yes	Yes	Yes
F-stat	14.27	57.15	14.28	15.93	16.01
Wild cluster bootstrap P-value	0.002	0.052	0.004	0.000	0.000
Observations	5,041	1,915	5,530	7,887	7,902
R^2	0.835	0.864	0.836	0.838	0.838

(continued)

Effect sizes obtained with 2SLS or OLS estimates are very similar, although slightly larger for attitudes, hours worked, and leisure enjoyed by females. Two reasons may explain this. The first is that the 2SLS coefficient measures the local average treatment effect of the sex ratio among convicts only. The sex ratio was much higher in this subpopulation and while convict women married free men, the reverse was rarely true. Convict women were therefore particularly well-situated to extract a high bargain. The second is that the OLS coefficient may suffer from attenuation bias. Convicts were all of marriageable age, between 15 and 50 years of age when transported (Nicholas, 1988, p.14), whereas the rest of the population in the census includes younger and older people. The convict sex ratio therefore more precisely measures the sex ratio that is relevant for the marriage market and the mechanism we describe.

TABLE 7
(cont'd): Long-run effects for females: historical sex ratios and time use — 2SLS

	11	12	13	14	15
	Panel C: OLS				
	Leisure time	Time spent taking care of children	Time spent on housework and household errands	Feel rushed	Have spare time
Historical sex ratio	0.310	−0.472	−0.066	−0.029+	0.020
	(0.675)	(0.774)	(0.452)	(0.019)	(0.018)
	[0.687]	[0.788]	[0.460]	[0.019]	[0.018]
State FE	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes	Yes
Contemporary poa controls	Yes	Yes	Yes	Yes	Yes
Historical controls	Yes	Yes	Yes	Yes	Yes
Minerals and land type	Yes	Yes	Yes	Yes	Yes
Number of convicts	Yes	Yes	Yes	Yes	Yes
Wild cluster bootstrap P-value	0.706	0.598	0.918	0.22	0.42
Observations	5,041	1,915	5,530	7,887	7,902
R^2	0.178	0.182	0.159	0.093	0.055
	16	17	18	19	20
	Panel D: Reduced form				
	Leisure time	Time spent taking care of children	Time spent on housework and household errands	Feel rushed	Have spare time
Historical sex ratio among convicts	0.069**	−0.016	−0.012	−0.002***	0.002**
	(0.030)	(0.049)	(0.027)	(0.001)	(0.001)
	[0.030]	[0.050]	[0.027]	[0.001]	[0.001]
State FE	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes	Yes
Contemporary poa controls	Yes	Yes	Yes	Yes	Yes
Historical controls	Yes	Yes	Yes	Yes	Yes
Minerals and land type	Yes	Yes	Yes	Yes	Yes
Number of convicts	Yes	Yes	Yes	Yes	Yes
Wild cluster bootstrap P-value	0.190	0.790	0.742	0.002	0.120
Observations	4,845	1,915	5,530	7,887	7,902
R^2	0.184	0.182	0.159	0.093	0.056

Notes: Sample of females only. For regressions of "Time spent taking care of children" and "Time spent housework, household errands": intensive margin only. See Table 4 for the list of controls. The historical county population has been excluded from the set of "Historical controls" because of a multicollinearity issue with the total number of convicts in a county ("Number of convicts"). Standard errors in parentheses have been corrected for heteroskedasticity and for clustering at the historical county level. Number of clusters (historical counties): 28. Standard errors in square brackets are bias-corrected cluster-robust to adjust for the small number of clusters (see Cameron and Miller, 2015). The reported *p*-values at the bottom of Table 6 have been corrected by the wild cluster bootstrap method by Cameron *et al*. (2008) based on a 1,000 replications. ***, **, *, and + indicate statistical significance at the 1%, 5%, 10%, and 15% level, respectively.

In Section 2 of the Supplementary appendix, we document the consequences of male-biased sex ratios for female labour force participation and occupational choices in the medium-run, before the onset of multicultural migration to Australia after the Second World War. Our analysis relies on the 1933 Census and reveals medium-run results that are consistent with our long-run results: female labour force participation and the share of women in high-ranking occupations were negatively associated with the historical sex ratio, and the effect on occupations is robust to the 2SLS estimation strategy.

6. CULTURAL PERSISTENCE AS PART OF THE MECHANISM

Male-biased sex ratios have effects on female labour supply, time use, and occupational choices not only in the short-run but also in the long-run, even long after sex ratios have reverted back to normal. Variation in past sex ratios is also associated with systematic variation in present-day cultural attitudes towards gender roles, even though the settler population of Australia was initially ethnically and culturally homogenous. This suggests that the historical circumstance associated with a male-biased sex ratio shifted cultural norms held about gender roles and the relative status of men and women in relationships, which have persisted to this day.

However, several mechanisms other than the evolution and persistence of cultural norms could explain the persistent effect of sex ratios on female work and time use. We discuss these first, before turning to cultural transmission mechanisms.

6.1. *Persistence mechanisms*

Male-biased sex ratios could exert a negative and persistent influence on female employment if male-biased sex ratios had distorted industrial specialization in a way that durably lowered the demand for female labour, for example towards male-intensive economic activities. In that case, what we observe today would be due to the persistence of economic specialization rather than the persistent effect of the historical sex ratio. The empirical evidence that such a channel may be present is weak. Historically, high and low sex ratios areas did not differ systematically from one another in terms of economic specialization. Today, we find that employment shares in only 5 out of 19 different sectors are systematically associated with the historical sex ratio (Supplementary Appendix Table A6) and these sectors combined represent only 17.5% of the employed labour force. We further reflect on this channel, including a discussion of local historiographies that support our interpretation, after Table A6 in the Supplementary Appendix. Importantly, while this channel may explain results pertaining to female work, it cannot explain why women would substitute leisure, rather than housework, to labour market work.

Past circumstances in the marriage market may also have durably affected the respective incentives to invest in education for women (undermining them) and for men (encouraging them) (Chiappori *et al.*, 2009). This in turn could explain why fewer women today reach high-ranking occupations in areas where sex ratios were the most male-biased in the past. We find no empirical evidence suggestive of such a channel. There is no statistically significant relationship between women's educational achievement today, or in 1933, and the historical sex ratio (see Supplementary Appendix Table A7). There is also no evidence of differential selection of women into the labour force, or even into part- or full-time occupations, across high and low sex ratio areas.[27] For men, the relationship between educational outcomes in 2011 and the historical sex

27. On average, 24.41% of working women in high sex ratio areas (defined as above the median historical sex ratio) have studied beyond high school, against 24.95% in low sex ratio areas. The difference is not statistically significant. At the intensive margin, 15.93% of full-time working women in high sex ratio areas have studied beyond high school, against 16.96% in low sex ratio areas (p of the difference in means: 0.31).

ratio is negative, which goes contrary to the theoretical prediction and is not robust to the instrumentation strategy (see Column 2 of Supplementary Table A8).[28] Moreover, again, this education channel does not explain why women consume more leisure, nor does it explain why people would hold specific attitudes towards gender roles at home and in the workplace, as opposed to attitudes towards, for example, female political leaders.

Three remaining mechanisms could explain the persistent negative effect of historical sex ratios on female labour supply: (1) a persistence of a compositional effect, (2) a persistence of a bargaining power effect, or (3) a shift in norms about the appropriate role of women. More specifically, past gender specialized behaviour as an immediate response to variations in sex ratios, may have become a cultural norm that has persisted over time regardless of present-day sex ratios.

Persistence of the compositional effect would imply that marriage rates should be higher in areas where sex ratios were more male-biased in the past. This is not the case (see Supplementary appendix, Table A9). Moreover, the fact that we observe higher leisure consumption by women in areas that were more male-biased in the past further dispels a persistence of the compositional channel as an explanation for our results. Persistence in the bargaining position of women explains why female labour supply is lower and consumption of leisure higher in areas that were more male-biased in the past. However, it does not explain the differences observed in cultural attitudes towards gender roles.

Hence, our results suggest that the influence of sex ratios has persisted in the long run by shaping cultural norms about both (2) the relative bargaining position of men and women in a relationship and (3) attitudes about gender roles. We explore in more detail the potential transmission channels of cultural attitudes about the appropriate role of women in the next subsection.

6.2. *Cultural persistence: the roles of family, marriage, and migration*

If, as discussed in Section 2.2, gender norms are transmitted within families, and if Australia's past shaped cultural attitudes towards gender roles in the way that we describe, people whose parents were born in Australia should be more likely to hold this norm. To test for such vertical cultural transmission in more detail, we add an interaction term between the historical sex ratios and a dummy indicating at least one Australian parent (mother or father) when we examine the determinants of progressive attitudes towards female work.[29]

Regression results are in Columns 1 and 2 of Table 8. The coefficient associated with the historical sex ratio alone is no longer statistically significant, suggesting that historical sex ratios have no influence on people who are not born of Australian parents. The main effect of having an Australian parent is positive and statistically significant, but its interaction with the historical sex ratio is negative, statistically significant, and large in magnitude: more than twice as large as in the sample as a whole. In other words, Australian parents transmit more progressive norms, but not where sex ratios were more male-biased historically.[30]

28. In the second stage of the 2SLS, the relationship between female educational outcomes in 2011 and the historical sex ratio is negative (see Column 1 of Supplementary Table A8) but this result is not robust to correcting standard errors for clustering at the county level and correcting for the small number of clusters (see wild cluster bootstrap p at the bottom of Column 1).

29. Splitting the sample further into Australian born mother and Australian born father is problematic due to multicollinearity.

30. The coefficient associated with the historical sex ratio itself (the sum of the main effect and the interaction with having an Australian parent) is overall negative and significant (p of 0.000).

TABLE 8
Persistence: vertical cultural transmission, migration, and homogamy

	1	2	3	4	5	6
	Progressive attitude: female work					
Historical sex ratio	0.024	0.014	0.053**	0.038*	0.069	0.067
	(0.018)	(0.015)	(0.026)	(0.021)	(0.047)	(0.050)
Australian parent	0.304***	0.302***				
	(0.061)	(0.060)				
Australian parent * Historical sex ratio	−0.060***	−0.059***				
	(0.022)	(0.021)				
Low migration			0.101*	0.102		
			(0.058)	(0.062)		
Low migration * Historical sex ratio			−0.078***	−0.074***		
			(0.025)	(0.019)		
High Homogamy					0.087	0.087
					(0.112)	(0.132)
High Homogamy * Historical sex ratio					−0.088*	−0.095*
					(0.048)	(0.051)
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes
Present-day postal area controls	Yes	Yes	Yes	Yes	Yes	Yes
Historical controls	No	Yes	No	Yes	No	Yes
Minerals and land type	No	Yes	No	Yes	No	Yes
Observations	42,866	42,284	42,866	42,284	42,947	41,928
R^2	0.167	0.169	0.166	0.168	0.167	0.168

Notes: The table reports OLS estimates. All regressions are with a constant and HILDA wave fixed effects. See Table 4 for the list of controls. "Individual controls" also include gender. "Low migration" refers to postal areas where the proportion of residents born in Australia is higher than the mean proportion of residents born in Australia as per the 2011 Census. "Australian parent" is a dummy equal to one if respondent has an Australian father or an Australian mother (mean: 0.68). "High migration" refers to postal areas where the proportion of residents born in Australia is lower than the median proportion of residents born in Australia as per the 2011 Census. Homogamy refers to the average proportion of people of Australian descent in the postal area who married someone also of Australian descent. "Low Homogamy" are postal areas whose predicted level of homogamy lies below the median level of homogamy, which is 86%. "High Homogamy" refers to postal areas whose predicted level of homogamy lies above the median. Homogamy is predicted by the sex ratio today, degree of urbanization, income, education, shares of employment in eighteen different industries and respondents' parents' countries of birth in the postal area. Standard errors are reported in parentheses and have been corrected for heteroskedasticity and for clustering at the historical county level (78 clusters). ***, **, *, and + indicate statistical significance at the 1%, 5%, 10%, and 15% level, respectively.

Consistent with the theoretical prediction regarding the role of migration discussed in Section 2, we find that recent migration has an attenuating influence on cultural persistence. Belloc and Bowles (2013) discuss how immigration should make experimentation easier and may accelerate transition from one cultural convention to another. We find that the historical sex ratio is associated with more conservative gender norms in areas where migration in recent years[31] was low, but not where it was high (Columns 3 and 4).[32] These results also reveal that people of differing ancestry systematically display different attitudes even if they live in the same area. This implies that the relationship between historical sex ratios and present-day outcomes is unlikely to be due to unobservable local characteristics or to self-selection of people to localities on the basis of taste.

31. The census reports migration over the last 5-year period.

32. The coefficient associated with the historical sex ratio itself (the sum of the main effect and the interaction with having low migration) is overall negative and significant (p of 0.000).

In Section 2 we discussed other mechanisms that might contribute to persistence, in particular the issue of coordination on the marriage market and homogamy. We provide some evidence on the relationship between marriage homogamy and the persistence of conservative gender norms in Columns 5 and 6 of Table 8. We define homogamy as the probability that one's partner is born in Australia when one is also born in Australia: 86% on average. Table A10 in the Supplementary Appendix illustrates that homogamy brings direct benefits: people are happier in their relationship when married to someone ethnically similar. As we are concerned that homogamy is an endogenous outcome to the degree of cultural persistence, we rely on a measure of homogamy predicted by several characteristics of the postal area: education, degree of urbanization, ancestry composition, average median income, sex ratio today, and employment shares in nineteen different sectors. We define high and low homogamy postal areas as above or below the median predicted homogamy.

The results show that past sex ratios are associated with conservative views only in areas where predicted homogamy is high. In contrast, no effect is found in areas with low homogamy.[33] Such strategic complementarities in the marriage market are compatible with the apparent paradox of rapid adaptation of cultural norms yet cultural persistence. The situation we study is that of a large shock to the marriage market, one able to lead to rapid adaptation of social norms that facilitated male success in finding a wife. Holding such views would be an efficient investment in a market with such excess demand (Angrist, 2002). Our interpretation of persistence is that these norms locked in, even after sex ratios had reverted back to normal, because of the strategic complementarity of gender views in the marriage market, together with vertical transmission within families.

All these results are robust to instrumenting the historical population sex ratio by the sex ratio among convicts only. Results of the first and second stage, as well as of the reduced form and the simple OLS specification in the reduced sample where convicts were present historically, are presented in Supplementary Table A11. We correct standard errors for the small numbers of clusters using the two methods discussed in Section 4.1. As all the results pertain to interaction effects between the historical sex ratio and either having at least one Australian parent, living in a low migration area, or living in a high homogamy area, we perform the 2SLS analysis in each of the three relevant subsamples. As before, the convict sex ratio is a strong instrument, with the F-stat of the excluded instrument in the first stage regressions above 15. In the second-stage regression of holding progressive attitudes towards female work, the coefficient associated with the historical sex ratio is negative and statistically significant at the 5% level for respondents with an Australian parent, at the 10% level in areas where marriage homogamy is high, and at the 15% level in low migration areas.

7. CONCLUSION

This article shows that past male-biased sex ratios can leave a large and persistent imprint on women's labour supply decisions and on their occupational choice in the short and long run. Male-biased sex ratios result in women reducing their labour supply. We have also documented, in the long run when the data enables us to do so, that these effects translate into the consumption of more leisure by women and into more conservative views held about gender roles. As a likely consequence of the reduction in their labour supply and of more conservative attitudes, women are less likely to rise to high-ranking occupations. These findings are consistent with the predictions of

33. The coefficient associated with the historical sex ratio itself (the sum of the main effect and the interaction with homogamy) is overall negative and significant (p of 0.002).

household bargaining models that male-biased sex ratios lead to an improvement in the bargaining position of women, and subsequently a reduction in the labour supply of women and an increase in their consumption of leisure. To the best of our knowledge, this article is the first to document that these effects can persist into the long run, well after sex ratios have reverted back to normal. We document the role of cultural norms in sustaining such persistence.

The differences that we find in women's employment outcomes are associated with persistent differences in cultural attitudes towards women working. This indicates that cultural norms can emerge as an adaptive evolutionary response to a large shock in the marriage market and persist in the long run, even when they are no longer necessarily adaptive.

We find that the presence of strategic complementarities between cultural norms, discussed here in the context of the marriage market, underlies the persistence of culture. We believe that the presence of strategic complementarity between cultural norms solves the apparent paradox of a rapid adaptation of cultural norms combined with cultural persistence over a long period of time. One implication is that persistence will be stronger and last longer for norms that exhibit stronger strategic complementarities and in situations, like the marriage market, where experimentation can be costly. A more detailed exploration of this mechanism is left for future research.

Although our results may be specific to a certain technological context — work opportunities for women were very poor in 19th century Australia — and although the deviation from a balanced sex ratio that we study is much larger than deviations observed today in certain parts of the world, a noteworthy implication is that a temporary imbalance in the sex ratio can have significant consequences for society that can endure in the long-run, well beyond the imbalance itself.

Acknowledgments. We are indebted to Michèle Tertilt for invaluable comments and suggestions. We are also grateful to Renee Adams, Chris Bidner, Alison Booth, Monique Borgerhoff-Mulder, Sam Bowles, Rob Boyd, Rob Brooks, Raquel Fernández, Gigi Foster, Gabriele Gratton, Ralph de Haas, Kim Hill, Hongyi Li, Leslie Martin, Terra McKinnish, Suresh Naidu, Allison Raith, Marc Sangnier, Paul Seabright, Jesse Shapiro, Peter Siminski, and audiences at the NBER Summer Institute Political Economy 2014, the Santa Fe Institute, Australian National University, the Institute for Advanced Studies in Toulouse, Hong Kong UST, Monash University, QUT, Sciences-Po, UC Berkeley, University of Sydney, UNSW, and Wollongong University for comments and suggestions. This research has benefited from the financial support of UNSW Business School. The article uses unit record data from the Household, Income and Labour Dynamics in Australia (HILDA) Survey. The HILDA Project was initiated and is funded by the Australian Government Department of Families, Housing, Community Services and Indigenous Affairs (FaHCSIA) and is managed by the Melbourne Institute of Applied Economic and Social Research (Melbourne Institute). The findings and views reported in this article are, however, those of the authors and should not be attributed to either FaHCSIA or the Melbourne Institute. All errors and omissions are our own.

Supplementary Data

Supplementary data are available at *Review of Economic Studies* online.

REFERENCES

ABRAMITZKY, R., DELAVANDE, A. and VASCONCELOS, L. (2011), "Marrying Up: The Role of Sex Ratio in Assortative Matching", *American Economic Journal: Applied Economics*, **3**, 124–157.

ALESINA, A., GIULIANO, P. and NUNN, N. (2013), "On the Origins of Gender Roles: Women and the Plough", *The Quarterly Journal of Economics*, **128**, 469–530.

ALFORD, K. (1984), *Production or Reproduction? An Economic History of Women in Australia, 1788–1850*, (Melbourne: Oxford University Press).

ALMOND, D., EDLUND, L. and MILLIGAN, K. (2013), "Son Preference and the Persistence of Culture: Evidence from South and East Asian Immigrants to Canada", *The Population and Development Review*, **39**, 75–95.

ANGRIST, J. (2002), "How Do Sex Ratios Affect Marriage and Labour Markets? Evidence from America's Second Generation", *The Quarterly Journal of Economics*, **117**, 997–1038.

BECKER, G. S. (1973), "A Theory of Marriage: Part I", *Journal of Political Economy*, **81**, 813–46.

BECKER, G. S. (1974), "A Theory of Marriage: Part II", *Journal of Political Economy*, **82**, S11–26.

BECKER G. S. (1981), *A Treatise on the Family*, (Cambridge, MA: Harvard University Press xii, 288 pp).

BECKER, G. S., LANDES, E. M. and MICHAEL, R. T. (1977), "An Economic Analysis of Marital Instability", *Journal of Political Economy*, **85**, 1141–1187.

BELLOC, M., and BOWLES, S. (2013), "The Persistence of Inferior Cultural-Institutional Conventions", *American Economic Review*, **103**, 93–98.
BERTRAND, M., PAN, J. and KAMENICA, E. (2015), "Gender Identity and Relative Income within Households", *The Quarterly Journal of Economics*, **130**, 571—614.
BIDNER, C. and SAND, B. (2012), "Industrial Composition, Bargaining, and the Gender Wage Gap: Evidence from U.S. Cities", (Mimeo, York University).
BISIN, A. and VERDIER, T. (2001), "The Economics of Cultural Transmission and the Dynamics of Preferences", *Journal of Economic Theory*, **97**, 298–319.
BOEHNKE, J., and GAY, V. (2017), "The Missing Men: World War I and Female Labour Participation", (Working Paper, University of Chicago).
CAMERON, A. C., GELBACH, J. and MILLER, D. L. (2008), "Bootstrap-Based Improvements for Inference with Clustered Errors", *Review of Economics and Statistics*, **90**, 414–427.
CAMERON, A. C. and MILLER, D. L. (2015), "A Practitioner's Guide to Cluster-Robust Inference", *Journal of Human Resources*, **50**, 317–373.
CAMM, J. (1978), "Historical Geography and Past Populations: 19th century New South Wales", *Australian Geographical Studies*, **16**, 111–125.
CARRANZA, E. (2014), "Soil Endowments, Female Labour Force Participation, and the Demographic Deficit of Women in India", *American Economic Journal: Applied Economics*, **6**, 197–225.
CHIAPPORI, P.-A. (1988), "Rational Household Labour Supply", *Econometrica*, **56**, 63–90.
CHIAPPORI, P.-A. (1992), "Collective Labour Supply and Welfare", *Journal of Political Economy*, **100**, 437–467.
CHIAPPORI, P.-A., FORTIN, B. and LACROIX, G. (2002), "Marriage Market, Divorce Legislation, and Household Labour Supply", *Journal of Political Economy*, **110**, 37–72.
CHIAPPORI, P.-A., IYIGUN, M. and WEISS, Y. (2009), "Investment in Schooling and the Marriage Market", *American Economic Review*, **99**, 1689–1713.
CHUNG, W. and GUPTA, M. D. (2007), "Why is Son Preference Declining in South Korea? The Role of Development and Public Policy, and the Implications for China and India" (Policy Research Working Paper 4373).
Commonwealth of Australia Constitution Act 1900(Imp).
DOEPKE, M. and TERTILT, M. (2009), "Women's liberation: What's In It for Men?", *The Quarterly Journal of Economics*, **124**, 1541–1591.
DOEPKE, M., TERTILT, M. and VOENA, A. (2012), "The Economics and Politics of Women's Rights", *Annual Review of Economics*, **4**, 6.1–6.34.
DOEPKE, M. and ZILIBOTTI, F. (2008), "Occupational Choice and the Spirit of Capitalism", *The Quarterly Journal of Economics*, **123**, 747–793.
EDLUND, L. and LEE, C. (2009), "Son Preference, Sex Selection and Economic Development: Theory and Evidence from South Korea", (Columbia University Discussion Paper No. 0910-04).
FERNÁNDEZ, R. (2008), "Culture and Economics", in Durlauf, S.N. and L.E. Blume (eds) *The New Palgrave Dictionary of Economics*, (UK: Palgrave Macmillan).
FERNÁNDEZ, R. (2103), "Cultural Change as Learning: The Evolution of Female Labour Force Participation over a Century", *American Economic Review*, **103**, 472–500.
FERNÁNDEZ, R. and FOGLI, A. (2009), "Culture: An Empirical Investigation of Beliefs, Work and Fertility", *American Economic Journal: Macroeconomics*, **1**, 146–177.
FERNÁNDEZ, R., FOGLI, A. and OLIVETTI, C. (2014). "Mothers and Sons: Preference Formation and Female Labour Force Dynamics", *Quarterly Journal of Economics*, **119**, 1249–1299.
FORTIN, N. (2005), "Gender Role Attitudes and the Labour-Market Outcomes of Women across OECD Countries", *Oxford Review of Economic Policy*, **21**, 416–438.
FRANCIS, A. M. (2011), "Sex Ratios and the Red Dragon: Using the Chinese Communist Revolution to Explore the Effects of the Sex Ratio on Women and Children in Taiwan", *Journal of Population Economics*, **24** 813–837.
GOLDIN, C., and KATZ, L. (2002), "The Power of the Pill: Oral Contraceptives and Women's Career and Marriage Decisions", *Journal of Political Economy*, **110**, 730–770.
GREENWOOD, J., SESHADRI, A. and VANDENBROUCKE, G. (2005), "The Baby Boom and Baby Bust", *American Economic Review*, **95**, 183–207.
GROSSBARD-SHECHTMAN, A. (1984), "A Theory of Allocation of Time in Markets for Labour and Marriage", *The Economic Journal*, **94**, 863–882.
GROSSBARD-SHECHTMAN, S., and NEIDEFFER, M. (1997), "Women's Hours of Work and Marriage Market Imbalances", in I. Persson and C. Jonung, (eds) *Economics of the Family and Family Policies* (London: Routledge).
GROSSBARD, S. and AMUEDO-DORANTES, C. (2008), "Cohort-level Sex Ratio Effects on Women's Labour Force Participation", *Review of Economics of the Household*, **6**, 309–309.
HANSEN, C. W., JENSEN, P. S. and SKOVSGAARD, C. V. (2015), "Modern Gender Roles and Agricultural History: The Neolithic Inheritance", *Journal of Economic Growth*, **20**, 365–404.
HESKETH T. and XING, Z. W. (2006), "Abnormal Sex Ratios in Human Populations: Causes and Consequences", *Proceedings of the National Academy of Sciences of the USA*, **103**, 13271–13275.
LEHRER, E. and CHISWICK, C. (1993), "Religion as a Determinant of Marital Stability", *Demography*, **30**, 385–404.
MCLEAN, I. W. (2012), *Why Australia Prospered: The Shifting Sources of Economic Growth*. (Princeton, New Jersey, USA: Princeton University Press).

MEREDITH, D. and OXLEY, D. (2005), "Contracting Convicts: The Convict Labour Market in Van Diemen's Land 1840-1857", *Australian Economic History Review*, **45**, 45–72.
National Wage and Equal Pay Cases (1972) 147 CAR 172.
NICHOLAS, S. (EDS) (1988), *Convict Workers: Reinterpreting Australia's Past*, (Australia: Cambridge University Press).
NUNN, N. (2009), "The Importance of History for Economic Development", *Annual Review of Economics*, **1**, 65–92.
OLIVETTI, C. (2014), "The Female Labor Force and Long-Run Development: The American Experience in Comparative Perspective," NBER Chapters, in *Human Capital in History: The American Record*, (National Bureau of Economic Research, Inc.) 161–197.
OPESKIN, B. and KIPPEN, R. (2012), "The Balance of the Sexes: The Feminisation of Australia's Population, 1901-2008", *Population, Space, and Place*, **18**, 517–533.
OSTER, E. (2018), "Unobservable Selection and Coefficient Stability: Theory and Evidence", *Journal of Business Economics and Statistics*. (Forthcoming).
OXLEY, D. (1994), "Packing her (Economic) Bags: Convict Women Workers", *Aistralian Historical Studies*, **26** 57–76.
OXLEY, D. (1996), *Convict Maids: The Forced Migration of Women to Australia*. (Melbourne: Cambridge University Press).
QIAN, N. (2008). "Missing Women and the Price of Tea in China: The Effect of Sex-Specific Earnings on Sex Imbalance", *The Quarterly Journal of Economics*, **123**, 1251–1285.
RAO, V. (1993). "The Rising Price of Husbands: A Hedonic Analysis of Dowry Increases in Rural India", *Journal of Political Economy*, **101**, 666–677.
RICHERSON, P. J. and BOYD, R. (2005). *Not By Genes Alone: How Culture Transformed Human Evolution.* (Chicago and London: The University of Chicago Press).
SALT, A. (1984), *These Outcast Women: The Parramatta Female Factory 1821–1848* (Sydney: Hale and Iremonger Pty Ltd).
Select Committee on Transportation (1837–1838), *Report, Minutes of Evidence, Appendix, Index* (Great Britain: House of Commons Parliamentary Papers).
WEI, S.-J. and ZHANG, X. (2011), "The Competitive Saving Motive: Evidence from Rising Sex Ratios and Savings Rates in China", *Journal of Political Economy*, **119**, 511–564.
XUE, M. M. (2016), *High-Value Work and the Rise of Women: The Cotton Revolution and Gender Equality in China*. Available at SSRN: https://ssrn.com/abstract=2389218.
YOUNG, P. (1998). *Individual Strategies and Social Structure: An Evolutionary Theory of Institutions*. (Princeton: Princeton University Press).