Structural Transformation over 150 years of Women's and Men's Work *

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October 2022 – **Preliminary version**

Abstract

We build a consistent measure of male and female work for the US for the period 1880-2019 – encompassing intensive and extensive margins – by combining data from the US Census and several early sources. The resulting measure of hours, including paid work as well as unpaid work in family businesses, displays an asymmetric U-shape for women, with a modest decline up to mid-20th century and a sustained rise afterwards. For men, hours fall throughout the sample period. We empirically and theoretically relate these trends to the process of structural transformation, and namely the reallocation of labour across agriculture, manufacturing and services, and the marketization of home production. We propose a multisector model of the economy with uneven productivity growth, income effects, and consumption complementarity across sectoral outputs. At early stages of development, declining agriculture leads to rising services (both in the market and the home) and leisure, implying a fall in market work for both genders. At later stages of development, structural transformation reallocates labor from manufacturing into services, and a large service economy implies an important marketization process, progressively reallocating work from home to market services. Given gender comparative advantages, the first channel is more relevant for men, implying a decrease in male hours, and the second channel is more relevant for women, implying an increase in female hours.

*We would like to thank Ben Bridgman, Julieta Caunedo, Jonna Olsson, Valerie Ramey, Marc Teignier, Akos Valentinyi and Guillaume Vandenbroucke for helpful discussions. We are grateful to Amber Cai and Grayce Gibbs for excellent research assistance. Rachel Ngai: London School of Economics and CEPR; Claudia Olivetti: Dartmouth College and NBER; Barbara Petrongolo: Oxford University and and CEPR.

1 Introduction

Most high-income countries have witnessed a spectacular increase in women's participation to the labor market during the second half of the 20th century. For example, the female employment rate in the US more than doubled from about 30% in 1940 to about 70% in 2000, and other rich countries followed similar paths, albeit with varying delays with respect to the US experience. Furthermore, the substantial decline in gender inequalities stands in sharp contrast with many other dimensions of inequality, which were widening over most of the period. However, rising female participation is not a universal phenomenon. In fact, female employment has been slightly falling in the developing world during recent decades, and it has been falling in high-income countries in other historical windows. As a consequence, the relationship between female employment and GDP per head may be non-monotonic, and is often described as a U-shape, an idea that has been pioneered in early work by Sinha (1967), Boserup (1970) and Durand (1975). In contrast, male employment tends to fall throughout various stages of development.

This paper empirically and theoretically relates the relationship between male and female work and economic development through the lens of two processes: structural transformation across the broad sectors of agriculture, manufacturing and services, and the marketization of home production. To this purpose, we build a consistent measure of employment for the US over 1880-2019, encompassing both extensive and intensive margins, where special emphasis is given to measuring unpaid family work in the pre-1940 era.

We describe trends on persons in work using data from the Census of Population from 1880 onwards. Starting in 1940, the definition of employment in the Census – coinciding with the definition currently adopted by ILO – covers both paid and unpaid employment. The latter typically includes unpaid work in family businesses, mostly family farms. Before 1940, only "gainful" work is counted as employment in the Census, and we obtain an estimate of unpaid work based on the share of persons living on farms and the (gainful) occupation of their head of household (Ruggles 2015). For example, if a woman is living on the farm, does not report a gainful occupation, and is married to a self-employed farmer, she is classified as an unpaid family worker, motivated by evidence that farms relied heavily on family labor, and all family members who were old enough to work would typically contribute to farm production. Based on these calculations, the female employment-to-population ratio falls from 57% in 1880 to 41% in 1960, then rising to 73% in 2019, while male employment falls throughout the sample period, from 95% in 1880 to 81% in 2019.

The Census also contains information on working hours from 1940, but there exists no unified or consistent source before then. We thus combine information from the Census of Manufacturers and several one-off reports and surveys commissioned by state Bureaus of Labor,[1] which typically sampled specific geographies, sectors, or occupations. Thanks to early labor regulations and a structured work week, coverage for the manufacturing sector is reasonably systematic and information on hours seems more reliable than for other sectors Whaples (1990). Coverage is sparser for the broad service sector, and quite limited for agriculture. Combining data on bodies and hours from the various sources, we find that women's working hours fell from about 17 hours per week during the late 19th century, reaching a minimum of about 15 hours in the mid-20th century, before rising to 27 hours in recent years. The resulting U-shape in female hours has a much shallower left branch than the corresponding body-count, because hours worked in unpaid farm work – prevalent over the earlier period – are markedly lower than in regular, gainful employment.

To rationalize the simultaneous evolution of male and female work and the industry structure, we model a multisector economy in which individuals consume output from three sectors – agriculture, manufacturing and services – and allocate their time to market work, home-production and leisure. The three types of goods are poor substitutes in consumption, with a minimum food requirement in the consumption of agricultural goods, implying that the demand is less income elastic than demand for manufacturing and services. Services can be produced both in the market and the home, with market- and home-produced services being close substitutes for each another. Productivity growth is uneven across sectors, being higher in agriculture and manufacturing than in services. Within the broad service sector, productivity growth is faster in the market than in the home, for example because the scale of market production is better conducive to labor specialization and technology adoption.

As outputs from the three sectors are poor substitutes in consumption, faster produc-

[1]Some of these have been reorganized into wider collections such as the Historical Statistics of the United States, 1860-1930; the Historical Labor Statistics Project at the University of California (Carter et al., 1991); the "Women Working, 1800-1930" project of the Harvard University Library's Open Collections Program – among others.

tivity growth in agriculture and manufacturing leads to structural transformation and a rise in services. As part of increased service output is produced within the home, structural transformation implies a decline in market hours. Conversely, faster productivity growth in market than home services, which are good substitutes for each other in consumption, leads to marketization of home production and an increase in market work. The simultaneous evolution of hours of work and the industry structure can be summarized in two main phases. At early stages of development, when the agricultural sector is large, structural transformation is the main force at play, leading to declining agriculture, rising service production both in the market and the home, and rising leisure due to income effects. This implies a decline in market work, via both the rise in home services and leisure. At later stages of development, once the agricultural share is small, structural transformation mostly shapes labor reallocation from manufacturing into services. At the same time, a large service economy implies an important marketization process, progressively reallocating work from home to market services and raising market hours.

Patterns of gender specialization, reflecting innate or acquired comparative advantages and other gender-specific factors such as social norms about female work, determine the relative strength of these forces for men and women. Specifically, women are over-represented in services, especially home services, relative to agriculture and (even more so) manufacturing. In the early phase, structural transformation implies a larger fall in female market hours, as home services are more intensive in female work. In the later phase, marketization implies a larger increase in female market hours, while male hours mostly bear the consequences of de-industrialization. The combination of uneven productivity growth and gender specialization may therefore induce a U-shape in female market hours, and monotonically declining male market hours.

Our paper contributes to several strands of literature on the long-run evolution of female work. The U-shape hypothesis was initially postulated by Sinha (1967) and further advanced by Boserup (1970), Durand (1975) and Goldin (1990, 1995), among others, discussing a variety of factors at play. In early agricultural societies, women are heavily involved in the labor force, often as unpaid workers in family businesses. As economies grow, following both technology adoption in agriculture and industrialization, the locus of production moves out of the household and into large-scale agriculture and factories, in tandem with the process of urbanization. Female participation declines, following a combination of income effects, male comparative advantages in manufacturing, as well as social customs limiting women's entry in manufacturing. As economic development progresses, the improvement in women's education and the expansion of white-collar jobs attract women into the labor market, due higher opportunity costs of home making and female comparative advantages in white collar occupations, which would not entail the same social stigma as factory work. Evidence presented by Goldin (1995) lends support to the U-shape hypothesis on a cross-section of countries observed in the early 1980s, as does later work on cross-country panels (see Olivetti 2014 and Doss et al. 2022). On the intensive margin, Bick et al. (2018) find that working hours tend to decrease monotonically for both men and women with country-level GDP per head.

Evidence from within-country evolutions is more limited, due to the difficulty of measuring unpaid women's work and work in agriculture in general before WW2. Goldin (1990) suggests that female labor force participation in the US was likely decreasing between the late 19th century and early 20th century, based on a revision of the 1890 Census statistics so as to include typically under counted occupations in the female labor force. This revision implied that female participation was likely as high in 1890 as it was in 1940, with the bottom of the U occurring somewhere in between. By combining data from the Census, CPS and Kendrick (1961), Ramey and Francis (2009) show evidence of roughly flat female market hours until 1940, and rising afterwards. We build on this body of work by bringing together several data sources for the earlier period, characterizing both the extensive and intensive margins of female participation since 1880. In addition, we formalize the link between gender trends and the changing industry structure in a unified framework that explains labor reallocation within and across sectors.

Our work is also closely related to a more recent literature on the relationship between the rise of the service economy and female employment, including (among others) Lee and Wolpin (2006), Akbulut (2011), Ngai and Petrongolo (2017), Rendall (2018), Bridgman et al. (2018), Buera et al. (2019) and Cerina et al. (2021). This work typically highlights the role of the service sector in creating jobs for which women have a comparative advantage and, closely related to this paper, the framework of Ngai and Petrongolo (2017) generates structural transformation and marketization of home production as consequences of uneven productivity growth. By focusing on gender and industry trends over recent decades, this body of work is silent about the role of agriculture in shaping female employment in the pre-WW2 period, and our paper aims to fill this gap in knowledge. We argue that a perspective on the earlier period is important not simply to understand gender trends in economic history, but – importantly – to shed light on the ongoing transition out of agriculture in the developing world. In this vein, independent work by Doss et al. (2022) also highlight the role of gender norms regarding agriculture work in the observed relationship between GDP per head and female employment across low income countries.

Finally, our paper relates to work on the evolution of aggregate hours of work. Ngai and Pissarides (2008) consider the implications of uneven productivity growth for aggregate working hours, Vandenbroucke (2009) and Boppart and Krusell (2020) emphasize the role of income effects in hours' decline, and Bick et al. (2022) combine structural transformation and variation in the fixed cost of work to model intensive and extensive margins. We contribute a gender dimension to this literature and highlight that the combination of structural transformation and marketization can simultaneously explain monotonically declining hours for men and U-shaped hours for women.

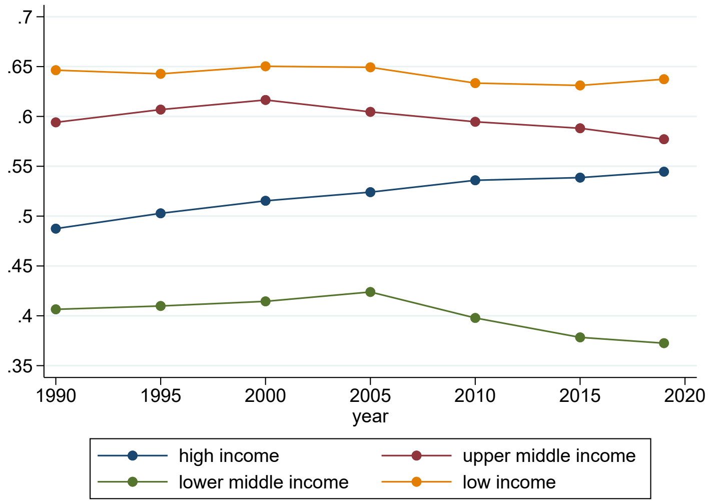
The rest of the paper is organized as follows. The next Section presents evidence on employment, hours and wages dating back to 1880, combining a variety of data sources. The model of Section 3 rationalizes the trends shown in a multisector economy with uneven productivity growth and gender comparative advantages. Section 4 gives a simple quantitative illustration of model properties and Section 5 concludes.

2 Evidence

2.1 International evidence

The steady rise in female employment experienced in most high-income countries since WW2 is not a universal phenomenon, as indeed female employment has been falling in other parts of the world and/or other time windows. For example, in recent decades, rich countries have been the only part of the world in which female employment was rising, while female employment was indeed falling everywhere else. This is shown by internationally consistent ILO data of female employment reported in Figure 1, which plots the employment to population ratio for women aged 25 and above in four macro regions of the world: high-income countries, upper middle-income countries, low-middle income countries ad low-income countries.[2] Interestingly, differences in international trends are not systematically correlated to trends in fertility (reported in Appendix Figure 1), which have been declining everywhere. Hence one may rule out explanations of international trends in female employment solely based on international differences in fertility.

Figure 1: Employment-to-population ratio around the world, 1990-2019



The Employment rates are based on the ILO definition of employment, covering work for pay, profit or family gain in cash or kind. Sample: women aged 25+.

We next restrict to a sample of 17 high-income countries and Panel A in Figure 2 plots female employment rates against levels of economic development over a longer time period, from 1840-2005. The pre-1950 employment data are drawn from the International Historical Statistics, Goldin (1990) and Pencavel (1986); and from 1950 onwards they are provided by ILO. Development is proxied by (log) read GDP per head, provided by Maddison Historical Statistics. As also shown by (Olivetti, 2014) for 1890-2005, the relationship between female participation and economic development in this cross-section is non-monotonic, and it can be approximated by a quadratic fit. Panel B in Figure 2 provides the same scatter plot, where the quadratic fit (red line) is now based on a regression that controls for both country and year fixed-effects. The green line is based on a regression that additionally controls for the share of agriculture in total employment and its square, and the resulting quadratic fit is tilted anti-clockwise, i.e. the decline in agriculture explains (in an accounting sense) much of the non-monotonic pattern in

[2]For 15-24 age group, much of the decline in participation in the developing world is driven by rising enrolment in education, hence we restrict the sample in Figure 1 to those aged 25+.

female employment, by predicting much lower levels of female employment at low levels of development. Finally, the orange line is based on a regression that further controls for the service share and its square, which in turn explains some of the rise in female employment at high levels of development.[3]

2.2 Employment

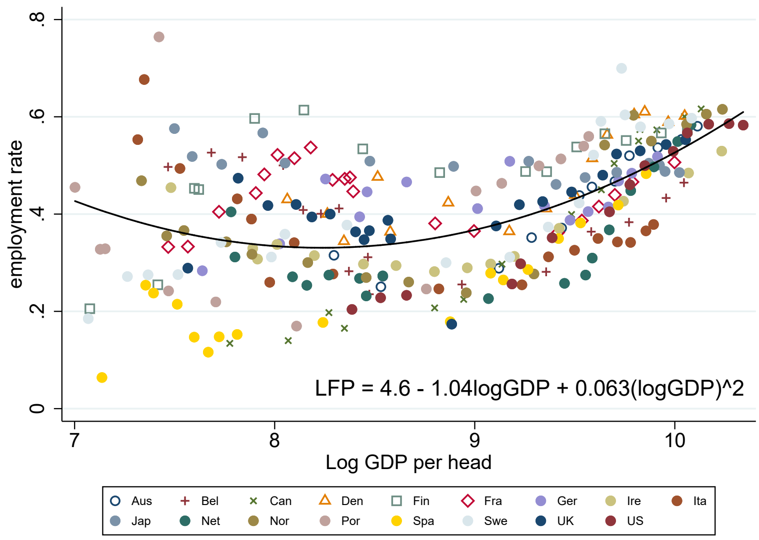
The correlations shown in Figure 2 suggest that changes in the industry structure may have played a role in shaping long-run trends in female employment, and in what follows we investigate this idea further on US micro data from the Census of Population and American Community Survey (ACS) combined. Ideally, and to speak directly to the role of unpaid work at early stages of development, we should measure employment based on the ILO definition, covering work for pay, profit or family gain in cash or kind. In particular, this definition should cover unpaid family workers, i.e. "relatives who assist without pay in a family-operated income-producing enterprise such as a farm, store or handicraft industry" (Durand, 1975). While the ILO definition of employment is well-established nowadays, it is typically not available in historical data. In particular, in the US Census, it only becomes available in 1940, with some inconsistencies in detailed definitions in the decades that follow. For example, from 1940 onwards, unpaid family workers were considered employed if they worked at least 15 hours per week, while the threshold for paid work is one hour per week. Before 1940, employment is mostly defined as reporting any gainful occupation, although attempts to cover unpaid work started in 1910, with the indication that women working regularly on the family farm should be classified as a farm laborers even if they are not paid wages. It is additionally stated that "a wife working for her husband ... should be returned as an employee, even though not receiving wages," without imposing qualifications about farm work. More restrictive definitions of unpaid work were used in 1920 and 1930, regarding people working on the farm "regularly and most of the time".[4] In summary, the key drawback of Census data is that they do not provide a systematic estimate of unpaid family work when this was more widespread.

[3] Very similar qualitative results are obtained from regressions that do not control for country or year fixed-effects.

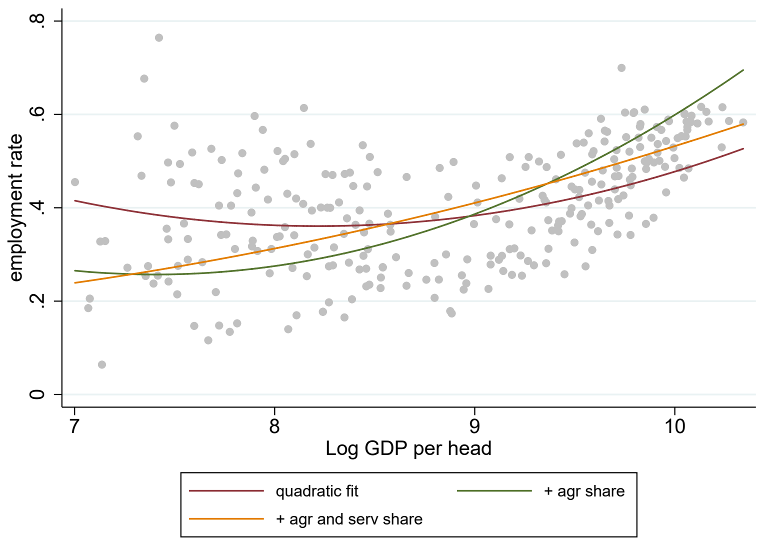
[4] See the Census documentation for information on overall comparability of employment status over time and instructions to enumerators https://usa.ipums.org/usa/voliii/inst1910.shtml, https://usa.ipums.org/usa/voliii/inst1920.shtml and https://usa.ipums.org/usa/voliii/inst1930.shtml for criteria used in specific years.

Figure 2: Female employment, economic development and the industry structure, 1840-2005

Panel A: Female employment and GDP per head



Panel B: Female employment, GDP per head and the industry structure



The pre-1950 employment data are drawn from the International Historical Statistics, Goldin (1990) and Pencavel (1986); and from 1950 onwards they are provided by ILO. Development is proxied by (log) read GDP per head, provided by Maddison Historical Statistics. (see Olivetti, 2014 for a detailed description of data sources).

Figure 3: Employment to population ratio, 1880-2019.

The sample includes individuals aged 18-64. Individual weights are used in the calculation of employment rates. The definition of employment changes from “gainful employment” to “ILO employment” in 1940. Individual weights are used in the calculation of employment rates. Source: US Census and ACS, 1880-2019.

Figure 2 plots male and female employment rates using Census data from 1880 onwards (with the exception of 1890, as the corresponding individual files went lost), based on gainful employment from 1880-1930, and ILO employment from 1940 onwards. To limit the impact of trends in schooling and retirement we restrict to the 18-64 population throughout. The female employment to population ratio (Panel A) rises from about 16% to 72% over our sample period. The blip in female employment in 1910 reflects the adjustment for unpaid work described above. Male employment stays at or above 90% until the mid-20th century and later gradually falls to about 80%. Very high gainful employment for men before 1940 suggests that unpaid family work was of little relevance for male employment rates. The main endeavour in what follows is therefore to systematically account for unpaid female work.

There isn’t a unified data source that allows us to directly estimate the undercount of female employment in the agricultural sector in the Census, but a few pieces of evidence from various sources support the idea that Census employment only captured a small portion of female agricultural work. Smuts (1960) notes that social attitudes towards women’s employment as well as the unstructured/unpaid nature of female work in agriculture were typically reflected in early Census instructions, which suggested enumerators should use caution in counting women as gainfully employed. To give a sense of magnitudes, Smuts (1960) reports that in 1890, when about 4 million white married women lived on farms, the Census only counted about 23 thousand of them in farm occupations. In 1950, when the population living on farms was much smaller, nearly

200 thousand white married women were counted as unpaid family farm workers. The conclusion drawn is that "hundreds of thousands [women] were counted as housewives in 1890, even though they did enough work on family farms to be counted as farm laborers in [more] recent censuses". Another piece of evidence in this direction is provided by the Purnell Act Time-Diary Studies of the 1920s and 1930s (described below), documenting that homemakers living on farms were spending on average 12 hours per week on farm work, and would be therefore classified as employed according to the ILO definition of employment.

Similarly, work by Ruggles (2015) on the role of the family enterprise in US economic history documents that production was largely carried out within family units – mostly family farms – for most of the 19th century and the early 20th century, and wage work that was sufficient to entirely support a household was rare before 1900. Up until 1850, more than half of the US population lived on farms, and more than one third still did so in 1900. Farms relied heavily on family labor, and "all family members who were old enough contributed to farm production." Family business were also common in the non-farm sector, in retail, hospitality, repair, small-scale manufacturing etc., and all family members were expected to be involved.

To account for unpaid employment in family businesses, we adopt the adjustment proposed by Ruggles (2015), which consists in classifying as employed women in the Census without a gainful occupation who live on the farm and whose head of household is a self-employed farmer. Ruggles (2015) also proposes an analogous adjustment for the non-farm population, by classifying as employed women without a gainful occupation, whose head of household is self-employed. We implement both corrections in our estimates, although the latter adjustment is much less relevant quantitatively than the former.[5]

The resulting employment rates are shown in Figure 4, which also shows the industry composition of employment based on the industry directly reported in the Census, or the industry of the head of household for the imputed family workers.[6] Panel A for women

[5] While data for 1940 onwards are meant to identify unpaid family workers, the hours threshold to be classified as such varies over time and is different . We therefore apply the Ruggles (2015) adjustment in all Census years for workers who are not in a gainful occupation. The implied adjustment is quantitatively negligible from 1960 onwards.

[6] We have dropped the 1910 Census from our sample, because the exceptions introduced to the count of unpaid workers make the 1910 data hardly comparable to data for adjacent decades, even after the Ruggles (2015) adjustment, as shown in Appendix Figure 2. Indeed a remaining 1910 blip in the adjusted series implies that the 1910 enumeration instructions added to the labor force women whose head of household was not self-employed (otherwise they would be included in the adjusted employment series). Hence there is no way to identify this category of unpaid women in other decades.

shows a clear U-shape in employment rates, starting at nearly 57% in 1870, reaching a trough in 1960 at 47% and the rising again to 72% in 2019. The bulk of the decline in female employment up until 1960 is associated to the decline of unpaid work on farms, which has virtually disappeared by 1960. The bulk of the rise in female employment since 1960 is instead associated to the rise in services, employing 65% of women in 2019, corresponding to 89% of those in work. These trends qualitatively replicate the cross-country evidence shown in Figure 2. For men (Panel B), the adjusted employment rate replicates very closely the unadjusted employment rate of Figure 2. The slight decline in male employment reflects declining agriculture up until the 1960s, and declining manufacturing afterwards, partly offset by the rise in services.

2.3 Hours

The evidence discussed above only covers the extensive margin of employment, and we need to account for the intensive margin in order to measure the evolution of male and female labor inputs over time.[7] This is especially important as hours per employed person decreased substantially during our sample period, with some variation across sectors and genders. Costa (2000) notes that the length of the working week fell from 60 in the 1890s to 48 in the 1920, following the reduction of the working day from 10 to 8 hours.[8] The transition from the 6-day to 5-day working week during the 1920s and 1930s brought the typical work week down to 40 hours in 1940, and smaller reductions have been achieved since then with the introduction of various forms of leave, whether paid or unpaid. Together with the decline in average hours, their cross-sectional dispersion also substantially decreased, as the largest hours declines were concentrated at the top of the distribution.

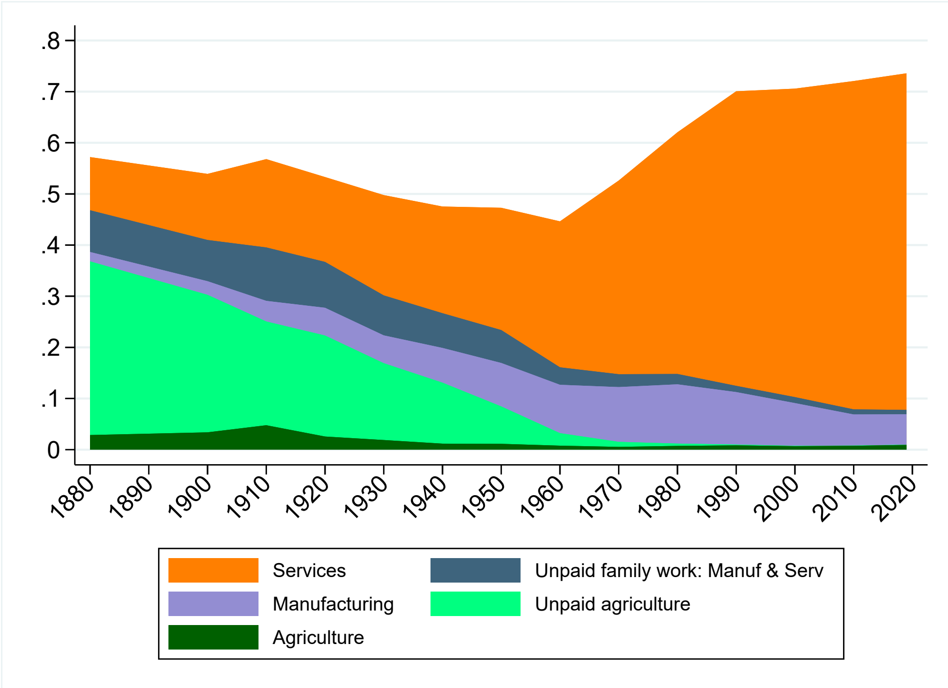
Starting in 1940, information on working hours is provided by the Census. There is no unified source of information on hours for the earlier period, and we therefore draw from a variety of data sources. We use data collected in the Historical Statistics of the United States (HSUS), covering the period 1860-1930. The main underlying sources are the Census of Manufacturers, the Weeks Report, the Aldrich Report, and the series produced by

[7] The distinction between extensive and intensive margin is especially important for women at earlier stages of development, see evidence documented in Dinkelman and Ngai (2022) for several African countries, where high female employment rates coexist with relatively low hours.

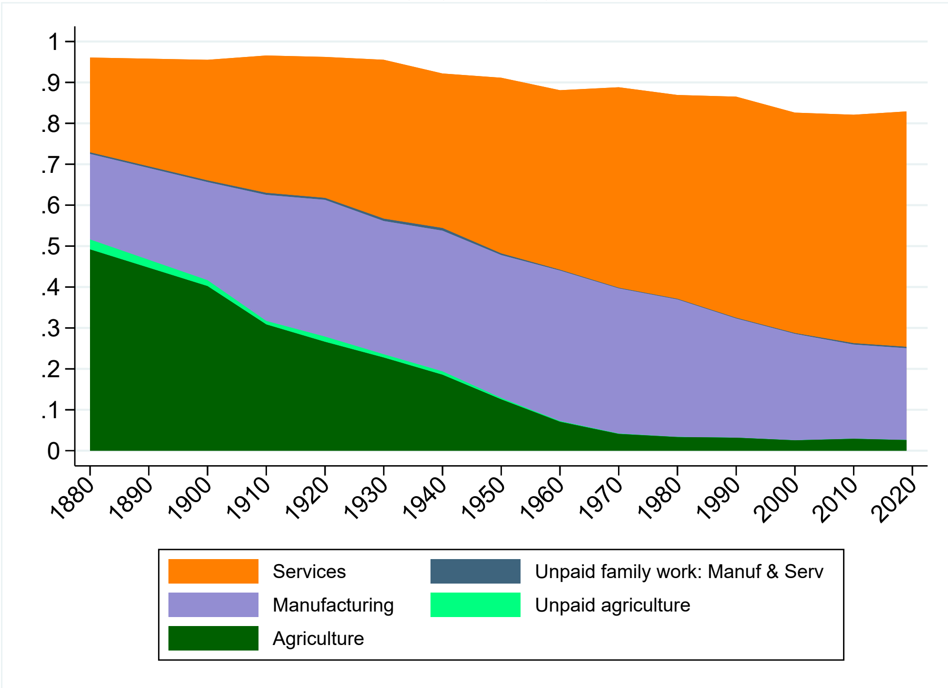
[8] See Goldin (1988) for a discussion of the consequences of maximum working hours legislation pre-1920.

Figure 4: Adjusted employment shares by industry, 1880-2019.

Panel A: Women



Panel B: Men



The sample includes individuals aged 18-64. Employment figures are adjusted to take into account unpaid family work, according to Ruggles (2015). Individual weights are used in the calculation of employment rates. Source: US Census and ACS, 1880-2019.

Ethel Jones, Albert Rees and John Owen, described in detail by Whaples (1990, chapter 2).[9] The most reliable estimates of working hours regard the manufacturing sector, where employers had typically introduced precisely specified hours schedules (Whaples, 2001). Coverage of the service sector is more limited, and there is virtually no information on agricultural workers. Data from HSUS are only made available as industry averages and are disaggregated by gender from 1914. We complement the HSUS data with collections of state-level studies. The Historical Labor Statistics Project (HLSP) at the University of California collects data from more than 150 reports published between 1874 and WWI by 20 State Bureaus that gathered labor statistics. These studies have been pooled and digitized in recent decades[10] The complete dataset covers about 100 thousand workers in 14 states. Leaving out studies that do not report occupation or industry, our sample includes 52.5 thousand men 25.5 thousand women across 12 states[11] working for pay in manufacturing, services and agriculture, surveyed between 1884 and 1901. For the 1920s and 1930s, we draw from the collection "Women Working, 1800-1930" project of the Harvard University Library's Open Collections Program, which covers more than 4,000 studies. This collection is helpful to bridge to coverage gap between earlier sources and the Census, but it contains very little information on male hours.

To estimate hours in manufacturing, we use HSUS data for 1880 and 1914-1930. As no gender disaggregation is provided for 1880, we assume identical hours for men and women, in line with evidence that hours in textiles, in which women are over-represented, were extremely close to hours in manufacturing as a whole. Hours by gender for 1890 and 1900 are estimated based on the studies in the HLSP, showing very similar weekly hours for men and women, and consistent with the aggregate hours figure from the HSUS for 1890-1900. A two-hour gap in male and female hours emerges in the HSUS in 1914 and it gradually widens in the next two decades. The series we build from these sources shows a substantial fall in weekly hours per worker in manufacturing, from 61.8 in 1880 to 44.5 and 40.5 in 1930 for men and women, respectively.

For the service sector, according to the HLSP, male hours were around 64 per week during 1890-1901, and female hours fell from 61 to 57, having imposed the same 18-65 age

[9] See the Millennial Edition at https://hsus.cambridge.org/HSUSWeb/HSUSEntryServlet.

[10] The data and documentation are available at https://eh.net/database/historical-labor-statistics-project-series/. See Carter et al. (1991) for a detailed description of the project.

[11] California, Connecticut, Indiana, Iowa, Kansas, Maine, Michigan, Montana, New Hampshire, Ohio, Rhode Island, Wisconsin.

restrictions as on the Census data. For the 1920s (1920-1928), six studies in the"Women Working, 1800-1930" project cover women's hours in trade and laundries, giving an average of 48 per week. For the 1930s (1934-1936), three similar studies (covering trade, hospitality and laundries) give an average hours of 43 per week. Limited information on men is reported for comparison purposes. For example, male hours in the hospitality sector in 1934 average 49 per week. For women, we use all data available from the 1890s to the 1930s, while for men we linearly interpolate between the 1890s and 1940, when Census data become available. The interpolated data are closely in line with data reported by Kendrick (1961, Table A-IX) for the trade sector.[12]

For agriculture, information on working hours is especially scant, as the activity was not lending itself to systematic reporting. Much of the workforce was self employed and, even among laborers, work schedules were mostly determined by daylight, weather and seasonal conditions. Within the HLSP, only two studies (both for Kansas) report information on working hours, for a total of 20 observations on men and women combined in the mid-1880s, and an average of 68.5 hours per week. This is within the 60-84 hour range given by the 1870 Massachusetts Report of the Bureau of the Statistics of Labor for the typical work week in agriculture. As no other similar sources of working hours in agriculture are available for the late 19th century, we keep working hours in agriculture constant at 68.5 for 1880-1910, as suggested by discussions in Kendrick (1961, p. 354) and Barger (1955) about lack of any definite trend in hours in agriculture pre-1920. We then interpolate a linear trend in agricultural hours between 1910 and 1940.

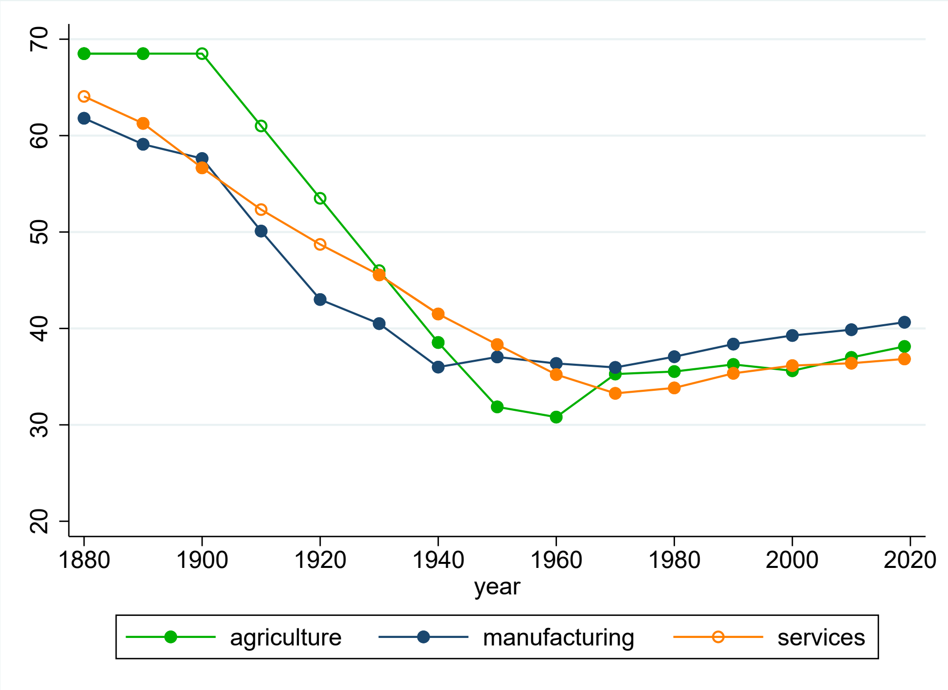
For 1940 onwards, hours are obtained from the Census and American Community Survey for men and women aged 18-64. The combined series for hours per (paid) worker are plotted in Figure 5. For both men and women hours decline in all three sectors until mid-20th century and remain stable thereafter, with moderate differences across sectors and genders.

For unpaid hours, a valuable source is provided by the Purnell Act Time-Diary Studies commissioned in 1925 by the Department of Agriculture to study the time use of

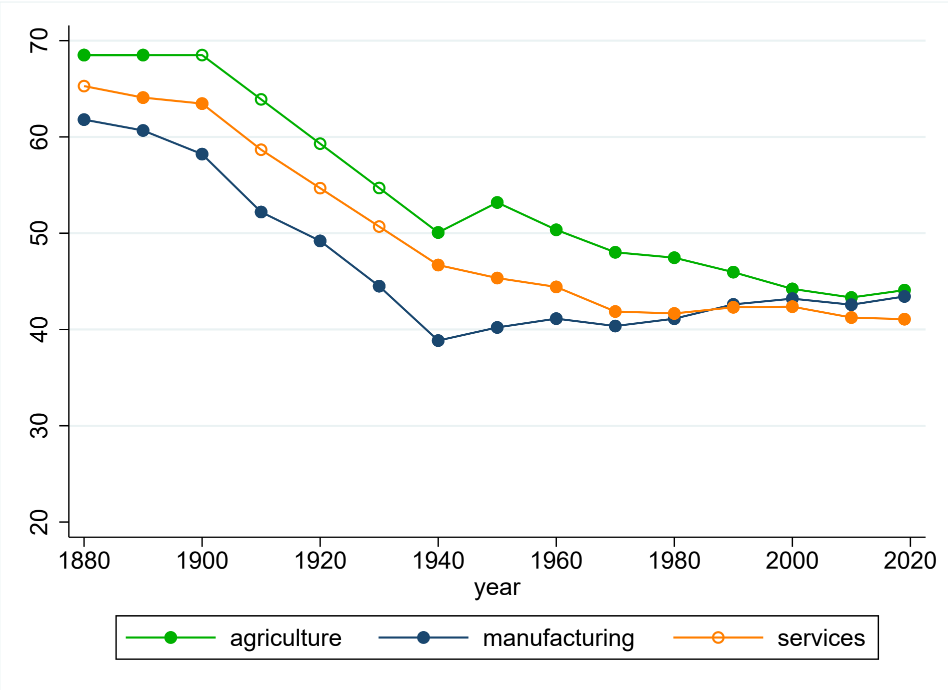
[12]While hours data outside the manufacturing sector are virtually non-existent before the 1890s, a report on the condition of women and child wage-earners during the 19th century (US Bureau of Labor, 1910) gives evidence of substantially longer work weeks than in the early 20th century in both manufacturing and services. Within the service sector, the study reports daily hours from 12-15 among domestic servants in 1869 and from 12-14 among laundresses (US Bureau of Labor 1910, vol 9, p. 183-184). This suggests a clear downward trend in hours in services in the decades leading to the 1890s, and we impose the same downward trend as measured on the data for manufacturing.

Figure 5: Paid hours per employee, 1880-2019.

Panel A: Women



Panel B: Men



The series plotted represent average weekly hours per (paid) employee, conditional on positive hours. Sources: HSUS, HLSP and Women Working (1880-1930); US Census of Population and ACS (1940-2019). Whenever individual data are available, the sample is restricted to 18-64 year old and individual weights are used to calculate averages. Solid circles represent raw data; hollow circles represent estimates/interpolation.

women on farms across a number of State Experiment Stations. The surveys were mostly conducted in the mid-late 1920s, with a handful spanning over the next three decades, and a combined sample of nearly 4,000 housewives (see Vanek 1973 and Ramey 2009 for a detailed description of the studies). Evidence summarized by Vanek (1973, Table 3.2) implies that, during the 1920s amd 1930s, farm homemakers were spending on average 11.7 hours per week on farm work during spring.[13].

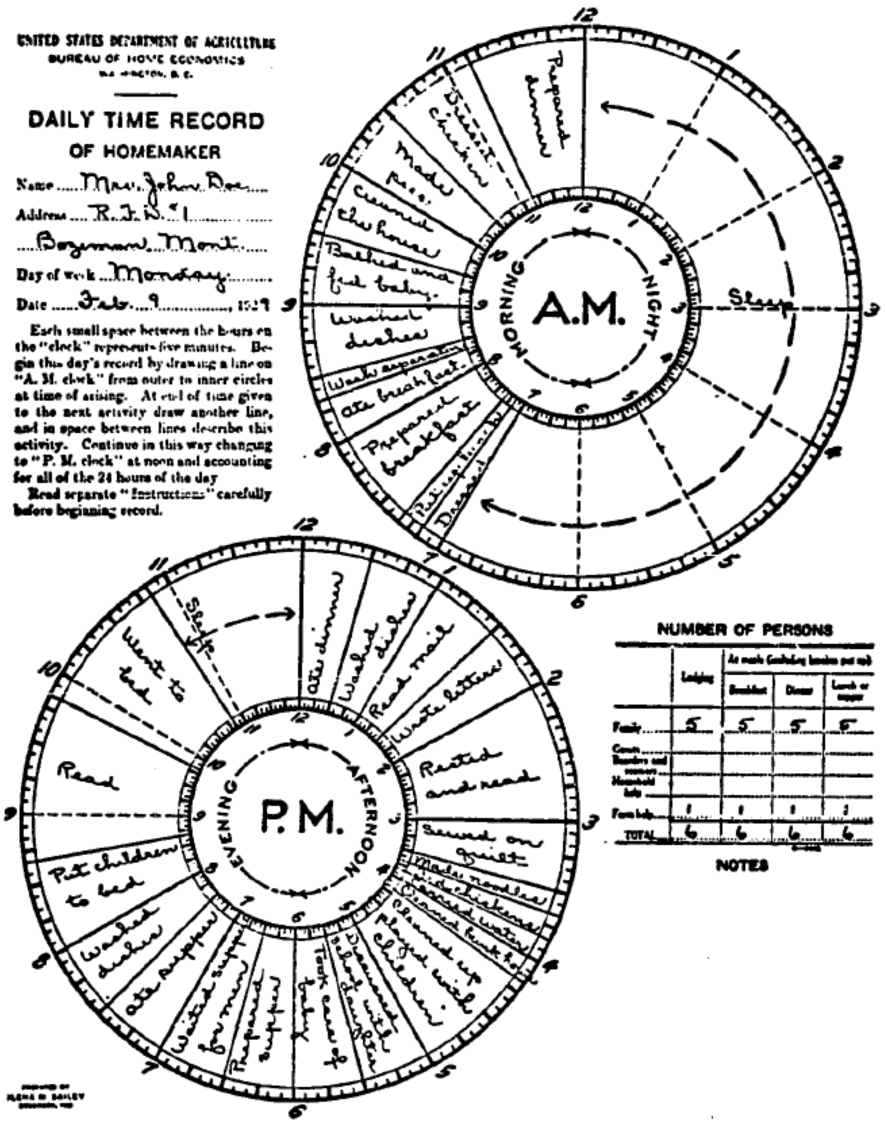
There are two reasons to believe that this represents an underestimate of the average homemaker's involvement in unpaid work in agriculture. First, adequate levels of literacy and numeracy were required to keep detailed records of activities (Figure 6 shows an example of the typical diary), implying that the survey would oversample highly-educated women. Indeed, the Whittemore and Neil (1929) study from Rhode Island reports that "only 11 of the 96 reporting on their education failed to complete eight grades ... and 31 went to college". One would thus expect that, due to income effects, families of relatively high socio-economic status would be more likely to hire outside labor to work on the farm, reducing the time involvement of housewives. Second, whenever hired labor was present on the family farm, time spent on food preparation would typically include meals for the employees, thus contributing to farm production. While the diaries would not distinguish between time to prepare meals for family members and farm employees, the US Bureau of Human Nutrition reports an average 2.3 hour difference in the time devoted to food activities by farm and non-farm rural households, against a virtually identical time use across all other components of domestic work. It is therefore likely that those 2.3 extra hours would be devoted to meal preparation for laborers.

Given these points, we consider the 11.7 estimate for weekly hours on family farms as a lower bound for the actual amount of unpaid hours worked by the average homemaker in agriculture. This applies to both men and women, but – as shown in Figure 4 – this is largely irrelevant for men, as only a tiny proportion of them works as an unpaid family member. As an upper bound, we use information on unpaid hours in agriculture is provided by the Census from 1940 onwards, as unpaid family members are considered employed for Census purposes if they work at least 15 hours per week. Based on this

[13]The sample size used to obtain this estimate is 2523, including all housewives on farms, surveyed between 1924-1936. The diaries document slight seasonal variation in hours spent by housewives on farm activities. Hours worked in spring are most closely comparable to information on hours provided in the Census, whose reference day is April 1st since 1930. Average working hours across all seasons are 9.5, in line with the estimate of 1 hour 22 minutes per day by Pidgeon (1937, p. 354).

"restrictive" definition, average unpaid hours in agriculture in 1940-50 are 48.2 for men and 32.7 for women, only slightly lower than the corresponding paid hours (51.5 and 35.3, respectively).

Figure 6: A typical record of the use of time during one day of a rural homemaker.



Each circle represents 12 hours, for AM and PM activities, respectively. The circumference is split into 144 five-minutes intervals. Respondents were required to draw radial lines to indicate the time spent on each activity. Source: Vanek (1973, Figure 2.1).

To obtain a series for the overall labour inputs in the three sectors, we combine the paid hours series from Figure 5, the unpaid hours estimate described above, and the employment shares plotted in Figure 4. In particular, for unpaid hours in agriculture, we let estimates range between a lower bound of about 12 hours per week and an upper bound of 40 hours per week. For manufacturing and services, we use the (lower-bound) estimate of 12 hours per week. While Census data for 1940-1950 provide an (upper-bound) estimate for unpaid hours in manufacturing and services that is very close to that obtained for agriculture, we have no information available for the earlier decades and therefore we pick a conservative estimate of 12 hours per week.

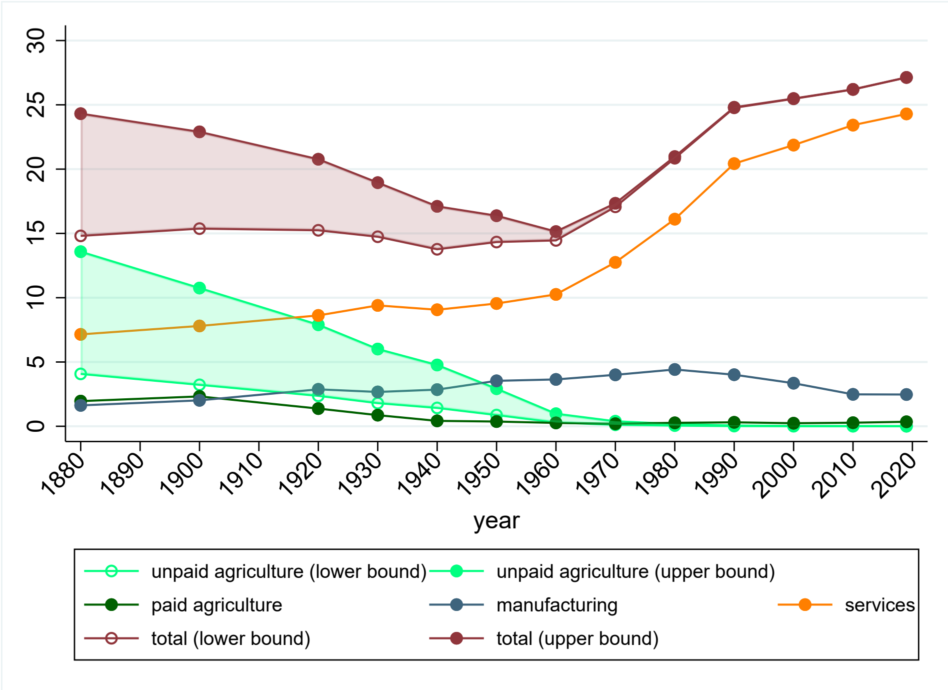
The resulting series are shown in Figure 7, where the shaded areas represent variation between upper and lower bounds in agriculture and in total work, respectively. As the unpaid work margin is nearly irrelevant for men, the corresponding upper and lower bounds are both close to zero. Based on the lower-bound estimates for unpaid work, total work for women is roughly flat around 15 hours per week until about 1960 and then increases gradually to about 27 hours in 2019. Based on the upper-bound, hours describe a roughly symmetric U-shape, with the turning point around 1960. The pre-1960 decline reflects the decline in unpaid agriculture and the post-1960 increase reflects the rise in services. Unsurprisingly, this trend mimics the extensive margin of employment shown in Figure 4. For intermediate values of unpaid hours, female work follows an asymmetric U-shape, with a mild decline pre-1960 and a sustained increase thereafter. For men, hours decline substantially until 1940, reflecting the decline in agriculture. The post-1940 decline is male hours is instead mild, as the decline in male hours in manufacturing is partly offset by an increase in services.

2.4 Wages

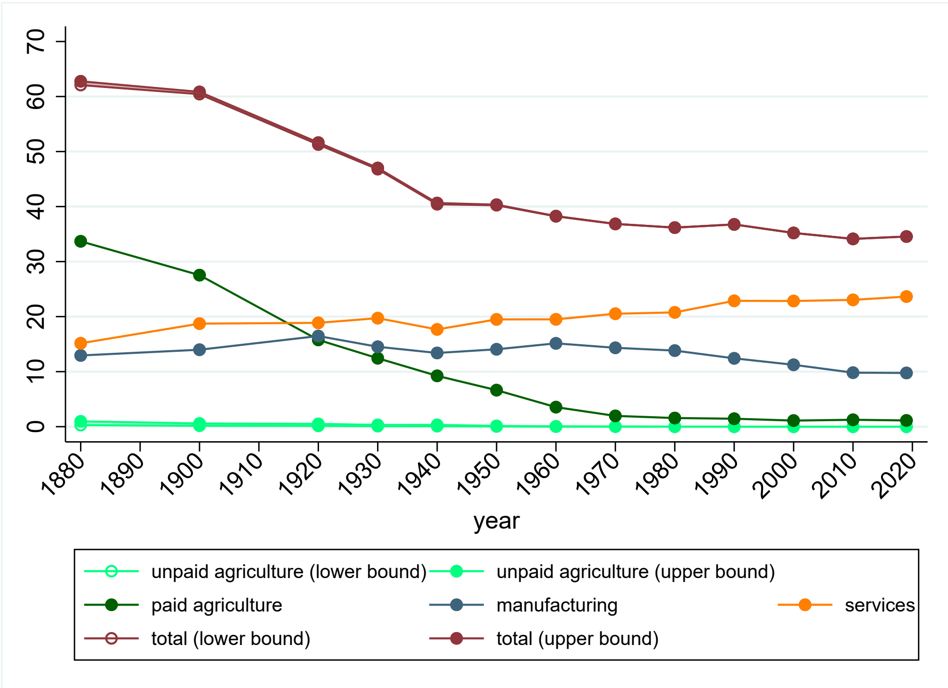
We build a series for the gender wage ratio using a combination of HLSP and Census data. Micro data from the HLSP include information on weekly wages for all three sectors and allow us to estimate gender wage ratios for 1884-1901, controlling for a small set of characteristics. Results from wage regression on these data are reported in Table 1. The specification in column 1 includes all observations with non-missing data on weekly wages, and only controls for gender and study fixed effects, which capture systematic differences in study-level contexts, including the years and states in which surveys were carried out. The resulting gender gap is very high, around 88 log points. Column 2 further controls for age and occupation, and shows that a large portion of this gap is explained by these characteristics, reflecting women's negative selection into paid employment (see also Goldin 2006 on large income effects in female participation in the late nineteenth century, leading to negative selection). Columns 3 and 4 restrict the sample to the manufacturing and service sectors, revealing that gender gaps are, other things equal, much larger in

Figure 7: Hours per person, 1870-2019.

Panel A: Women



Panel B: Men



The series are obtained by multiplying the hours per employed person of Figure 5 by the respective employment rates of Figure 4, assuming that unpaid weekly hours in a sector are half of the corresponding paid hours, and allocating unpaid work outside agriculture to manufacturing and services in equal shares.

agriculture, consistent with stronger negative selection of women in paid agriculture than in other sectors. Columns 6 and 7 further control for the interaction between occupations and gender, but we do not seem to have enough power to detect gender differences in returns to occupations, as the associated coefficients are very imprecise. Using the results from columns 4, which control for characteristics and seem less affected by selection on unobservables as they exclude agriculture, the estimated gender gap is 50 log points, corresponding to a gender wage ratio of 0.6.

Census data are used to run equivalent regressions for 1940 onwards. As education is available in the Census (but not in the historical data), the Census-based regressions control for four education categories, age and its square. For comparability with the earlier data, weekly wages are used, and the sample is restricted to individuals working at least 35 hours per week and 40 weeks per year. The resulting gender ratio for the whole sample period is represented by the red series in Figure 8, showing a roughly untrended wage ratio until 1970, followed by a clear upward trend. Both the level of the wage-ratio and the 1950 blip are consistent with estimates reported by O'Neill (1985, Table 1) for 1939-1982, obtained on data from the Current Population Reports of the U.S. Department of Commerce.

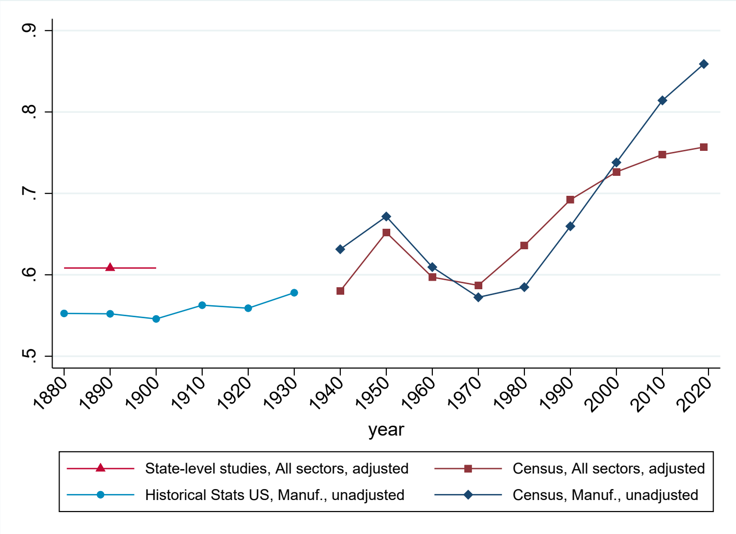
A longer time series for the wage ratio for the earlier period can be obtained from the HSUS, with the caveats that this is based on aggregate data (thus wages may not be adjusted for characteristics) and only covers manufacturing employees. This series can be complemented for the post-1940 period using Census data. The resulting series for manufacturing is represented by the blue plot in Figure 8. The manufacturing (unadjusted) series lies below the adjusted series for the whole economy in the earlier period, when women in paid employment have on average worse observable characteristics than men. However the post-1980 wage convergence was faster in the manufacturing sector. Having said this, the two series follow very similar trends. In the calibration exercise of Section 4.1, we smooth short-run fluctuations in the series for the wage ratio by fitting a spline function with a knot at 1960. The fitted values will be used as data moments in the calibration.

Table 1: Wage regressions, 1884-1901.

	(1)	(2)	(3)	(4)	(5)	(6)
Sectors:	All	All	Man+Serv	Man+Serv	Man+Serv	All
Female	-0.884	-0.511	-0.606	-0.497	-0.676	-0.659
	(0.0552)	(0.0309)	(0.0329)	(0.0283)	(0.140)	(0.124)
Skilled manual		0.201		0.223	0.205	0.202
		(0.0246)		(0.0269)	(0.0201)	(0.0204)
Clerical		0.245		0.272	0.300	0.292
		(0.0441)		(0.0472)	(0.0375)	(0.0322)
Professional		0.619		0.633	0.551	0.552
		(0.0618)		(0.0617)	(0.0247)	(0.0237)
F × skilled manual					0.176	0.126
					(0.197)	(0.178)
F × clerical					0.0754	0.0954
					(0.216)	(0.212)
F × professional					0.343	0.379
					(0.200)	(0.204)
Other controls	study FE	study FE	study FE	study FE	study FE	study FE
		age, age^2	age, age^2	age, age^2	age, age^2	age, age^2
Observations	55611	52004	45776	44751	44751	52004
Adj. R^2	0.562	0.605	0.441	0.522	0.525	0.608

Notes. The sample includes individuals aged 18-64 with non missing information on weekly wages. Dependent variable: log weekly wage. Source: HLSP, 1884-1901.

Figure 8: Female to male wage ratio



Notes. Sources: Historical Labor Statistics Project, 1884-1901; Historical Statistics of the United States, 1880-1930; US Census and ACS, 1940-2019.

2.5 Home production and leisure

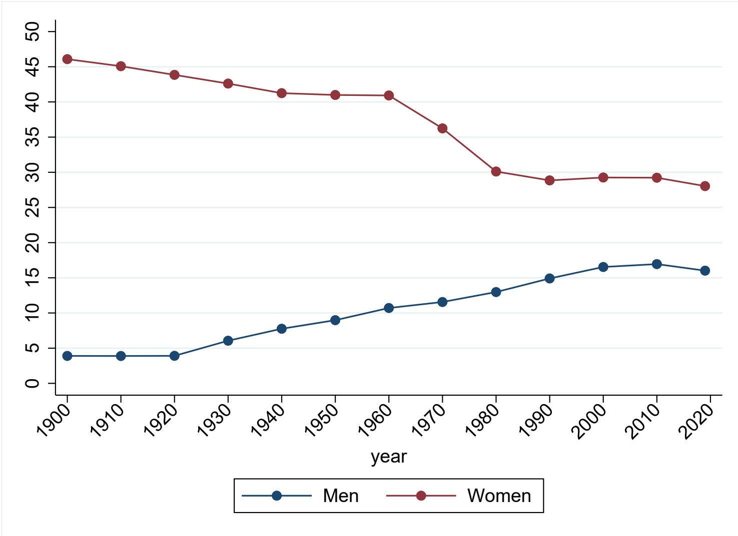
To obtain hours on home production, we combine the 1900-2012 series produced by Ramey and Francis (2009, updated) for men and women aged 18-64 with 2019 data from the American Time Use Survey (using the same selection criteria and definitions as Ramey and Francis 2009). The resulting series are plotted in Figure 9. Leisure hours are obtained as the difference between 100 – an estimate of the weekly hour endowment, net of sleep and personal care time – and total work in the home and the market.

3 The Model Economy

The economy is populated by a measure one of households, each consisting of one male and one female spouse, consuming output from three sectors – agriculture, manufacturing and services – and allocating their time to leisure, market work and home-production.

Each sector is populated by identical firms, hiring male and female labor. All markets are perfectly competitive and, given labor mobility, wages are equalized across sectors for both genders.

Figure 9: Home production hours



Notes. Sources: Ramey and Francis (2009) for 1900-2010 and ATUS, 2019.

3.1 Firms

The representative firm in each sector $j = a, m, s$ produces output using the following technology:

$$Y_j = A_j N_j, \quad N_j = \left[\xi_j l_{fj}^{\frac{\eta-1}{\eta}} + (1-\xi_j)\, l_{mj}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}; \quad j = a, m, s, \tag{1}$$

where A_j is a sector-specific productivity index and N_j is a CES aggregator of male labor l_{mj} and female labor l_{fj}, with an elasticity of substitution η and a sector-specific female weight ξ_j, representing gender comparative advantages. We do not distinguish between paid and unpaid work at this stage: family farms are part of the agricultural sector a and family workers who are not paid a formal wage are nevertheless remunerated via sale of agricultural output.[14]

We impose the following assumptions regarding the gender-specific parameters ξ_j and sector-specific productivity growth:

$$A1 \;:\; \{\xi_s, \xi_h\} > \{\xi_a, \xi_m\}$$
$$A2 \;:\; \{\gamma_a, \gamma_m\} > \gamma_s \geq \gamma_h$$

Assumption A1 states that services, whether in the market and the home, use female labor more intensively than both agriculture and manufacturing. Assumption A2 states that

[14] We explicitly model family farms in Section B.5.

productivity growth in agriculture and manufacturing is faster than in market services, and productivity growth in market services is in turn faster than in home production. These two assumptions are consistent with evidence presented in Section 4.

Taking output price p_j as given, profit maximization in each sector implies

$$p_j \frac{\partial Y_j}{\partial l_{gj}} = w_g, \tag{2}$$

where w_g denotes wages for each gender $g = m, f$. Thus the gender wage ratio is equal to the marginal rate of technical substitution:

$$w \equiv \frac{w_f}{w_g} = \frac{\xi_j}{1-\xi_j}\left(\frac{l_{mj}}{l_{fj}}\right)^{\frac{1}{\eta}}; \qquad j = a, m, s. \tag{3}$$

The higher female comparative advantage ξ_j, the more intensive sector j in female employment.

3.2 Households

The representative household enjoys utility from consumption of agricultural output, manufacturing goods and services, as well as leisure. Services can be purchased in the market or produced at home. Consumption of each type of good is denoted by c_i, $i = a, m, z$, where c_z denotes the composite bundle of market and home services. Utility is given by

$$\begin{aligned} U(c_a, c_m, c_z, c_l) &= \ln c + \phi \ln c_l; \\ c &= \left[\omega_a (c_a - \bar{c})^{\frac{\varepsilon-1}{\varepsilon}} + \omega_m c_m^{\frac{\varepsilon-1}{\varepsilon}} + \omega_z c_z^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}} \end{aligned} \tag{4}$$

with $\sum_i \omega_i = 1$ and $\varepsilon < 1$, implying poor substitutability across output of different sectors. The $\bar{c} > 0$ term captures subsistence consumption of agricultural output. Consumption of services c_z is modelled as a CES aggregator of market services c_s and home services c_h:

$$c_z = \left[\psi c_s^{\frac{\sigma-1}{\sigma}} + (1-\psi)\, c_h^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \tag{5}$$

where we impose $\sigma > 1$ to indicate that market and home services are good substitutes. Home services are produced with a similar technology as market services:

$$c_h = Y_h = A_h N_h, \quad N_h = \left[\xi_h l_{fh}^{\frac{\eta-1}{\eta}} + (1-\xi_h)\, l_{mh}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}. \tag{6}$$

Household leisure L_l is a function of male and female leisure time:

$$c_l = N_l, \quad N_l = \left[\xi_l l_{fl}^{\frac{\eta_l - 1}{\eta_l}} + (1 - \xi_l) \, l_{ml}^{\frac{\eta_l - 1}{\eta_l}} \right]^{\frac{\eta_l}{\eta_l - 1}} \tag{7}$$

where $\eta_l < 1$ indicates that male and female leisure time are complement in utility.

The household chooses the demand for each good and the time allocation of each member to leisure, home production and labor supply to the market. Taking prices and wages as given, the household maximize the utility function in (4) subject to the constraints (4)-(7) and the budget constraint:

$$\sum_{i=a,m,s} p_i c_i \leq w_m \left(L_m - l_{mh} - l_{ml} \right) + w_f \left(L_f - l_{fh} - l_{fl} \right). \tag{8}$$

Optimization implies that the value of the marginal product of labor is equal to the wage as in (2) so we define the implicit price of home production and leisure goods as:

$$p_j \equiv \frac{w_g}{\partial c_j / \partial l_{gj}}; \quad j = h, l \tag{9}$$

and condition (3) extends to home production and leisure.

3.3 Market clearing

Labor market clearing for each gender implies

$$\sum_{j=a,m,s} l_{gj} = L_g - l_{gh}; \qquad g = m, f,$$

where L_g is total time endowment by gender.

Goods market clearing in each market sector implies

$$c_j = Y_j; \qquad j = a, m, s. \tag{10}$$

3.4 Equilibrium

Optimization by households and firms implies that the (3) condition holds for $j = a, m, s, h, l$. To describe equilibrium, it is convenient to define $I_j(w)$ as women's' income share in sector j:

$$I_j(w) \equiv \frac{w_f l_{fj}}{w_f l_{fj} + w_m l_{mj}} \qquad \forall j \tag{11}$$

$$= \left[1 + \left(\frac{1 - \xi_j}{\xi_j} \right)^{\eta_j} w^{\eta - 1} \right]^{-1}, \tag{12}$$

where (12) follows from using (3) and $\eta_j = \eta$ for $j \neq l$.

Similarly, define $I(w)$ as women's' income share in the economy:

$$I(w) \equiv \frac{w_f L_f}{w_m L_m + w_f L_f} = \frac{w}{L_m / L_f + w}. \tag{13}$$

Let's define next relative expenditure across any two sectors as:

$$E_{kj} \equiv \frac{p_k Y_k}{p_j Y_j}, \quad \forall j, k \tag{14}$$

where the relative price is derived in the Appendix B.1 using the free mobility of labor as

$$\frac{p_j}{p_k} = \frac{A_k \xi_k^{\frac{\eta_k}{\eta_k - 1}} \left[I_k(w) \right]^{\frac{1}{1-\eta_k}}}{A_j \xi_j^{\frac{\eta_j}{\eta_j - 1}} \left[I_j(w) \right]^{\frac{1}{1-\eta_j}}}. \qquad \forall j, k \tag{15}$$

By the definition of income shares, the relative female time allocation can be expressed as a function of relative expenditure:

$$\frac{l_{fk}}{l_{fj}} = \frac{I_k(w)}{I_j(w)} E_{kj}. \quad \forall j, k \tag{16}$$

The relative male time allocation follows from substituting (16) into (3):

$$\frac{l_{mk}}{l_{mj}} = \left(\frac{\xi_j (1 - \xi_k)}{(1 - \xi_j) \xi_k} \right)^{\eta} \frac{I_k(w)}{I_j(w)} E_{kj}. \quad \forall j, k \tag{17}$$

For a given equilibrium wage ratio w, equations (16) and (17) imply that forces that increase expenditure in sector k relative to sector j also increase the relative female and male time allocation to sector k relative to sector j. Relative expenditures are driven by the processes of marketization and structural transformation, which are described below.

3.5 Marketization and Structural transformation

To describe marketization of services, consider the household's optimal choice of home and market services, implying that the marginal rate of substitution should be equal to relative prices. Given relative prices derived in Appendix B.1, Appendix B.2 shows that the relative expenditures across market and home services evolve as follows:

$$E_{sh} \equiv \frac{p_s Y_s}{p_h Y_h} = \left(\frac{A_s}{A_h} \right)^{\sigma - 1} \left[\left(\frac{\xi_h}{\xi_s} \right)^{\eta} \frac{\mathrm{I}_h(w)}{\mathrm{I}_s(w)} \right]^{\frac{\sigma-1}{\eta-1}} \left(\frac{1 - \psi}{\psi} \right)^{\sigma}. \tag{18}$$

As market and home services are good substitutes ($\sigma > 1$), faster productivity growth in the market sector gradually reallocates expenditure from home to market services, as implied by the rise in the first term in (18).

Based on similar steps as for marketization, Appendix B.2 derives the relative expenditures across agriculture, manufacturing and services, describing structural transformation The expenditure in manufacturing goods relative to services is given by:

$$E_{ms} \equiv \frac{p_m c_m}{p_s c_s} = \left(\frac{p_m}{p_s}\right)^{1-\varepsilon} \left(\frac{\omega_m}{\omega_z}\right)^{\varepsilon} \psi^{\frac{\sigma(1-\varepsilon)}{\sigma-1}} \left(\frac{1}{E_{sh}}+1\right)^{\frac{\sigma-\varepsilon}{\sigma-1}}. \tag{19}$$

Substituting for relative prices using (15) gives:

$$E_{ms} = \frac{A_m}{A_s}^{\varepsilon-1} \left(\frac{\omega_m}{\omega_z}\right)^{\varepsilon} \psi^{\frac{\sigma}{1-\sigma}} \left[\left(\frac{\xi_m}{\xi_s}\right)^{\eta} \frac{I_s(w)}{I_m(w)}\right]^{\frac{\varepsilon-1}{\eta-1}} \left(\frac{1}{E_{sh}}+1\right)^{\frac{\sigma-\varepsilon}{\sigma-1}} \tag{20}$$

Expression (20) implies that expenditure in manufacturing goods relative to market services falls via two channels. First, marketization implies a rise in E_{sh}. Second, as manufacturing and services are poor substitutes ($\varepsilon < 1$), faster productivity growth in manufacturing reallocates expenditure from manufacturing into services.

The expenditure in manufacturing goods relative to agriculture is given by:

$$\begin{aligned} E_{ma} &= \left(1-\frac{\bar{c}}{y_a}\right)\left(\frac{p_m}{p_a}\right)\frac{c_m}{c_a-\bar{c}} \\ &= \left(1-\frac{\bar{c}}{y_a}\right)\left(\frac{p_m}{p_a}\right)^{\varepsilon-1}\left(\frac{\omega_m}{\omega_a}\right)^{\varepsilon} \end{aligned} \tag{21}$$

Substituting for relative prices using (15) gives:

$$E_{ma} = \frac{A_m}{A_a}^{\varepsilon-1} \left(\frac{\omega_m}{\omega_a}\right)^{\varepsilon} \left[\left(\frac{\xi_m}{\xi_a}\right)^{\eta} \frac{I_a(w)}{I_m(w)}\right]^{\frac{\varepsilon-1}{\eta-1}}. \tag{22}$$

There are two forces in (22) that contribute to the rise in manufacturing expediture relative to agriculture. First there is an *income effect* working through $\bar{c}/y_a$, which is falling over time while agricultural output rises relative to subsistence consumption, thanks to technological improvements in agriculture. Second, there is a *relative price effect* working via $\frac{A_m}{A_a}^{\varepsilon-1}$: similarly as for the expenditure reallocation between manufacturing and services, as manufacturing and agricultural goods are poor substitutes, faster productivity growth in agriculture implies a reallocation of expenditure towards manufacturing.

The time allocation of men and women to each sector can be obtained by combining expenditure ratios (18), (20) and (22) with the labor allocation conditions (16) and (17). Specifically, marketization reallocates labor from home to market services. Given (17), this process will be stronger for women than for men the higher ξ_h relative to ξ_s, i.e. the higher female presence in home rather than market services. Structural transformation reallocates labor from agriculture to manufacturing and services, and from manufacturing into services. Given comparative advantages, (17) implies that transition into manufacturing is especially relevant for men, while transition into services is especially relevant for women.

Using (20) and (21), Appendix B.2 also derives the expenditure in agriculture relative to composite services bundle (market and home services):

$$E_{az} = \frac{\left(1+\frac{1}{E_{sh}}\right)^{(1-\varepsilon)}}{1-\frac{\bar{c}}{y_a}} \left(\frac{A_a}{A_s}\right)^{\varepsilon-1} \left(\frac{\omega_a}{\omega_z}\right)^{\varepsilon} \psi^{\frac{\sigma(\varepsilon-1)}{1-\sigma}} \left[\left(\frac{\xi_a}{\xi_s}\right)^{\eta} \left(\frac{I_s(w)}{I_a(w)}\right)\right]^{\frac{\varepsilon-1}{\eta-1}}$$

Both structural transformation component – the rise in relative productivity term A_a/A_s and the income effect $\bar{c}/y_a$ drive expenditure reallocation from agriculture into overall services.

3.6 Leisure and gender wage ratio

To complete the equilibrium time allocation Appendix (B.3) derives the optimal leisure time as:

$$\frac{l_{fl}}{L_f} = \frac{I_l(w)}{I(w)\left(\frac{E_{ml}}{\left(1-\frac{\bar{c}}{y_a}\right)\bar{E}_{ma}} + \sum_{j\neq a} E_{jl}(w)\right)}. \quad (23)$$

where

$$\bar{E}_{ma} \equiv \left(\frac{p_m}{p_a}\right)^{\varepsilon-1} \left(\frac{\omega_m}{\omega_a}\right)^{\varepsilon}$$

and the E_{lm} term is derived as:

$$E_{lm} = \phi\left(\frac{1}{\bar{E}_{ma}} + 1 + \frac{1}{E_{ms}} + \frac{1}{E_{mh}}\right); \quad E_{mh} = E_{ms}E_{sh}. \quad (24)$$

Condition (23) highlights income effects in leisure time. As the food constraint $\bar{c}$ becomes relatively less important with the growth in agricultural output y_a, female leisure increases. As (3) hold for leisure, male leisure rises too. The income effect disappears as $\bar{c}/y_a$ approaches zero, thus the model generates an increase in leisure at early stages of development and relatively constant leisure afterwards.

Appendix (B.4) derives a second expression for the share of leisure time as a function of the gender wage ratio using the female time constraint. Together with the condition (23), the equilibrium reduces to solving an implicit function for the equilibrium gender wage ratio. Given the equilibrium wage ratio, time allocation by gender are derived using (16) and (17).

3.7 Market Hours

We have now defined all components that determine equilibrium market hours for each gender:

$$M_g \equiv l_{ga} + l_{gm} + l_{gs} = L_g - l_{gh} - l_{gl} \tag{25}$$

Given time endowment L_g, changes in market hours reflect changes in home production and leisure, which are in turn driven by the process of marketization and structural transformation.

Specifically, marketization implies an increase in market hours for each gender, via a fall in l_{gh} and a rise in l_{gs}, especially so for women than for men, due to comparative advantages. Structural transformation reduces market hours via two channels. The first works via income effects, raising leisure l_{gl}. The second works via relative price effects, reallocating labor from agriculture and manufacturing into overall services, including home services. To understand the overall evolution of market hours, one needs to understand the relative strength of structural transformation and marketization at various stages of development. Structural transformation is especially strong during early development stages, when the agriculture share is large and its fast productivity growth sheds labor into both leisure and services via income and substitution effects, respectively. Market hours are thus predicted to fal for each gender. But these forces weaken as the economy grows, the agricultural share gets smaller and the service share gets larger. Meanwhile, the manufacturing share first rises with the decline in agriculture and the falls with the rise in services. Given comparative advantages, marketization becomes the dominant force for women and female hours start growing. Marketization is weaker for men, who are nevertheless affected by structural transformation and declining manufacturing. Thus male hours decline.

4 A quantitative illustration of model properties

To illustrate the role of structural transformation and marketization in shaping observed trends in market hours by gender, we calibrate the model using data on gender wage ratio, time allocation and sector-specific productivity growth. Besides uneven productivity growth across sectors, we allow for changes in gender-specific factors. First, we let the ratio of female-to-male population L_f/L_m, proxying gender-specific time endowment, to change as in the data, shown in Figure 10 (right-hand side axis).[15] Second, we allow the gender-specific parameters in the production function $\{\xi_a, \xi_m, \xi_s\}$ to vary exogenously over time, proxying within-sector gender-biased demand shifts (as in Heathcote et al. 2010). Changes in these parameters may capture technological changes that alter gender comparative advantages – for instance the mechanization of agriculture or brawn-saving technology in manufacturing – and/or changes in social norms about female work, possibly shaping relative labor demand in each sector. The quantitative role of uneven productivity growth across sectors can be obtained by shutting down these gender-specific channels.

4.1 Calibration

The model aims to predict male and female time allocation across sectors, as documented in sections 2.2-2.5. We set the elasticity parameters $(\eta_j, \sigma, \varepsilon)$ equal to values proposed and used in the related work and measure productivity growth rates γ_j from available data. As data quality is less reliable for the earlier period, we calibrate the remaining parameters to match data targets in 1950 (our period T): we normalize $A_{aT}L_{fT} = 1$; we set gender-specific parameters $\{\xi_{aT}, \xi_{mT}, \xi_{sT}, \xi_h, \xi_l\}$, preference parameter ϕ and effective productivity terms $\{\hat{A}_{shT}, \hat{A}_{msT}, \hat{A}_{maT}\}$ to match the gender wage wage ratio w_T and the

[15] In the model, L_g denotes time endowment of the representative household member of gender g. Assuming that each individual has the same time endowment to allocate across the market, home and leisure, the relative time endowment L_m/L_f in the economy is given by the ratio of male to female population in the data.

Table 2: Calibrated Parameters

Parameters	Values	Data or targtes
Model free parameters		
γ_m, γ_s	2.5%, 1.4%	BEA for 1947-2020
γ_h	0.95%	Bridgman (2016) and Bridgman et al. (2022)
γ_a post-1950	3.6%	BEA for 1950-2020
γ_a pre-1950	2.3%	Kendrick (1961) for 1880-1950
σ	2.5	Various estimates in Aguiar et al. (2012)
ϵ	0.002	Herrendorf et al. (2013)
η, η_l	2, 0.2	Ngai and Petrongolo (2017)
L_{ft}/L_{mt}	Figure 10	Census data
Calibrated parameters		
$A_{aT}L_{fT}$	1	Normalization
ϕ	0.96	Relative hours in leisure vs manufacturing in 1950
ξ_h, ξ_l	0.56, 0.25	Wage ratio and hours ratio in home and leisure in 1950
$\hat{A}_{maT}$	0.31	Relative hours in manufacturing vs agriculture in 1950
$\hat{A}_{msT}$	6.10	Relative hours in manufacturing vs services in 1950
$\hat{A}_{shT}$	0.93	Relative hours in market services vs home in 1950
$\xi_{aT}, \xi_{mT}, \xi_{sT}$	0.24, 0.23, 0.30	Wage and hour ratio in market sectors in 1950
$\bar{c}$	0.018	Agriculture employment share in 2019

time allocation $\frac{l_{gjT}}{L_{gT}}$ for each gender g and activity j, where[16]

$$\begin{aligned}
\hat{A}_{shT} &\equiv \frac{A_{sT}}{A_{hT}}\left(\frac{\psi}{1-\psi}\right)^{\frac{\sigma}{\sigma-1}} \\
\hat{A}_{msT} &\equiv \frac{A_{mT}}{A_{sT}}\left(\frac{\omega_m}{\omega_z}\right)^{\frac{\varepsilon}{\varepsilon-1}}\psi^{\frac{\sigma}{1-\sigma}} \\
\hat{A}_{maT} &\equiv \frac{A_{mT}}{A_{aT}}\left(\frac{\omega_m}{\omega_a}\right)^{\frac{\varepsilon}{\varepsilon-1}}
\end{aligned} \tag{26}$$

We set the minimum food requirement $\bar{c}$, calibrating the strength of income effects, to match the agricultural employment share in 2019. The baseline parameters are reported in Table 2.

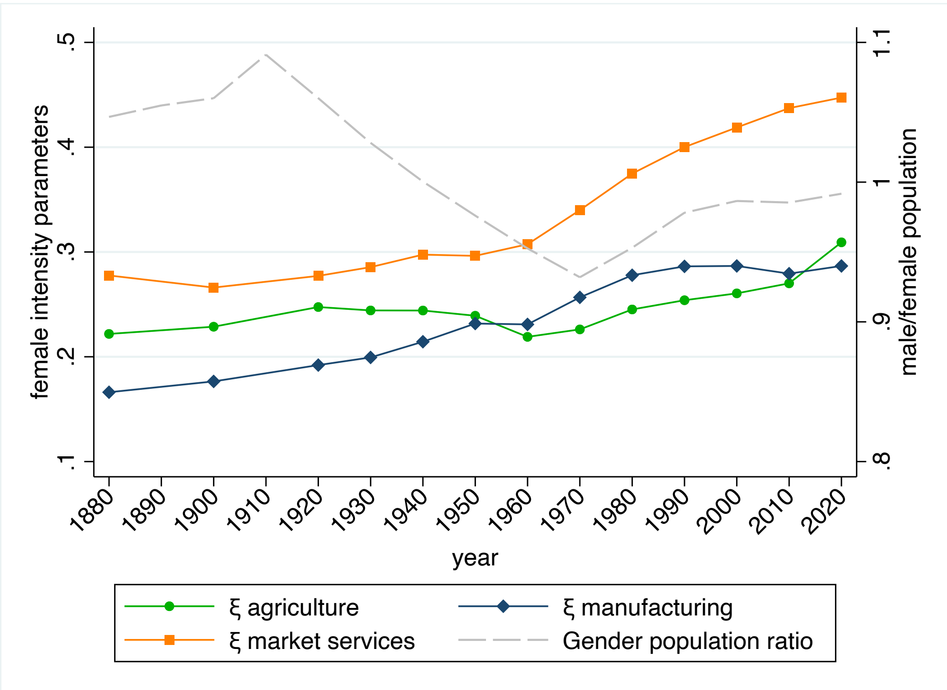
Specifically, $\{\xi_{aT}, \xi_{mT}, \xi_{sT}, \xi_h, \xi_l\}$ are obtained from (3) using w_T and l_{fjT}/l_{mjT} for $j = a, m, s, h, l$ and $T = 1950$. These are used to obtain $I_{jT(w)}$ using (12) and E_{kjT} using (16). Equations (18) and (20) are then used to derive $\hat{A}_{shT}$ and $\hat{A}_{msT}$. For given $\bar{c}$, equation (21) is used to derive $\hat{A}_{maT}$. Equation (24) can then be used to obtain ϕ. This procedure implies that the model matches exactly the time allocation and wage ratio in 1950, and the model explanatory power will be assessed bu looking at trend predictions

[16] As implied by (26), we do not need separately identify relative productivity terms A_{jT}/A_{kT} and preference terms ω_j and ψ in this calibration.

before and after 1950.

Predictions for time allocation in other periods are derived as follow. Given $\bar{c}$, data on L_{mt}/L_{ft} and the calibrated $\{\phi, \xi_h, \xi_l\}$, the predicted time allocation in each period depends on $\{A_{at}L_{ft}, \hat{A}_{sht}, \hat{A}_{mst}, \hat{A}_{mat}\}$ and $\{\xi_{at}, \xi_{mt}, \xi_{st}\}$. Using data on the wage ratio and time allocation l_{fjt}/l_{mjt}, we compute ξ_{jt}, $j = a, m, s$ according to (3). The implied ξ_{jt} for the market sectors $j = a, m, s$ are reported in 10. Consistent with assumption A1 made in Section 3, female comparative advantages are higher in market services, followed by agriculture and manufacturing. Also, given the calibrated $\xi_h = 0.56$, female comparative advantages in any market sector are lower than in the home.

Figure 10: Gender-specific factors, 1880-2019.



Note: The ξ_{jt} series are obtained from equation (3), using data on gender-specific hours and the wage ratio. For the wage ratio, linear spline predictions are used, as shown in Figure 8.

Given targeted values in period T, the values of $\{A_{at}L_{ft}, \hat{A}_{sht}, \hat{A}_{mst}, \hat{A}_{mat}\}$ for any other other period t depend on productivity growth. Growth rates for agriculture, manufacturing and services are obtained from the BEA for the period 1947-2020, and for home production they are based on Bridgman (2016) and Bridgman et al. (2022) for the period 1929-2020. We impose constant productivity growth for our whole sample period for all sectors except agriculture. For pre-1950 agriculture, we use estimates by Kendrick (1961), which deliver an average productivity growth of 2.3%. We combine these with the BEA-based estimate of of 3.6% productivity growth post-1950. The increase in agricultural productivity growth reflects, among other factors, compositional effects linked to the gradual decline of family farms, where productivity growth is typically lower than in larger, modern farms. Appendix B.5 considers an extension with family farms and highlights these compositional effect in the transition from family farms to modern agriculture.

Finally, we calibrate subsistence consumption $\bar{c}$ so as to match the 2019 employment share in agriculture. The implied $\bar{c}/y_a$ ratio declines from 62% in 1880 to 18% in 2019. As we exactly match the time allocation in 1950, this means that $\bar{c}$ is pinned down by the decline in agriculture employment share from 1950 to 2020.

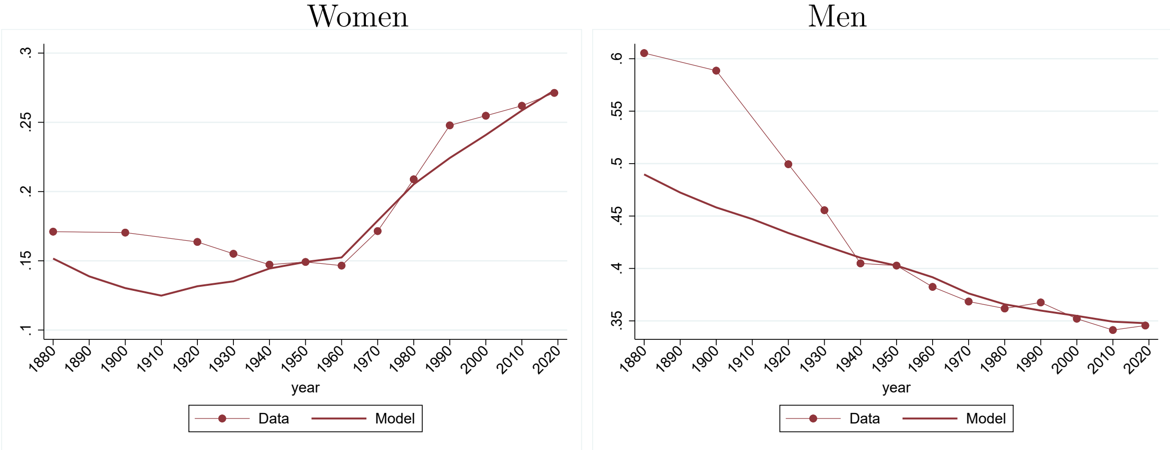
4.2 Model predictions

Model predictions combine the effect of uneven productivity growth and gender-specific factors. These include changes in the ξ_j parameters, proxying changes in relative labour demand by gender within sector, and in the population ratio L_f/L_m, proxying changes in relative labour supply.

The evolution in market hours is shown in Figure 11, where the dotted and solid lines represent actual and predicted values, respectively. For the data series, we assume an intermediate value for unpaid hours in agriculture (20 hours per week), which lies within the range considered in Figure 7. The model qualitatively reproduces the asymmetric U-shape we observe for female hours, but it under-predicts their pre-1950 decline. The model also predicts a decline in male market hours although, quantitatively, it under-predicts their pre-1950 decline.

Figure 12 separately highlights the roles of various factors in observed gender trends. We normalize all series with respect to their 1950 values (as implicitly done in Figure 11, having calibrated parameters to exactly match the full 1950 allocation). For women, structural transformation and marketization are the only forces that can predict the pre-1950 decline in market hours (solid line). In fact, changes in gender-specific demand would predict a monotonic increase in hours throughout the sample period (dashed line), and changes in gender-specific supply are virtually neutral (dotted line). In the later period, the rise in female hours mostly reflects changes in gender-specific demand and, to a lesser extent, structural transformation and marketization. For men, the pre-1940 decline can, to some extent, be explained by structural transformation and marketization, while the

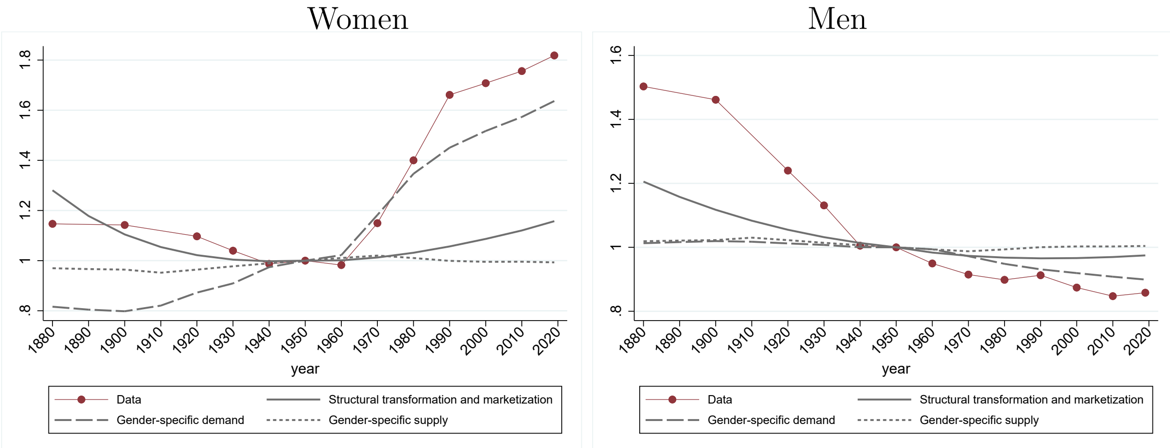
Figure 11: Market hours by gender, 1880-2019.



Notes. Market hours include time worked in agriculture, manufacturing and market services. The data series are build under the assumption that unpaid workers in agriculture work 20 hours per week. Model predictions encompass the role of structural transformation and marketization (varying γ_j across sectors and $\bar{c} > 0$), gender-specific labor demand (varying ξ_{jt} over time), and gender-specific labor supply (varying L_{ft}/L_{mt} over time).

other two forces have no explanatory power. In the later period, the fall in men hours reflect a combination of structural transformation and marketization as well as changes in gender-specific demand.

Figure 12: Market hours by gender: A decomposition of various forces, 1880-2019.

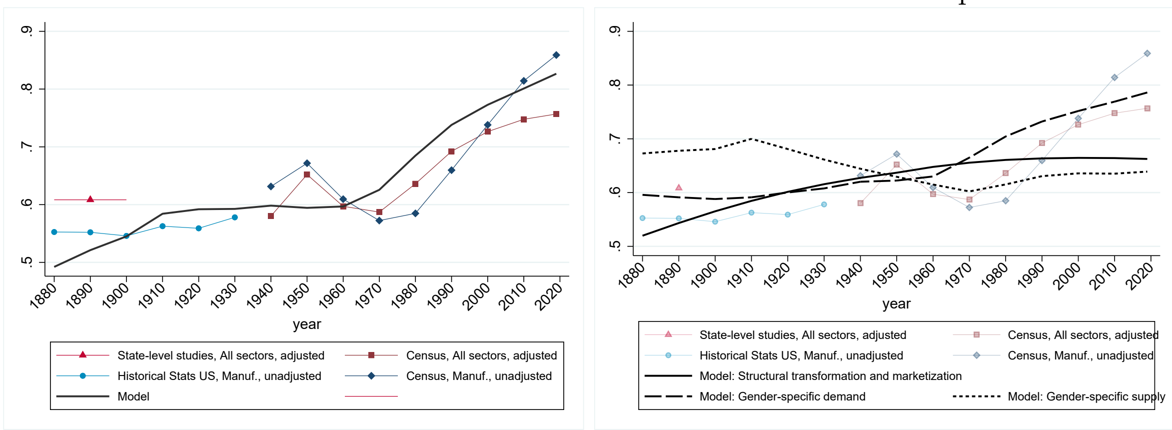


Notes. Market hours include time worked in agriculture, manufacturing and market services. The data series are built under the assumption that unpaid workers in agriculture work 20 hours per week. Structural transformation and marketization reflect varying γ_j across sectors and $\bar{c} > 0$; gender-specific labor demand reflects changes in ξ_{jt}; gender-specific labor supply reflects changes in L_{ft}/L_{mt}.

We finally present evidence on model predictions regarding the gender wage ratio in Figure 13. The solid line in Panel A represents the change in the wage ratio predicted jointly by all three forces. The model reproduces well the relatively flat wage ratio up until 1960, and the following rise, except for the slight pre-1910 increase that is not present in the data. Panel B represents the role of the three model forces and shows that most of the trend in the wage ratio can be explained by the pattern of gender-specific demand, namely relatively flat relative demand until 1960, and rising afterwards.

Figure 13: Predictions for the gender wage ratio, 1880-2019.

Panel A: Overall | Panel B: Decomposition



Notes. Data on the wage ratio are described in detail in Section 8. Predictions in Panel A encompass the role of structural transformation and marketization (varying γ_j across sectors and $\bar{c} > 0$), gender-specific labor demand (varying ξ_{jt} over time), and gender-specific labor supply (varying L_{ft}/L_{mt} over time). Predictions in Panel B represent the role of each force separately.

5 Conclusions

By combining data from the US Census and several early sources, this paper has built a consistent measure of male and female work for the US over the period 1880-2019, covering intensive and extensive margins. The resulting measure of hours, including paid work as well as unpaid work in family businesses, displays an asymmetric U-shape for women, with a modest decline up to mid-20th century and a sustained rise afterwards. For men, hours fall throughout the sample period.

We empirically and theoretically relate these trends to the process of structural transformation, and namely the reallocation of labour across agriculture, manufacturing and services, and the marketization of home production. We propose a multisector model of the economy with uneven productivity growth, income effects, and consumption complementarity across sectoral outputs. At early stages of development, declining agriculture leads to rising services (both in the market and the home) and leisure, implying a fall in market work. At later stages of development, a large service economy implies an important marketization process, progressively reallocating work from home to market services and raising market hours. The first phase is characterized by a decline in hours for both genders. In the second phase, marketization implies an increase in female hours, reflecting the consequences of de-industrialization. We finally illustrate the quantitative properties of the model in a simple calibration exercise.

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A Auxiliary tables and figures

Figure 1: Average fertility around the world, 1950-2019.

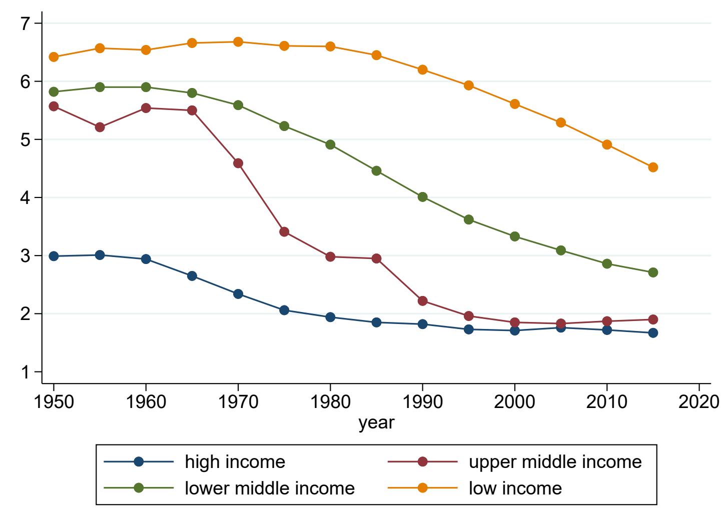
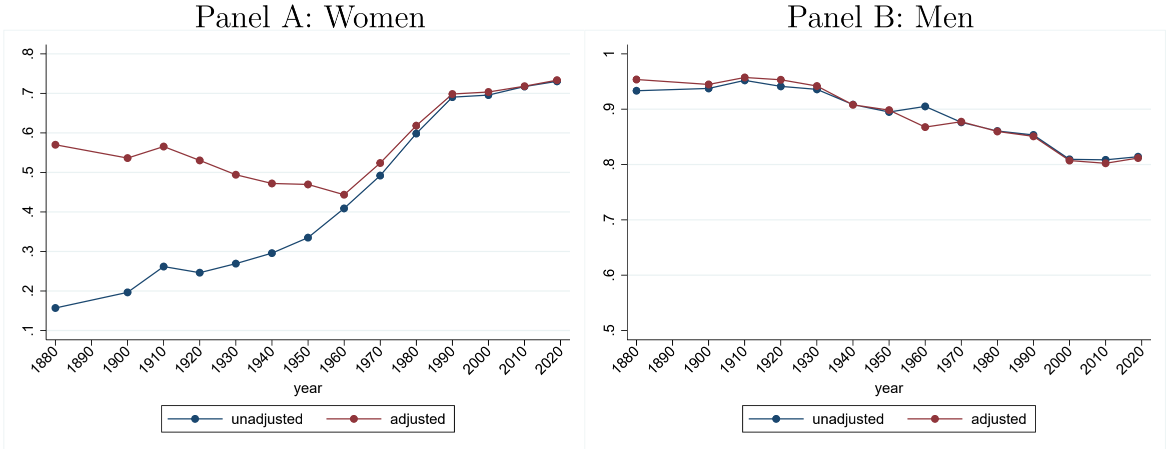


Figure 2: Adjusted employment to population ratios, 1880-2019.

Panel A: Women Panel B: Men



The sample includes individuals aged 18-64. Individual weights are used in the calculation of employment rates. The definition of employment changes from "gainful employment" to "ILO employment" in 1940. The adjusted series are obtained following the Ruggles (2015) method. Source: US Census and ACS, 1880-2019.

B Derivation of model results

B.1 Relative prices

Using the production function (1) and condition (12), we can express

$$\frac{N_j}{l_{fj}} = \left(\frac{\xi_j}{I_j\left(w\right)}\right)^{\frac{\eta_j}{\eta_j-1}}; \qquad \forall j. \tag{27}$$

Free mobility implies that marginal revenue product of labor is equalized across sectors, i.e. (2) holds for all $j = a, m, s, h, l$. For female labour, across any two sectors j and k the following must hold

$$p_j A_j \xi_j \left(\frac{N_j}{l_{fj}}\right)^{1/\eta_j} = p_k A_k \xi_k \left(\frac{N_k}{l_{fk}}\right)^{1/\eta_k}. \tag{28}$$

Substituting (28) into (27) gives relative prices as a function of the gender wage ratio:

$$\frac{p_j}{p_k} = \frac{A_k \xi_k^{\frac{\eta_k}{\eta_k - 1}} \left[I_k(w)\right]^{\frac{1}{1-\eta_k}}}{A_j \xi_j^{\frac{\eta_j}{\eta_j - 1}} \left[I_j(w)\right]^{\frac{1}{1-\eta_j}}}. \qquad \forall j, k \tag{29}$$

B.2 Marketization and Structural Transformation

The household's optimal choice of home and market services, implying that the marginal rate of substitution should be equal to relative prices

$$\frac{p_h}{p_s} = \frac{1-\psi}{\psi}\left(\frac{c_s}{c_h}\right)^{1/\sigma}. \tag{30}$$

Given the relative prices in (15) and the production functions, the relative expenditures across evolve as in (18).

Use (30) to obtain an useful expression from utility function (5):

$$\frac{c_z}{c_s} = \psi^{\frac{\sigma}{\sigma-1}}\left(\frac{1}{E_{sh}} + 1\right)^{\frac{\sigma}{\sigma-1}}. \tag{31}$$

Across manufacturing and market services:

$$\frac{p_m}{p_s} = \left(\frac{\omega_m}{\omega_z}\right)\left(\frac{c_z}{c_m}\right)^{\frac{1}{\varepsilon}}\left(\psi\left(\frac{c_z}{c_s}\right)^{\frac{1}{\sigma}}\right)^{-1} \tag{32}$$

Rearranging to obtain:

$$\frac{c_m}{c_s} = \left(\frac{\omega_m p_s}{\psi \omega_z p_m}\right)^{\varepsilon}\left(\frac{c_z}{c_s}\right)^{\frac{\sigma-\varepsilon}{\sigma}} \tag{33}$$

Using the expression for c_z/c_s in (31),

$$\frac{c_m}{c_s} = \left(\frac{\omega_m p_s}{\omega_z p_m}\right)^{\varepsilon}\psi^{\frac{\sigma(1-\varepsilon)}{\sigma-1}}\left(\frac{1}{E_{sh}} + 1\right)^{\frac{\sigma-\varepsilon}{\sigma-1}}, \tag{34}$$

and the relative expenditure:

$$E_{ms} \equiv \frac{p_m c_m}{p_s c_s} = \left(\frac{p_m}{p_s}\right)^{1-\varepsilon}\left(\frac{\omega_m}{\omega_z}\right)^{\varepsilon}\psi^{\frac{\sigma(1-\varepsilon)}{\sigma-1}}\left(\frac{1}{E_{sh}} + 1\right)^{\frac{\sigma-\varepsilon}{\sigma-1}}, \tag{35}$$

substituting the relative prices (15)

$$E_{ms} = \hat{A}_{ms}^{\varepsilon-1}\left[\left(\frac{\xi_m}{\xi_s}\right)^{\eta}\left(\frac{I_s(w)}{I_m(w)}\right)\right]^{\frac{\varepsilon-1}{\eta-1}}\left(\frac{1}{E_{sh}}+1\right)^{\frac{\sigma-\varepsilon}{\sigma-1}} \tag{36}$$

$$\hat{A}_{ms} \equiv \frac{A_m}{A_s}\left(\frac{\omega_m}{\omega_z}\right)^{\frac{\varepsilon}{\varepsilon-1}}\psi^{\frac{\sigma}{1-\sigma}}. \tag{37}$$

Across household purchase of manufacturing and agriculture, the optimal consumption implies:

$$\frac{p_m}{p_a} = \left(\frac{\omega_m}{\omega_a}\right)\left(\frac{c_a-\bar{c}}{c_m}\right)^{\frac{1}{\varepsilon}}, \tag{38}$$

Define a term $\bar{E}_{ma}$

$$\bar{E}_{ma} \equiv \left(\frac{p_m}{p_a}\right)\left(\frac{c_m}{c_a-\bar{c}}\right) = \left(\frac{p_m}{p_a}\right)^{\varepsilon-1}\left(\frac{\omega_m}{\omega_a}\right)^{\varepsilon} \tag{39}$$

where using the relative price (15):

$$\bar{E}_{ma}(w) = \hat{A}_{ma}^{\varepsilon-1}\left(\left(\frac{\xi_m}{\xi_a}\right)^{\eta}\left(\frac{I_a(w)}{I_m(w)}\right)\right)^{\frac{\varepsilon-1}{\eta-1}}. \tag{40}$$

where

$$\hat{A}_{ma} \equiv \frac{A_m}{A_a}\left(\frac{\omega_m}{\omega_a}\right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{41}$$

The relative expenditure across agriculture and manufacturing is

$$E_{ma} = \left(1-\frac{\bar{c}}{y_a}\right)\bar{E}_{ma}(w); \tag{42}$$

Finally, we derive an expression of the expenditure of agriculture relative to the composite service by defining an implicit price for the composite service p_z as:

$$p_z c_z = p_h c_s + p_h c_h = \left(1+E_{sh}^{-1}\right)p_s c_s \tag{43}$$

The expenditure of agriculture relative to composite services is:

$$E_{az} = \frac{p_a c_a}{p_z c_z} = \frac{1}{1+E_{sh}^{-1}}\left(\frac{E_{ms}}{E_{ma}}\right)$$

substituting the expression for E_{ms} and E_{ma},

$$E_{az} = \frac{1}{1+\frac{1}{E_{sh}}}\left(\frac{\left(\frac{A_m}{A_s}\left(\frac{\omega_m}{\omega_z}\right)^{\frac{\varepsilon}{\varepsilon-1}}\psi^{\frac{\sigma}{1-\sigma}}\right)^{\varepsilon-1}\left[\left(\frac{\xi_m}{\xi_s}\right)^{\eta}\left(\frac{I_s(w)}{I_m(w)}\right)\right]^{\frac{\varepsilon-1}{\eta-1}}\left(\frac{1}{E_{sh}}+1\right)^{\frac{\sigma-\varepsilon}{\sigma-1}}}{\left(1-\frac{\bar{c}}{y_a}\right)\left(\frac{A_m}{A_a}\left(\frac{\omega_m}{\omega_a}\right)^{\frac{\varepsilon}{\varepsilon-1}}\right)^{\varepsilon-1}\left(\left(\frac{\xi_m}{\xi_a}\right)^{\eta}\left(\frac{I_a(w)}{I_m(w)}\right)\right)^{\frac{\varepsilon-1}{\eta-1}}}\right)$$

which simplifies to

$$E_{az} = \frac{\left(1+\frac{1}{E_{sh}}\right)^{(1-\varepsilon)}}{1-\frac{\bar{c}}{y_a}} \left(\frac{A_s}{A_a}\right)^{1-\varepsilon} \left(\frac{\omega_a}{\omega_z}\right)^{\varepsilon} \psi^{\frac{\sigma(\varepsilon-1)}{1-\sigma}} \left[\left(\frac{\xi_a}{\xi_s}\right)^{\eta} \left(\frac{I_s(w)}{I_a(w)}\right)\right]^{\frac{\varepsilon-1}{\eta-1}}$$

B.3 Leisure

From household optimization, using the implicit price of leisure in (9), the optimal consumption of manufacturing goods and leisure goods satisfies:

$$\frac{p_l}{p_m} = \frac{c}{\omega_m}\left(\frac{\phi}{c_l}\right)\left(\frac{c_m}{c}\right)^{\frac{1}{\varepsilon}} \tag{44}$$

which implies

$$E_{lm} = \frac{\phi}{\omega_m}\left(\frac{c}{c_m}\right)^{\frac{\varepsilon-1}{\varepsilon}} \tag{45}$$

Using the the utility function (4),

$$E_{lm} = \phi\left[\frac{\omega_a}{\omega_m}\left(\frac{c_a-\bar{c}}{c_m}\right)^{\frac{\varepsilon-1}{\varepsilon}} + 1 + \frac{\omega_z}{\omega_m}\left(\frac{c_z}{c_m}\right)^{\frac{\varepsilon-1}{\varepsilon}}\right], \tag{46}$$

which can be rewritten as

$$E_{lm} = \phi\left[\frac{\omega_a}{\omega_m}\left(\frac{c_a-\bar{c}}{c_m}\right)^{\frac{\varepsilon-1}{\varepsilon}} + 1 + \frac{\omega_z}{\omega_m}\left(\frac{c_z}{c_s}\frac{c_s}{c_m}\right)^{\frac{\varepsilon-1}{\varepsilon}}\right], \tag{47}$$

where using (38), (31) and (34),

$$E_{lm} = \phi\left[\frac{\omega_a}{\omega_m}\left(\frac{p_m\omega_a}{p_a\omega_m}\right)^{\varepsilon-1} + 1 + \left(\frac{\omega_z}{\omega_m}\right)^{\varepsilon}\left(\frac{p_m}{p_s}\right)^{\varepsilon-1}\psi^{\frac{\sigma(\varepsilon-1)}{\sigma-1}}\left(\frac{1}{E_{sh}}+1\right)^{\frac{\varepsilon-1}{\sigma-1}}\right], \tag{48}$$

where from the relative expenditure derived in (35) and (39),

$$E_{lm} = \phi\left(\frac{1}{\bar{E}_{ma}} + 1 + \frac{1}{E_{ms}} + \frac{1}{E_{mh}}\right); \quad E_{mh} = E_{ms}E_{sh} \tag{49}$$

B.4 Equilibrium wage ratio

This section provides the derivation of the equilibrium wage ratio.

Given the constant-return-to-scale home production function,

$$p_h c_h = p_h\frac{\partial c_h}{\partial l_{mh}}l_{mh} + p_h\frac{\partial c_h}{\partial l_{fh}}l_{fh}, \tag{50}$$

using the implicit price index for p_h and the household optimization, it implies

$$p_h c_h = w_m l_{mh} + w_f l_{fh}. \tag{51}$$

and the same holds for leisure:

$$p_l c_l = w_m l_{ml} + w_f l_{fl} \tag{52}$$

Thus the budget constraint can be rewritten as

$$\sum_{\forall i} p_i c_i = w_m L_m + w_f L_f, \tag{53}$$

Dividing through by $p_l c_l$ and re-arrange:

$$\frac{p_l c_l}{w_m L_m + w_f L_f} = \frac{1}{\frac{E_{ml}}{\left(1-\frac{\bar{c}}{c_a}\right)\bar{E}_{ma}} + \sum_{i \neq a} E_{il}}; \tag{54}$$

Using the definition of I_j :

$$\frac{l_{fl}}{L_f} = \frac{I_l(w)}{I(w)\left(\frac{E_{ml}(w)}{\left(1-\frac{\bar{c}}{y_a}\right)\bar{E}_{ma}(w)} + \sum_{i \neq a} E_{il}(w)\right)}. \tag{55}$$

A second equation for the share of leisure time is derived from female time constraint. Using the definition of I_j :

$$E_{kj} = \frac{p_k y_k}{p_j y_j} = \frac{w_f l_{fk}/I_k}{w_f l_{fj}/I_j}, \qquad \forall j, k = a, m, s, h, l \tag{56}$$

thus

$$\frac{l_{fk}}{l_{fj}} = \frac{I_k}{I_j} E_{kj}; \qquad \forall j, k, \tag{57}$$

Substituting it into female time constraint:

$$L_f = \sum_{j=a,m,s,h,l} l_{fj} = l_{fl} \sum_{\forall j} \frac{l_{fj}}{l_{fl}} = l_{fl} \sum_{\forall j} \frac{I_j}{I_l} E_{jl}, \tag{58}$$

thus

$$\frac{l_{fl}}{L_f} = \frac{I_l(w)}{I_a(w)\frac{E_{ml}}{\left(1-\frac{\bar{c}}{y_a}\right)\bar{E}_{ma}(w)} + \sum_{\forall j \neq a} I_j(w) E_{jl}(w)}. \tag{59}$$

First express (23) and (59) as functions of $\left(\frac{l_{fa}}{L_f}, w\right)$:

$$\frac{l_{fa}}{L_f} = \frac{I_a(w)}{I(w)\left[\left(1 + \left(1 - \frac{\bar{c}}{y_a}\right)\bar{E}_{ma}(w)\sum_{\forall j \neq a} E_{jm}(w)\right)\right]}, \tag{60}$$

and

$$\frac{l_{fa}}{L_f} = \frac{I_a(w)}{1+\left(1-\frac{\bar{c}}{y_a}\right)\bar{E}_{ma}(w)\sum_{\forall j\neq a} I_j(w) E_{jm}(w)} \tag{61}$$

Use the agriculture production function to express y_a as a function of l_{fa} :

$$y_a = A_a N_a = A_a L_f \left(\frac{N_a}{l_{fa}}\right)\left(\frac{l_{fa}}{L_f}\right), \tag{62}$$

we can rewrite the two equilibrium conditions in terms of (y_a, w) , which can be used to deliver an implicit function for w only. Substitute $\frac{l_{fa}}{L_f}$ as a function of y_a,

$$\frac{l_{fa}}{L_f} = \frac{y_a}{A_a L_f\left(\frac{N_a}{l_{fa}}\right)}$$

the first equation becomes

$$\begin{aligned}
\frac{y_a}{A_a L_f\left(\frac{N_a}{l_{fa}}\right)} &= \frac{I_a/I}{1+\left(1-\frac{\bar{c}}{y_a}\right)\bar{E}_{ma}\sum_{\forall j\neq a} E_{jm}}, && (63)\\
y_a + (y_a-\bar{c})\,\bar{E}_{ma}\sum_{\forall j\neq a} E_{jm} &= \frac{I_a}{I} A_a L_f\left(\frac{N_a}{l_{fa}}\right) && (64)\\
y_a &= \frac{\frac{I_a}{I} A_a L_f\left(\frac{N_a}{l_{fa}}\right)+\bar{c}\bar{E}_{ma}\sum_{\forall j\neq a} E_{jm}}{1+\bar{E}_{ma}\sum_{\forall j\neq a} E_{jm}} && (65)
\end{aligned}$$

and the second equation becomes

$$\begin{aligned}
\frac{y_a}{A_a L_f\left(\frac{N_a}{l_{fa}}\right)} &= \frac{1}{1+\left(1-\frac{\bar{c}}{y_a}\right)\bar{E}_{ma}\sum_{\forall j\neq a}\frac{I_j}{I_a} E_{jm}} && (66)\\
y_a + (y_a-\bar{c})\,\bar{E}_{ma}\sum_{\forall j\neq a}\frac{I_j}{I_a} E_{jm} &= A_a L_f\left(\frac{N_a}{l_{fa}}\right) && (67)\\
y_a &= \frac{A_a L_f\left(\frac{N_a}{l_{fa}}\right)+\bar{c}\bar{E}_{ma}\sum_{\forall j\neq a}\frac{I_j}{I_a} E_{jm}}{1+\bar{E}_{ma}\sum_{\forall j\neq a}\frac{I_j}{I_a}(w) E_{jm}} && (68)
\end{aligned}$$

B.5 Family farms

The focus of the model is to understand and quantify how the process of structural transformation can generate a U-shape market hours for women and a declining market hours for male. As we shown in the empirical section, prior to 1950, measuring unpaid family hours especially in family farms is quantitatively important for female market hours and the female agriculture hours. The model presented so far does not separate family business from market business and market hours in each sector includes both paid and unpaid hours. It is important to note that the presence of family business *per se* does not contribute to the U-shape: hours in family business is part of market hours so reallocation across market and family business does not change total market hours. It is how the presence of family business changing the process of structural transformation that affected the dynamics of market hours by gender. More specifically, give the prevalence of women's work in family farms in the 19th century, the decline in family farms is associated with the decline in agriculture which as we shown in the baseline is important for the decline in market hours.

We now extend the model by introducing a separate production function for family farm where household receive revenue from the sale of farm output. The production function for family firm is:

$$y_n = A_n N_n, \quad N_n = \left[\xi_n l_{fn}^{\frac{\eta-1}{\eta}} + (1-\xi_n)\, l_{mn}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}; \tag{69}$$

The output of family firm is sold in the market at price p_n. The sale of the output from family firm enters as an income in the budget constraint and the time spent on family firm is taken out of time constraint:

$$\sum_{i=a,m,s} p_i c_i \leq w_m \left(L_m - l_{mh} - l_{mn} - l_{ml} \right) + w_f \left(L_f - l_{fh} - l_{fn} - l_{fl} \right) + p_n y_n \tag{70}$$

The interpretation is that a family farm only produce one variety (or a small set of varieties) of agricultural product whereas a household demands different varieties of produces from the agricultural market. The agricultural market includes produces of agriculture firms and all family farms in the economy. The market clearing for the final agricultural goods c_a satisfies:

$$c_a \equiv \left(\psi_n Y_n^{\frac{\sigma_n-1}{\sigma_n}} + (1-\psi_n)\, Y_a^{\frac{\sigma_n-1}{\sigma_n}} \right)^{\frac{\sigma_n}{\sigma_n-1}}, \qquad \sigma_n > 1 \tag{71}$$

which is a CES composite of the agriculture output from all agricultural firms (Y_a) and family farms (Y_n).

This extension introduces an additional source for the dynamics of hours when productivity growth in the representative market farm is higher than the family farm, i.e. growth of A_a is faster than the growth of A_n. When the two types of farms produce goods substitutes ($\sigma_n > 1$), faster productivity growth in the market implies a reallocation of hours from family farms to market farms – a process of *modernization*. The derivation of this process is similar to those of the marketization process. The optimal allocation of female and male hours for the family implies that the marginal rate of technical substitution across male and female hours equal to the relative wage, so condition (3) holds for the family farm as well. We can define the female income share $I_n(w)$ as in (12) and and the relative female hours across two types of farms satisfies

$$\frac{l_{fn}}{l_{fa}} = \frac{I_n(w)}{I_a(w)} E_{na}; \qquad E_{na} \equiv \frac{p_n Y_n}{p_a Y_a} = \hat{A}_{na}^{\sigma_n - 1} \left(\left[\left(\frac{\xi_a}{\xi_n} \right)^{\frac{\eta}{\eta-1}} \left(\frac{I_a}{I_n} \right)^{\frac{1}{\eta-1}} \right] \right)^{\sigma_n - 1} \tag{72}$$

$$\hat{A}_{na} \equiv \left(\frac{A_n}{A_a} \right) \left(\frac{\psi_n}{1-\psi_n} \right)^{\frac{\sigma_n}{\sigma_n - 1}} \tag{73}$$

which shows that as A_n/A_a falls, due to the slower productivity growth in the family farm, farm hours are reallocated from family farm to market farm.

By reallocating labor from family farm into market farm, this modernization implies an increase in the productivity growth of the aggregate agricultural sector over time. Thus it can have implications on the decline of agricultural employment and the dynamics of market hours. It is not possible to calibrate this extended model directly because we cannot separate farm output and paid farm hours into those by family farms and those by the market farms. Thus we cannot calibrate the productivity growth and production parameters for the family farms, nor an estimate for the elasticity of substitution σ_n. So the main text took the indirect approach by lowering the agricultural productivity growth for the pre-1950 periods since the main channel that the process of modernization contribute to the dynamics of market hours is through increasing the productivity growth rate of the aggregate agricultural sector.