

Gender gaps in wages and mortality rates during industrialization:  
the case of Alcoy, Spain, 1860-1914

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**Abstract**

What role did women play during industrialization? Interpretations of this key period of our history have been largely based on analyses of male work. In this paper, we offer evidence of the effects of women's involvement in the industrialization process that took place in Alcoy, Spain, over the period 1860-1914. Using data drawn from historical sources, we analyse labour-force participation rates and wage series for women and men in the textile industry and three other sectors of activity (education, health and low-skill services). We then connect the gender pay gaps with life expectancy indicators. Our results suggest that women's contribution to household income might have favoured the female life-expectancy advantage, an effect that seems to have been channelled through a reduction in the relative mortality rates of female infants and girls, at the expense of a higher mortality rate of working-age women.

Keywords: Industrialization, gender wage gap, female mortality advantage.

JEL Codes: J16, J31, N33, O14

## **1. Introduction**

The Industrial Revolution opened up unprecedented opportunities for women to enter the labour market and carry out paid work. The shift of labour away from agriculture towards industry—in many places, predominantly the textile industry—made the female population an abundant and dexterous labour force available to take on many of the tasks carried out in the factories. However, previous studies of industrialization have tended to overlook women's role in that process and instead have focused exclusively on the analysis of male work.

The participation of women in the labour market brought about substantial changes in their status in society. The interpretation of whether or not these changes were beneficial for women varies depending on whether historians take an optimistic or pessimistic perspective. According to the optimistic view (Neil McKendrick, 1974; Joyce Burnette, 1997; Jan de Vries, 2005, 2008), women would have enjoyed greater relevance and recognition in society because of their increased contribution to household income. According to the pessimistic view (Maxine Berg and Pat Hudson, 1992; Maxine Berg, 1993; Sara Horrell and Jane Humphries, 1995), women experienced great disadvantages during this period; indeed, they suffered a serious deterioration in their well-being due to the harsh working conditions. Hence, when studying the origin of female participation in the labour market, researchers have turned their attention to two particular aspects: on the one hand, the change in female earnings relative to male earnings brought about by the industrial revolution; and on the other hand, how women's participation in the labour force impacted their life conditions. These two aspects are at the centre of two classical, and recently renewed, lines of research: the analysis of gender wage gaps (recent surveyed by Francine D. Blau and Lawrence M. Kahn, 2017), and the history and causes of female advantage in

life expectancy (see, e.g., Claudia Goldin and Adriana Lleras-Muney, 2018; and Francisco Beltrán-Tapia and Domingo Gallego-Martínez, 2018, 2017).

A better understanding of the origins of female labour market participation is essential to help interpret current gender gaps in wages and the evolution of female life conditions. In this paper, we analyse data on labour market indicators and mortality rates in the Spanish city of Alcoy for the period 1860-1914, which is considered representative of the Industrial Revolution in Spain. Following data collection from historical archives and other sources, we firstly report and analyse female labour-force participation rates in Alcoy, which point to the substantial participation of women in the economic development of the city in that period. Secondly, and more importantly, we construct and analyse series of gender gaps in average daily wages paid in the city's key economic sector, the textile industry. We complement this information with gender wage gaps in three other sectors of activity of lesser importance in that period: education, health and low-skill services. Finally, we connect the labour-market gender gaps in industry with the so-called female advantage in life expectancy and gender gaps in mortality rates. Since the effects of the industrialization process could have affected differently to people of different ages, we construct and analyse gender mortality gaps at different ages. For example, the children or the elderly in a family unit could have been positively affected by the higher level of earnings entering the household thanks to the higher participation in the labour market of the adult female members; however, for those women actively participating in industry the detrimental effects of working would have been more directly noticeable.

Over the 18<sup>th</sup> century, women gradually abandoned agricultural and domestic work and assumed a central role in the putting-out system (Maxine Berg, 1991; Joyce Burnette, 1999). In that system, merchants acquired raw materials that they distributed among rural households, where some of the family members, mainly women, took on the tasks of spinning and weaving the fabrics (Robert Allen, 2009). New technological developments and the mechanization of the tasks gave rise to the onset of industrialization, which centralized the work in the factory (David Landes, 1969; Joel Mokyr, 1990). Many workers in the putting-

ut system lost their jobs, but many others, particularly women, found jobs in many of the tasks carried out in the factories (Maxine Berg and Pat Hudson, 1992).

As the industrialization process became more established, women increasingly left the labour market as male earnings and family income rose (Maxine Berg, 1991; Jan de Vries 2008; Angelique Janssens, 1997). Thus, the evolution of women's labour-force participation during industrialization followed a U-shape curve (Carmen Sarasúa, 2018), and female labour-force participation would not start to increase again until female educational levels began to catch up with those of men (Claudia Goldin, 1995).

How did the participation of women in the labour market affect the standard of living in that period of history and, in particular, gender differences in these living conditions? In contrast to the gender earning gap in favour of men, many studies have shown a female advantage in mortality rates and life expectancy in many parts of the world (Anna Barford et al., 2006; Steven Austad, 2006; Hiram Beltrán-Sánchez et al., 2015; Mark Cullen et al., 2016). Two countervailing effects on life conditions followed female participation in paid work during industrialization. On the one hand, as the level of household income increased thanks to women's greater contribution, household members would have been able to enjoy better nutrition and sanitary conditions. However, this *income-enhancing* effect could have been undermined by the harsh working conditions faced by women as their participation in the labour market intensified.

Even if we accept that women's participation in the labour market would have resulted in significant impacts in terms of their households' standard of living, it remains unclear why this would affect female and male life expectancy differently. In this regard, the recent works by Beltrán and Gallego-Martínez (2017 and 2018) about the “*missing girls*” anomaly in Spain in the 19<sup>th</sup> century, strongly suggest that girls suffered from discrimination and mortal neglect early in life. The evidence suggests that parents treated their sons and daughters differently in terms of food and care, and the authors specifically mention “*the presence of wage labour opportunities for women (...)*” (op. cit. 2018, p. 1) as a possible source of beneficial effects in girls' survival.

Contrary to the hypothesis of girls being discriminated against inside their households, Claudia Goldin and Adriana Lleras-Muney (2018) find no evidence that differences in mortality were due to differences in nutrition by gender. Using data on causes of deaths in Massachusetts from 1887 to around 1930, they argue instead that females between the ages of 5 and 25 had a disadvantage in mortality from infectious diseases; when infectious disease prevalence fell—according to the authors, largely due to public health interventions in the early 20<sup>th</sup> century—women benefited relatively more than men. Here we could argue that, as it seems to have happened with the incidence of the infectious diseases, the higher spending levels on nutrition and health within the household, even if equally distributed between male and female members, might have had different impacts depending on gender.

Thus, the analysis of the possible channels through which the reduction in gender wage gaps could have ended up affecting the relative life expectancy of men and women is certainly complex. While we are aware of the inherent difficulties of the analysis, in the last part of the paper we attempt to contribute to this debate by connecting the observed gender gaps in wages and labour-force participation rates with the gaps in life expectancy and mortality rates. To this end, we estimate the impact of gender wage gaps on gender gaps in mortality at different ages, while controlling for the probable joint impact of public health expenditures.

In summary, we analyse gender inequalities in both earnings and life expectancy using the excellent case study of Alcoy during the first Industrial Revolution; moreover, we explore the relationship between these gaps. Our work contributes to the existing literature on at least three fronts. Firstly, we present unpublished series of female labour-force participation rates in industry in Alcoy covering the period 1860-1914, which allows us to describe the role played by women in the workforce at that time. Secondly, we construct measures of gender wage gaps and analyse these gaps in the textile industry, along with gender wage gaps in the main occupations in education, health and low-skill services. Thirdly, we construct a measure of life expectancy at birth and mortality rates separately for men and women over the period and examine the link between the gender wage gaps in

industry and these indicators of life conditions. In doing so, we qualify existing evidence by addressing the relationship between gender wage gaps and gender mortality differences for different age intervals, while controlling for important covariates such as labour-force participation rates or public health expenditure.

Although this work focuses on a historical period and at a particular location, it offers insights that help understand the situation of women in the labour market nowadays. In particular, the paper describes the origins of the female discrimination in the labour force in the outset of the industrialization, describes the views of unions, and the society as a whole, as regards the role of women in the labour market, and analyses the trade-off between income and life conditions. Further, and in relation with the important challenges that technological changes impose us nowadays, the example of Alcoy serves as a case study where breakthrough technological changes in the industry induced profound labour market and societal adjustments, affecting both the demand and supply of labour, and a redefinition of the skills needed for the emerging jobs. Finally, the example of the initial industrialization and how it changed the role of women may also serve as a historical reference for developing areas that are still starting their industrialization processes.

The rest of the paper is structured as follows. In Section 2 we present the sources of data used and detail the methodology used to construct the series. In Section 3, we describe the social and economic context of Alcoy at that time. Section 4 is devoted to the descriptive and econometric analysis of the gender wage gaps, while in Section 5 we present the econometric estimation of the relationship between gender wage gaps and mortality rates. Finally, in Section 6 we present the conclusions drawn from the analysis.

## **2. Sources of data and series construction.**

The first empirical contribution of our work lies in the arduous data compilation process carried out in order to construct the wage series by gender and across four economic sectors in Alcoy during the industrialization period spanning from 1860 to 1914. These four sectors are the textile industry, which is by far the most important and representative sector

of the economy of Alcoy in that period; the education sector (schoolteachers); the health sector (doctors and midwives); and the low-skill service sector (workers such as janitors, gardeners, or maids). These four sectors were selected on the basis of both data availability and the fact that they represent the most important sectors in Alcoy during industrialization, given that the agricultural sector did not play a relevant role in this city and virtually no women worked in it. The period of time for which data is available both for men and women and for the four abovementioned economic sectors runs from 1860 to 1914. Thus, our analysis is restricted to that period of time.

In this section, we detail the different sources of information used and how the variables of the analysis have been constructed. We leave the analysis of these variables for the sections that follow.

*Labour-Force Participation Rates.* The data used to construct the labour-force participation rates by gender come from several sources of official statistics collected at different times by the municipal administration of Alcoy, as required by Spain's central government. They are:

- In 1803: "*Interrogatorio sobre las artes, oficios, fábricas de Alcoy*", (Survey of the arts, trades, and factories in Alcoy).
- In 1856: "*Estadística industrial*", (Industrial statistics)
- In 1884: "*Información oral y escrita practicada por la Comisión de Reformas Sociales en la provincia de Alicante*", (Oral and written information collected by the Committee for Social Reforms in the province of Alicante).
- In 1914: "*Estadística obrera en 25 de octubre de 1914*", (Labour statistics on 25<sup>th</sup> October 1914).

These sources provide the number of working men and women in the city over the years, which we divide by the male and female working-age population, respectively, taken from the official censuses carried out in Alcoy from 1857 onwards (we have considered working age to cover the range from 10 to 70 years old, given the lack of an official definition of working age in that period).

Wages in the textile industry. The industrial wages refer to weavers in the textile industry, which was the most important industrial segment in the city. The sources used in this case are:

- From 1860 to 1890: the minute books from the *Real Fábrica de Paños de Alcoy* (an institution which emerged from the early association of textile manufacturers created in the 16<sup>th</sup> century), preserved in its Archive (Archive of the Royal Factory of Fabrics of Alcoy). These books contain information about contracts as well as technical, political, commercial and labour issues faced by the manufacturers, including information on average wages paid by gender and year in the city's textile factories.
- From 1890 onwards the data come from the *Libros-Padrones de Cédulas Personales* (Census Books of Identity Cards). These identity cards, created in 1854, were the basis for the personal income tax. It was compulsory for the inhabitants of Alcoy to apply for a card and subsequently renew it. In the renewal documents, the applicant was asked about their job and wage; this information was not compulsory and was thus voluntarily provided. The data we have collected on wages of weavers in the textile industry have then been averaged per year and gender (over the whole period, we examined a total of around five hundred cards for men, and around two hundred for women).

The data we have compiled yields possibly one of the most important salary databases for that period in Spain, particularly considering the gender disaggregation of the wages.

Wages in the education sector (schoolteachers), in the health sector and in the low-skill service sector: These wages were paid by the municipality of Alcoy, and the source of information is the officially approved municipal budgets, where the municipality specified the wages paid to the public workers each year. In particular:

- In the case of the education sector, the wages correspond to the same job (schoolteacher) for both men and women.



- In the case of the health sector, the wages correspond to different jobs: men were doctors and surgeons, while women were midwives (many of whom also helped as nurses in Alcoy's hospital).
- In the case of the low-skill service sector, the information gathered corresponds to the wages paid to low-skill workers in the hospital, school and city hall, who provided their services as gardeners, cleaners, cooks, caretakers, etc.

The number of teachers per year in Alcoy's municipal school did not exceed 6 men and 4 women. As for the hospital, the available data for men and women refer to around 13 doctors and to 20 midwives/nurses per year, respectively. Thus, these wages cannot be considered important drivers of the economic level of the city in that period; however, we consider them highly interesting from the point of view of the comparison with the industrial wage gaps, and also for historical reasons since such data are fairly rare for this period.

In all cases, the data refer to daily nominal wages in each sector by gender and year. They have been deflated to get real wages using the cost-of-living index estimated in José J. García-Gómez and Antonio Escudero (2018) for the city of Alcoy and for all the years in the period 1860-1914. Thus, our variables are sector-year measures of male and female wages in real pesetas per day. As a result, we end up with measures for 440 wages (4 sectors, 55 years, 2 genders).

*Mortality rates by gender:* Female and male mortality rate series have been constructed using the data available in Ángel Beneito (1993) for the period 1860-1876, the death registry books preserved in the *Registro Civil* (civil registry) since the 1870s, and the official population censuses and statistics on the *Movimiento Natural de la Población* (Natural Population Movement) from the *Instituto Nacional de Estadística* (the Spanish National Statistics Institute). In particular, this research draws on the available censuses for 1860, 1877, 1900 and 1910. From this information we have built mortality tables by gender and age cohorts following an actuarial model (Enrique Vázquez, Francisco Camaño, John Silvi and Anne Roca, 2003). Mortality rates are defined as the ratio between the number of deaths of people of a given gender and age in a year, and the total population of the same gender and age in

that year. The rates are constructed for the census years, and interpolated for the years in between. In the case of infants, we have complemented the census information with data on the number of births each year (taken from Ángel Beneito, 1993) to correct for the under-registration of infants under one year of age, which was common in that period.

Besides the series of wages, we construct other measures that will serve as control covariates in the econometric setting. In particular, we construct measures of *public expenditures on health and education (real, per-capita), and literacy rates*. The series of public expenditure on health and education between 1860 and 1914 come from the officially approved budgets of the municipality of Alcoy, available at the *Archivo Municipal de Alcoy*. They are real per-capita measures (divided by the number of inhabitants of Alcoy and deflated as described above for wages). Finally, literacy rates by gender come from the official censuses and statistics available at the *Archivo Municipal de Alcoy* and the *Instituto Nacional de Estadística*.

### **3. Economic and social context.**

Alcoy is a city located in the South-East of Spain, in the Valencian Community (province of Alicante). The city's population is nearly 60,000 as of 2018, and was around 25,000 in 1860. Thanks to Alcoy's geographical location, the city enjoyed the advantage of having hydraulic energy and wool from the sheep that were herded in the surrounding area. However, the lack of cultivable land due to its mountainous, arid environment meant that there was no substantial agricultural sector in Alcoy, with farming tasks generally reserved for men.<sup>1</sup> Thanks to its entrepreneurs, trained workforce and hydropower, as well as the progressive mechanization of the tasks in the factories, by the mid-19th century Alcoy had become the second-largest wool producer in Spain, behind the area of Sabadell and Tarrasa

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<sup>1</sup> The "*Report of the Farmers Guild*", 1883, explicitly stated that "*due to the limitation of our farming land, it is not traditional among our workers' wives to devote themselves to agricultural tasks*". Also, the population censuses in the city, pointed out that the great majority of workers were occupied in the industrial sector, with the agriculture occupying a very small share of the labour force.

in Catalonia, and remained one of the leading producers of Spanish textiles until the late 20<sup>th</sup> century.

The development of the textile industry opened up unprecedented opportunities for women to enter the labour market, whether working inside the factories or at home. There are significantly more data on the labour-force participation and wages of women in industry, as well as related information and reports. The reports of the *Comisión de Reformas Sociales* (Committee for Social Reforms, 1985 [1889-1893]) constitute a valuable source of informal statements that also shed light on the social and economic environment of the city of Alcoy in that period.

According to one of the available reports, that of the *Weavers Society* in 1884, (p. 119), “*women search for employment outside their home out of sheer necessity, because their husbands’ wages do not suffice to meet the needs of the family. This, besides being morally detrimental due to the bad manners of many of those employed in the workplace and the neglect of young children, notably undermines the work of men in several jobs because women occupy men’s posts while being paid much less, which makes manufacturers prefer women to men*”. The report also adds that: “*(...) the trend should be to banish women from factories, replacing them with men, and relegating them to their home, which is their true place*”, (p. 44). These testimonies provide evidence that women’s labour-force participation was understood as justified only in cases of necessity, when they had to contribute to the household earnings. Moreover, it was expected that this participation should eventually be eliminated to avoid competition with men.

Another of the informants in the report states that “*unlike what happened with men, women’s working hours are not regulated; women regularly work from dawn to dusk, without fixed hours*” and concludes by saying that “*women’s bad working conditions lead to doleful consequences and it is essential to avoid them at all costs*”, (p. 45).

In Table 1 we present some figures on male and female labour-force participation rates in Alcoy during the period of analysis. As we can see, the female labour-force participation rates in the city were notably high during the first decades of the industrialization process, peaking at 63.40% during the 1880s.

[Table 1 about here]

A noticeable decline in women's labour-force participation rates occurred towards the end of the 19<sup>th</sup> century and the early years of the 20<sup>th</sup> century, dropping to a value of 48.8% in the first decade of the 20<sup>th</sup> century (around 35% in 1914). This reduction in female labour-force participation can be explained by several forces that intensified during the two last decades of the 19<sup>th</sup> century. On the one hand, the control exercised by the male workforce in the trade unions, who saw women as competitors driving wages downwards, led to the expulsion of many women from the factories. Along with this, women were pressured to return to their households by the so-called social hygienists and anarchists, for reasons relating to sexual control over women, childcare, improved hygiene and nutrition of the family members. Simultaneously, the technological and organizational modernization taking place in industry in the 1880s promoted changes in the legislation targeted at blocking women from working in many activities.<sup>2</sup> As a result, in Alcoy, as in many other regions during the first Industrial Revolution, the female labour-force participation rate began to decline as its production system became more modernized and the economic level of the city started to rise rapidly in 1880. It was at this time that the stereotypical image of the male breadwinner started to become more widespread (Pilar Pérez-Fuentes 1993; Enriqueta Camps, 1995).

To contextualize the female labour-force participation rates of Alcoy during the analysed period, we present in Table 2 some figures for industries in other European regions during the 19<sup>th</sup> century. These figures show that the female labour force-participation rates in Alcoy during those decades were quite closely in line with those observed in other regions as industrialization became established over the 19<sup>th</sup> century, at least in the textile and similar industries.

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<sup>2</sup> Initially, the smaller and skillful female hands were considered particularly suitable for some tasks as weaving, yarn, or textile-finishing, as well as for the management of the spinning jenny (whose introduction was one of the key developments in the earlier industrialization of weaving). As long as the industry was evolving, new machines were introduced which tend to be heavier and harder to manage, which then become a source of tasks almost exclusively undertaken by men.

[Table 2 about here]

Towards the end of the 19<sup>th</sup> century, female labour-force participation rates declined in many industrial cities around Europe, including Alcoy, falling to rates of around 30 to 35% in textile cities such as Odense in Denmark (55% in 1872, 34% in 1910) or Twente in the Netherlands (Sara Horrell and Jane Humphries, 1997; Cristina Borderías and Pilar López, 2001). Female labour-force participation in developed countries remained around these levels until the 1990s.

The economic development happened in a fairly uncontrolled way, which accentuated the negative consequences of such accelerated industrialization and the accompanying chaotic urbanization (Ricardo Revenga, 1904; José J. García-Gómez, 2016). State intervention was crucial to help alleviate these negative externalities, particularly the public health reform undertaken in Alcoy in the last years of the 19<sup>th</sup> century (José J. García-Gómez and Salvador Salort, 2014). Figure 1 shows the evolution of public sector intervention in terms of spending on both health and education. We also show literacy rates by gender in the city over the period, to convey a more complete picture of the evolution of living standards for Alcoy's population, other than in terms of wages and labour-force participation. A huge increase in public expenditures on health is evident from the mid-1880s onwards. Literacy rates also rose during the period, with male literacy rates rising from 38.75% in 1860 to 68.14% in 1914, and female rates changing from 14.11% to 36.25% over the same period. Hence, a remarkable difference between male and female literacy rates was evident and, although there was a positive and rapid change in these rates over the period, the gap between men and women widened even more.

[Figure 1 around here]

In the next two sections we provide more detail on the data concerning wages and the related gender gap, as well as their connection with our measures of life expectancy and gender mortality gaps.

#### **4. Gender wage gaps: differences across sectors and years.**

Table 3 displays the levels of the real wages for males and females across sectors and time, showing the statistical significance of the differences in all cases. The average wage per day for males ranged from 2.66 pesetas per day during the 1860s to around 3 pesetas in the first decade of the 20<sup>th</sup> century, following a sort of inverted U-shape with lower values at the beginning and end of the period and higher average wages in the intervening decades. The average wage for women was clearly below that for men over the whole period, with women's wages at around 70% of men's average wages at the beginning and end of the period, and as low as 43.5% during the 1880s. Hence, these initial results suggest that the gender earning gap in industry appears to be lower in the mid-1880s and the 1890s, coinciding with the intensification of the industrialization process in the city and when male wages, according to the figures in the table, reached their highest values.

[Table 3 about here]

The bottom half of Table 3 displays the average wages and gender differences across sectors for the whole period and for the four sectors of activity considered. Men earned the highest wages in the high-skill occupations of the service sectors, that is, in the health sector (doctors and nurses/midwives) and in the education sector (schoolteachers), followed by wages in industry and, finally, in the low-skill service sector (janitors, caretakers or gardeners). However, women's highest wages were earned in the education sector, while their lowest wages were earned in the health sector. The health sector was probably the one affected by the highest and most persistent degree of gender segregation across occupations and time: doctors were always men, and women always worked as midwives or nurses. In fact, women did not have access to any of the best paid occupations in the service sector, since they did not have access at all to high education levels in that period of history. Finally, the relatively good position of women in education stands out, with female teachers being greatly appreciated in this sector, a situation that has been historically acknowledged (e.g., San Román, 2000).

Figures 2 and 3 display the evolution of the gender wage gaps over the period of analysis. First, in Figure 2 we plot the (log of) male and female wages separately, as well as

the (log of) the male-to-female wage ratio. Male wages were above female wages during the whole period, with the gap widening appreciably up to the mid-1880s and decreasing later on until around 1905. In the later years of the observed period, the gap started to increase considerably again, so that by 1914 the gap had once again reached the levels of the 1880s.

Second, in Figure 3 we display the (log of) male-to-female wage ratios in all four sectors considered. The first observation to be made is the appreciable difference in wage gaps across sectors, with the health sector and the low-skill service sector exhibiting the highest gaps, with a clear inverted U-shape up to the mid-1880s. In general, from then onwards the wage gaps started to decline in all sectors, with the exception of the low-skill sector, where we see an upward trend in the size of the gap until the end of the century. In the early years of the 20<sup>th</sup> century, the wage gaps started to increase again. By 1914, the wage gap in industry had risen to the levels of the gaps in low-skill services.

The education sector merits special attention. The available data shows that male schoolteachers earned more than their female counterparts up to the mid-1880s (log of the male-to-female ratios above 0), but the gap improved slightly in favour of women from then onwards. In Spain, this sector received a vital boost with the *Moyano Law* of 1857, a central government law which made elementary education compulsory, and also aimed to promote middle-level and higher education. The enhanced demand for teachers from then onwards meant that women enjoyed a relatively good position in relation to men, especially when compared to other sectors of activity.

Other available data for Spain indicate that women's earnings during the 19<sup>th</sup> and mid-20<sup>th</sup> centuries range from 40 % to 70 % of men's earnings (Álvaro Soto Carmona, 1989; Pedro Pérez Castroviejo, 1992; Enriqueta Camps, 1995; Raimon Soler, 1997; Cristina Borderías and Pilar López, 2001; Luisa Muñoz, 2012; Margarita Vilar, 2014). In Table 4 we offer some detailed figures corresponding to factories in the textile and metal sectors. The highest wages earned by women were in the textile factory of *Colonia Sedó* in Barcelona: in the early years of the 20<sup>th</sup> century (from 1901 to 1919), women's wages there were equivalent to 77% of those earned by men. The lowest female relative wage corresponds to the steel

factory of *Santa Ana de Bolueta* in Vizcaya, with female-to-male ratios of below 50% in the last quarter of the 19<sup>th</sup> century, and *Altos Hornos de Vizcaya* with ratios around 38% over those years. The figures for the textile industry in Barcelona are quite closely in line with the wage gaps observed in Alcoy.

[Figure 2 about here]

[Figure 3 about here]

In order to give a more accurate account of the sign, magnitude and statistical significance of the observed differences, we now present some regression results in Tables 5 and 6.<sup>3</sup> Columns 1 to 5 in Table 5 show the estimates for different sectors and periods, first without and then with gender gaps in literacy rates and in labour-force participation rates, as well as public spending controls. In the regression analysis that follows, we split the whole period 1860-1914, identifying two subperiods: the first runs from 1860 to 1885, coinciding with the decades in which industrialization became established in the city, and the second runs from the mid-1880s to 1914, corresponding to a period of more widespread mechanization and the introduction of steam-powered machinery into the factories. This allows for a likely structural change in the estimated coefficients.

First, in column 1 we regress the wage gap on a set of three dummy variables that take the value 1 for each of the three sectors education, health and low-skill services, and the value 0 otherwise. The left-out category in this case is the textile sector, whose average wage gap level is represented by the constant. Next, in column 2, we allow wage gaps to have a different average value in each sector of activity and over the two periods considered (we include a dummy variable that takes the value 1 for all the years of the second subperiod (1885-1914), and we also interact it with all the sector dummy variables). Now the constant of the model measures the average wage gap in industry during the first subperiod. In column

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<sup>3</sup> We display at the bottom of Table 5 the Dickey-Fuller tests of unit root applied to the gender wage gap series; the results allow us to rule out concerns of non-stationarity at conventional levels of significance.



3, we further allow for different time trends within each of the two subperiods considered. In this specification, the estimated constant measures the gender wage gap in the textile sector in the first year of the first period. Finally, in column 4, we add to the specification the gender gaps in literacy rates and in labour-force participation rates (male minus female rates), and in column 5 we also include the available real per capita measures of public spending on health and education.

The regression analysis confirms the trends already observed in the above presented graphs: i) on average over the whole period the gender wage gap was positive in all sectors, with the health and the low-skill service sector showing statistically significant larger gaps than in the textile industry or the education sector; ii) gender wage gaps in all four sectors were, on average, lower in the second period than in the first, with the exception of the textile industry, for which the difference in the second period is positive (though not significant at conventional levels); iii) the estimation results capture the previously observed inverted U-shape in some wage gaps during the first period, since we estimate a significant non-linear trend in wage gaps, which is positive at the beginning but declines with time until the wage gaps reach the lowest levels observed in the second period; iv) the results are robust to the inclusion of these gender gaps in literacy and labour-force participation rates (column 4), as well as to the inclusion of the public spending variables (column 5).

A result that deserves special mention is the statistically significant and negative correlation of the literacy gaps with the wage gaps. This estimated effect of the literacy gender gap, however, may be a mixture of the effect of different levels of literacy between men and women and a possible different impact of changes in literacy for male and female working opportunities. For example, it could be possible that the enhanced literacy rates over the period (even if the gap widened) benefited women more than men when it comes to finding better paid jobs, which could explain why the higher literacy gaps lead to lower wage gaps over the period.

[Table 5 about here]

In order to further disentangle these effects, we display in Table 6 the decomposition of the wage differences by gender following the well-known Oaxaca-Blinder decomposition (Ronald Oaxaca, 1973; Alan Blinder, 1973). Using this technique, the differences in log wages for men and women are split into a component explained by differences in characteristics that vary by gender (in our case the literacy and participation gaps) and an unexplained component. The latter is taken as an estimate of the unequal pay for workers who have equal characteristics but are of a different gender. In our case, the dummy variables for sectors and periods are common to both the male and female samples, so the sectoral and temporal differences can only be attributed to different payments for men and women across these sectors and periods. We follow the same structure of estimation of Table 5.<sup>4</sup>

The results in Table 6 show that the gaps in the labour-force participation rates and literacy rates in favour of men significantly explain the positive wage gaps in their favour. The unexplained components of these two variables are negative, thus suggesting some sort of discrimination in favour of women, or, in other words, that literacy and participation rates result in pay increases higher for women than for men. These findings would thus provide support for the negative association found between literacy rates and wage gaps in Table 5. However, the estimated standard errors of these unexplained components are high and so these estimates are not statistically significant. Overall, the different payments received by men and women across sectors and over the years of the whole analysed period match quite closely with the results previously shown in Table 5. Finally, the results in the bottom half of Table 6 indicate that the bulk of the observed wage differential can be attributed to differences in the average characteristics of the female and male labour workers, while the

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<sup>4</sup> We use the two-fold decomposition, common in the literature, which expresses the outcome (wages) differences assuming that there is some nondiscriminatory coefficients vector  $\beta^*$  that serves as reference to determine the contribution of the differences in the explanatory variables. The wage differential is, in this case,  $W_m - W_f = (X_m - X_f) \beta^* + [X_m(\beta_m - \beta^*) + X_f(\beta^* - \beta_f)]$  with subscript  $f$  referring to female and  $m$  to male. The reference coefficients vector  $\beta^*$  is estimated as the coefficients from a pooled model over both groups. As regards the identification issue of detailed coefficients for dummy variables in Oaxaca decompositions, the estimation provided in Table 6 incorporates the correction proposed by Yun (2005), which makes the results to be independent of the choice of the omitted category

total unexplained part is negligible, probably because its detailed decomposition shows effects of opposite signs.

[Table 6 about here]

## **5. Gender wage gaps and gender mortality gaps.**

In this section we analyse the relationship between the gender wage gaps in that period and the gaps in life-expectancy and mortality rates. In this case we exclusively focus on wages in the industry and rule out wages of schoolteachers, doctors/midwives and low-skill jobs; the reason is that, by no means, these later wages could be considered as potential determinants of the general living conditions of people in the city since few people were occupied in these jobs.

Figure 4 shows the evolution of life expectancy by gender, showing that the so-called “female advantage” in life expectancy could also be observed in that period in Alcoy. We can distinguish three patterns over time. Up to 1875, life expectancy rose rapidly, both for men and women. This was followed by a period, up to the end of the century, where life expectancy remained virtually constant, with a slight decline affecting women and men equally. This decline is very likely the consequence of the fairly uncontrolled economic development occurring in the city, whereby the positive economic effects of industrialization could have been offset by the accelerated industrialization and chaotic urbanization during these years.

From 1900 onwards, life expectancy returned to a path of growth, a period where the enhanced economic level of the city was accompanied by a significant increase in the per-capita public health expenditure during the health reform (see Figure 1 above) and the improvements in the population’s working conditions (due to the pressure of unions, left-wing political parties, social hygienists and the anarchist press; see Álvaro Soto Carmona, 1989). Overall, during period 1860-1900, the life expectancy gap remained constant, with women living an average of 3.5 years more than men did. However, over the course of the

early 20<sup>th</sup> century, the differential in life expectancy of women over men increased, reaching a differential of 4.5 years in 1914.

In Tables 7 and 8, we present some estimation results to connect the gender wage gaps with the life-expectancy gaps. In this case, we define the gaps as female-to-male ratios to facilitate their interpretation as women's advantage over men. In Table 7, we estimate the female advantage in life expectancy at birth (female-to-male life expectancy ratio) following a sequential process: first, we perform the regression on the female-to-male wage ratios in the textile industry only; then, we add the female-to-male participation rate and literacy rate ratios (plus the time trend and its squared value); and, finally, we add the levels of public spending on health and education. All the explanatory variables are 5-year moving average measures (averaged wages over the current plus the 4 lagged years) both to avoid simultaneity bias in the estimated effects, and to allow changes in the labour market to affect mortality with certain lags.<sup>5</sup>

[Figure 4 about here]

The results in the first column of Table 7 suggest a positive effect of female-to-male wage ratios on the female advantage in life expectancy. In addition, the results in column 2 suggest that a reduction in the difference between women's and men's labour-force participation rate could have had a positive impact on the female longevity advantage during those years. Finally, the results in column 3 suggest that women's catching-up in terms of literacy correlated positively with the female life-expectancy advantage. The results are robust to the inclusion of public spending on health and education in the equation.

Hence, the 'life expectancy at birth' indicator points out a positive association between female earnings in that period and life conditions. This measure refers to the average number of years a newborn is expected to live if mortality patterns at the time of its birth remain constant throughout its life. To construct the measure in each period, we need to look

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<sup>5</sup> We checked for robustness with 3- and 4-year moving averages; results do not appreciably change.

at the number of people of different ages dying in that period, which provides a snapshot of the overall mortality characteristics for the population. Thus, changes in the mortality rates of people of different ages in the population are reflected in changes in life expectancy.

[Table 7 about here]

Therefore, the effects of the industrialization process on the life expectancy measure would depend on how industrialization affected people of different ages. For this reason, in Table 8 we analyse the impacts of the female-to-male gaps in wages on the female-to-male mortality rate ratios for different ages for the population of Alcoy in that period. Gender mortality gaps are available for ten age intervals that we have aggregated into six life stages: childhood 0<5 years, childhood 5<10 years, childhood 10<15 years, working-age adulthood covered by two age intervals (15<35 and 35<55) and old age (55 years or older). We use a finer disaggregation of the childhood age interval because, as emphasized by Bernard Harris (2001), the statistical preponderance of deaths at younger ages could obscure the relationship if treated together with ages 5 and upwards.

An interesting result emerges in Table 8: the estimated signs of the coefficients change depending on the life stage we are looking at: higher female-to-male earnings ratios correlate negatively and significantly with gender mortality gaps in childhood, the correlation turns positive for the working age intervals, before becoming negative again for the 65-or-older range. The weaker and non-significant correlation for the 10<15 years interval may be due to the fact that this interval could also include boys and girls working in the factories, and thus the effect is probably somewhere in between the effect for younger children and the effects for adults.

[Table 8 about here]

Hence, changes in women's earnings relative to men's during the period correlated significantly with changes in gender gaps in mortality rates. Female children and elderly women would have benefited from the higher earnings entering the household, while women

of working age probably suffered a deterioration in life conditions that was reflected in a reduction in their mortality advantage over men during that period. These impacts on mortality differentials might be behind the observed subsequent patterns in life expectancy, with the decline in infant mortality having an important positive impact on later life-expectancy differentials.

Our results for the effects of female wages on childhood mortality are largely consistent with the hypothesis of gender discrimination in the allocation of resources inside the household, as supported by the “*missing girls*” anomaly documented by Beltrán and Gallego-Martínez (2017 and 2018). The income-enhancing effect of the wage opportunities for women would have resulted in an alleviation of the relatively higher deprivation likely suffered by girls, with a subsequent beneficial impact on their survival. This outcome would have occurred at the expense of a higher mortality rate of working-age women.

## **6. Concluding remarks**

In this paper, we have analysed gender inequalities in both wages and life expectancy in Alcoy, Spain, during the first Industrial Revolution in the 19<sup>th</sup> century. In addition, we have explored the relationship between these gaps. The period under study runs from 1860 to 1914. Our analysis of the evolution of the gender wage gaps during the period of industrialization in Alcoy indicates that the gaps were, in general, considerable but varied across sectors. Moreover, the evolution of these gaps over time reveals differences across sectors that tended to decrease in the subperiod 1885-1900 with respect to the earlier 1860-1884 period, before rebounding in the early years of the 20<sup>th</sup> century.

How did this economic revolution and, in particular, the role of women in that process impact female life conditions? Our results suggest that the contribution of women to household income might have favoured the female life-expectancy advantage, an effect that seems to have been channelled through a reduction in the relative mortality rates of female infants and children, at the expense of a higher mortality rate of working-age women. These findings are in line with two of the best-established hypotheses regarding the life conditions

of people in that period of history: the first concerns the discrimination against and mortal neglect of girls in households during periods of severe poverty, and the second relates to the idea that the women's well-being was very adversely affected by the working conditions in the factories.

Future research in the line opened by this paper could provide further evidence on the connection between female earnings during industrialization and the evolution of gender differentials in life expectancy. Although theories about earnings and life conditions during that period of our history have been widely discussed, the empirical documentation of the interplay between the gender gaps in these two indicators is practically non-existent.

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Figure 1. Public Expenditures and Literacy Rates. Alcoy, 1860 - 1914

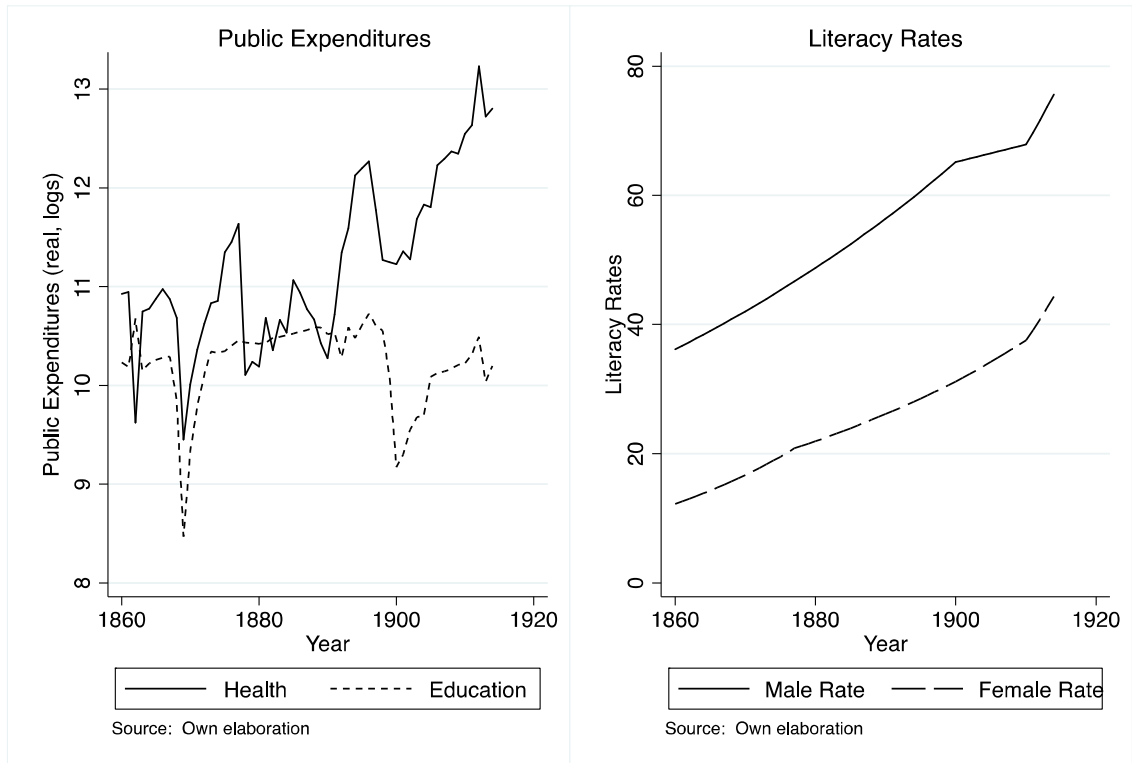
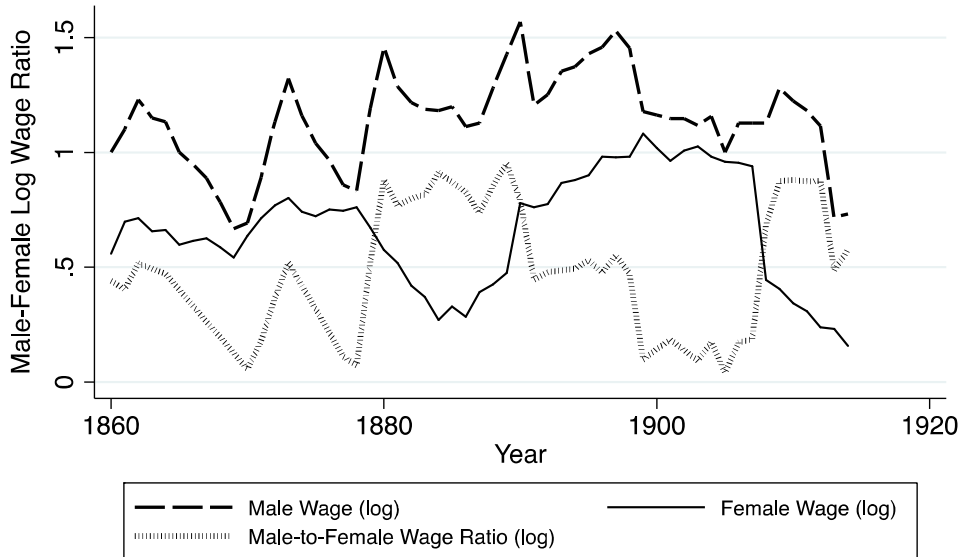
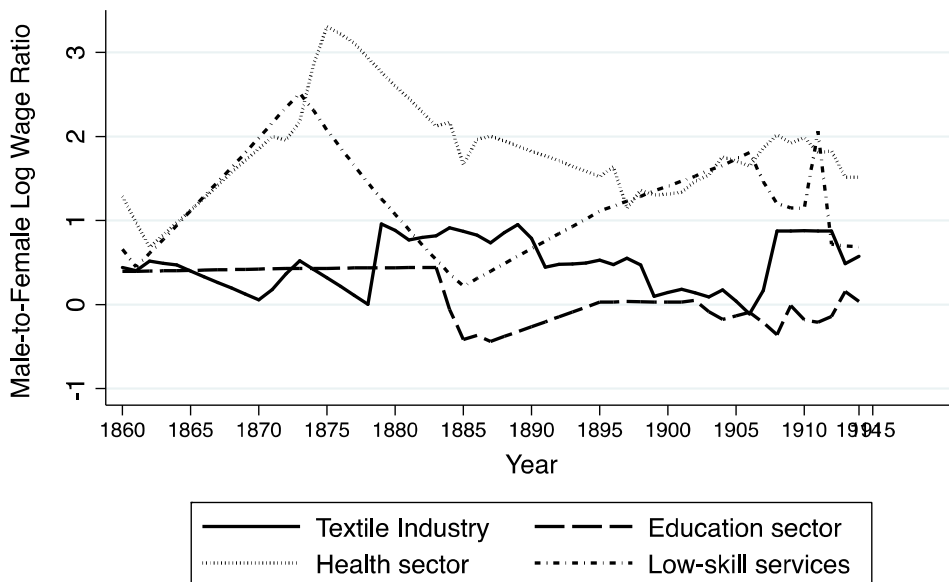


Figure 2. Gender Wage Gaps in the Textile Industry, Alcoy, 1860-1914



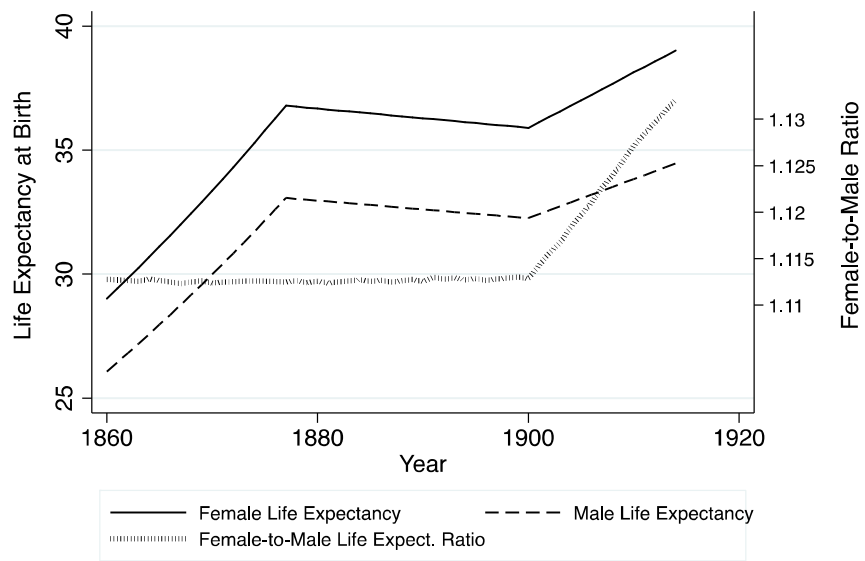
Source: Own elaboration

Figure 3. Gender Wage Gaps by Sector, Alcoy, 1860-1914



Source: Own elaboration

Figure 4. Life Expectancy at Birth by Gender, Alcoy, 1860-1914



Source: Own elaboration

Table 1.  
Labour-Force Participation Rates, by Gender. Alcoy, 1860-1914

Decades	Men (%)	Women (%)
1860-1869	61.24	47.58***
1870-1879	61.54	56.60***
1880-1889	61.83	63.40**
1890-1899	62.12	53.20***
1900-1914	62.50	48.80***
Industry	61.90	51.30***

Source: Own elaboration. Differences significant at: 1% \*\*\* ; 5 % \*\*

Table 2.  
Female Labour-Force Participation Rates in the Industry  
across several European Regions (1834 – 1914)

Year	Region	Industry	Female Rates
1834	Seine region	Spinning industry	36.00
1850	Lancashire	Textile industry	52.00
1850	Paris	Shoe manufacturing	40.00
1850	Paris	Paper industry	40.00
1856	Barcelona	Cotton and wool	41.00
1860	Verviers	Wool industry	70.00
1900	Ghent	Wool industry	50.00

Sources: Maxine Berg (1991), Alain Dewerpe (1996), Deborah Simonton (1998), and Carlos Arenas (2003).

Table 3. Wages by Gender across Sectors.  
Alcoy, 1860-1914

<i>Textile Industry</i>			
Decades	Male	Female	Female-male ratios
1860-1869	2.66	1.87***	70.39%
1870-1879	3.06	2.10***	68.60%
1880-1889	3.55	1.55***	43.53%
1890-1899	3.92	2.50***	63.78%
1900-1914	2.98	2.01***	67.27%
<i>Whole period 1860-1914, by sector</i>			
Industry	3.21	2.00***	62.25%
Education	6.63	5.93***	89.40%
Health	4.35	0.75***	17.12%
Low-skill services	2.07	1.12***	54.20%
All sectors and period	4.21	2.74***	65.17%

Source: Own elaboration (sources cited in Section 2).  
\*\*\*: Differences significant at 1%

Table 4. Gender Wage Gaps in several factories of Spain, 1856-1915

Factory	Year	Women wage / Men wage
Barcelona (all the city) <sup>a</sup>	1856	52 %
Santa Ana de Bolueta (Vizcaya) <sup>b</sup>	1877	48%
Santa Ana de Bolueta (Vizcaya)	1889	45%
Santa Ana de Bolueta (Vizcaya)	1897	49%
Colonia Sedó (Barcelona) <sup>c</sup>	1901-1919	77%
La Rambla (Barcelona) <sup>c</sup>	1901-1919	62%
La España Industrial (Barcelona) <sup>c</sup>	1901-1919	55%
Altos Hornos de Vizcaya (Vizcaya) <sup>d</sup>	1901-1915	38%

Sources: <sup>a</sup>Cristina Borderías and Pilar López Guallar, 2001; <sup>b</sup> Pedro Pérez Castroviejo, 1992; <sup>c</sup> Vilar 2014, op. cit. from Raimon Soler 1997, Enriqueta Camps 1995 and Álvaro Soto Carmona 1989. <sup>d</sup>Pérez Castroviejo, 1992, op. cit.



Table 5. Gender Wage Gaps (Alcroy, 1860-1914)

Dep. Variable: log (Male Wage/ Female Wage)

	(1)	(2)	(3)	(4)	(5)
Education sector	-0.360*** (0.058)	0.004 (0.054)	0.004 (0.100)	0.004 (0.101)	0.004 (0.103)
Health sector	1.345*** (0.089)	1.560*** (0.173)	1.560*** (0.149)	1.560*** (0.148)	1.560*** (0.148)
Low-skill services	0.278*** (0.095)	0.608*** (0.152)	0.608*** (0.140)	0.608*** (0.140)	0.608*** (0.139)
Period 2: 1885-1914		0.103 (0.081)	0.714*** (0.209)	1.197*** (0.376)	0.971** (0.406)
P2 * Education sector		-0.655*** (0.086)	-0.655*** (0.122)	-0.655*** (0.124)	-0.655*** (0.126)
P2 * Health sector		-0.387** (0.188)	-0.387** (0.169)	-0.387** (0.167)	-0.387** (0.167)
P2 Low-skill services		-0.595*** (0.186)	-0.595*** (0.174)	-0.595*** (0.175)	-0.595*** (0.174)
Period 1 trend			0.124*** (0.029)	0.135*** (0.030)	0.125*** (0.032)
Period 1 trend squared			-0.004*** (0.001)	-0.004*** (0.001)	-0.004*** (0.001)
Period 2 trend			0.002 (0.016)	0.733 (1.090)	0.131 (1.311)
Period 2 trend squared			0.000 (0.000)	-0.007 (0.009)	-0.002 (0.011)
Lab-force partic. rate gaps				-0.468 (0.770)	-0.045 (0.928)
Literacy rate gaps				-0.104** (0.051)	-0.124** (0.059)
Health pub exp. (log, real)					-0.744 (0.530)
Education pub exp. (log, real)					0.745 (0.502)
Constant (Textile Industry. 1st year Period 1)	0.477*** (0.041)	0.419*** (0.054)	-0.277 (0.170)	-0.127 (4.054)	2.336 (5.223)
Observations	220	220	220	220	220
Adj. R-squared	0.637	0.694	0.748	0.749	0.750

*Unit Root Dickey-Fuller Tests*<sup>a</sup>:

	Z-statistic	p-value
Textile industry	-3.070	0.001
Education	-1.870	0.033
Health	-2.646	0.005
Low-skill sector	-2.343	0.011

Period 1: years 1860-1884; Period 2: years 1885-1914.

Robust standard errors in parentheses \*\*\* p&lt;0.01. \*\* p&lt;0.05. \* p&lt;0.1

<sup>a</sup>: Augmented Dickey-Fuller tests applied to the gender gap series in each sector; the null hypothesis is that the variable contains a unit root, and the alternative is that the variable was generated by a stationary process.

Table 6.  
Oaxaca-Blinder Decomposition of Gender Wage Gaps. All sectors

	Explained (differences in characteristics)	Unexplained (differences in coefficients)
Lab-force partic. rate gaps	0.367*** (0.096)	-0.286 (1.048)
Literacy rate gaps	0.401*** (0.108)	-1.703 (1.905)
Health pub exp. (log, real)		0.047 (0.045)
Education pub exp. (log, real)		0.130 (0.101)
Period 2: 1985-1914		0.001 (0.022)
Education sector		0.390*** (0.045)
Health sector		0.152*** (0.031)
Low-skill services		0.743 (0.476)
P2 Education		-0.091*** (0.019)
P2 Health		-0.054** (0.021)
P2 Low-skill services		-0.083*** (0.022)
Period 1 trend		0.817*** (0.229)
Period 1 trend squared		-0.365*** (0.093)
Period 2 trend		0.055 (0.261)
Period 2 trend squared		0.271* (0.144)
Constant		0.403** (0.164)
Men	1.294*** (0.033)	
Women	0.502*** (0.062)	
Difference	0.792*** (0.070)	
Explained (differences in characteristics)	0.768*** (0.070)	
Unexplained (differences in coefficients)		0.024 (0.048)
Observations	440	

Period 1: years 1860-1884; Period 2: years 1885-1914.  
Robust standard errors in parentheses \*\*\* p<0.01. \*\* p<0.05. \* p<0.1

Table 7. Dependent variable: Female-to-Male Ratio of Life Expectancy Rates at Birth  
(OLS regression on Female-to-Male Log Wage Ratios,  
5-year moving averages of explanatory variables)

	(1)	(2)	(3)
$W^{\text{female}}/W^{\text{male}}$ in Industry (log)	0.0111*** (0.0019)	0.0020*** (0.0007)	0.0029*** (0.0009)
Female/Male Labour Force part. rate		0.0001* (0.0000)	0.0001** (0.0001)
Female/Male Literacy rate		0.0013*** (0.0001)	0.0013*** (0.0001)
Health pub exp. (log, real)			0.0002 (0.0002)
Education pub exp. (log, real)			-0.0008*** (0.0003)
Time trend <sup>a</sup>		-0.0127*** (0.0002)	-0.0127*** (0.0002)
Time trend squared		0.0020*** (0.0006)	0.0020*** (0.0006)
Constant	1.1041*** (0.0014)	1.1219*** (0.0013)	1.0641*** (0.0048)
Observations	55	55	55
Adj. R-squared	0.4799	0.9256	0.9918

Robust standard errors in parentheses \*\*\* p<0.01. \*\* p<0.05. \* p<0.1.

<sup>a</sup> Time trend: standard yearly-based trend divided by 10.

Table 8. Female-to-Male Ratio of Mortality Rates by age interval. Alcoy 1860-1914  
(SURE 6-equation regression on Female-to-Male Log Wage Ratios,  
5-year moving averages of explanatory variables)

	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5	Eq. 6
	Childhood (0-5 years)	Childhood (5-10 years)	Childhood (10-15 years)	Adulthood (15- 35 years)	Adulthood (35-55 years)	Old Age (>55 years)
$W^{\text{female}}/W^{\text{male}}$ in Industry (log)	-0.041* (0.024)	-0.066*** (0.019)	-0.036 (0.029)	0.041*** (0.007)	0.043*** (0.011)	-0.029*** (0.009)
Female/Male Lab Force rate	0.005 (0.003)	0.003 (0.002)	0.001 (0.004)	-0.003 (0.002)	-0.003 (0.002)	0.001 (0.001)
Female/Male Literacy rate	-0.020*** (0.004)	-0.003 (0.003)	0.046*** (0.005)	0.029*** (0.001)	0.006*** (0.002)	0.003* (0.002)
Health pub exp. (log, real)	-0.018* (0.010)	-0.010 (0.008)	0.002 (0.012)	0.010*** (0.003)	0.007 (0.004)	-0.002 (0.004)
Education pub exp. (log, real)	0.031** (0.013)	0.019* (0.010)	-0.009 (0.016)	-0.022*** (0.004)	-0.013** (0.006)	0.016*** (0.005)
Time trend <sup>a</sup>	-0.081*** (0.011)	-0.020** (0.009)	-0.445*** (0.014)	-0.254*** (0.003)	-0.007 (0.005)	0.121*** (0.004)
Time trend squared	0.039*** (0.008)	0.011* (0.006)	0.052*** (0.009)	0.013*** (0.002)	-0.002*** (0.003)	-0.016*** (0.003)
Constant	1.072*** (0.261)	0.716*** (0.210)	-0.528 (0.321)	0.503*** (0.079)	0.927*** (0.117)	0.337*** (0.104)
Observations (Years)	55	55	55	55	55	55
Constant	0.915	0.501	0.963	0.995	0.979	0.984

Robust standard errors in parentheses \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

<sup>a</sup> Time trend: standard yearly-based trend divided by 10.