UNIVERSITY OF OXFORD

Discussion Papers in Economic and Social History

Number 61, April 2006

EXPLORING CHANGES IN EARNINGS INEQUALITY DURING INDUSTRIALIZATION: BARCELONA, 1856–1905

NATALIA MORA-SITJA

Discussion Papers in Economic and Social History

1 Hans-Joachim Voth and Tim Leunig, *Did Smallpox Reduce Height? Stature and the Standard of Living in London, 1770–1873* (Nov. 1995)

2 Liam Brunt, *Turning Water into Wine – New Methods of Calculating Farm Output and New Insights into Rising Crop Yields during the Agricultural Revolution* (Dec. 1995)

3 Avner Offer, *Between the Gift and the Market: the Economy of Regard* (Jan. 1996)

4 Philip Grover, *The Stroudwater Canal Company and its Role in the Mechanisation of the Gloucestershire Woollen Industry, 1779–1840* (March 1996)

5 Paul A. David, *Real Income and Economic Welfare Growth in the Early Republic or, Another Try at Getting the American Story Straight* (March 1996)

6 Hans-Joachim Voth, *How Long was the Working Day in London in the 1750s? Evidence from the Courtroom* (April 1996)

7 James Foreman-Peck, *'Technological Lock-in' and the Power Source for the Motor Car* (May 1996)

8 Hans-Joachim Voth, *Labour Supply Decisions and Consumer Durables During the Industrial Revolution* (June 1996)

9 Charles Feinstein, *Conjectures and Contrivances: Economic Growth and the Standard of Living in Britain During the Industrial Revolution* (July 1996)

10 Wayne Graham, *The Randlord's Bubble: South African Gold Mines and Stock Market Manipulation* (August 1996)

11 Avner Offer, *The American Automobile Frenzy of the 1950s* (December 1996)

12 David M. Engstrom, *The Economic Determinants of Ethnic Segregation in Post-War Britain* (January 1997)

13 Norbert Paddags, *The German Railways – The Economic and Political Feasibility of Fiscal Reforms During the Inflation of the Early 1920s* (February 1997)

14 Cristiano A. Ristuccia, *1935 Sanctions against Italy: Would Coal and Crude Oil have made a Difference*? (March 1997)

15 Tom Nicholas, *Businessmen and Land Purchase in Late Nineteenth Century England* (April 1997)

16 Ed Butchart, *Unemployment and Non-Employment in Interwar Britain* (May 1997)

17 Ilana Krausman Ben-Amos, *Human Bonding: Parents and their Offspring in Early Modern England* (June 1997)

18 Dan H. Andersen and Hans-Joachim Voth, *The Grapes of War: Neutrality and Mediterranean Shipping under the Danish Flag, 1750–1802* (September 1997)

19 Liam Brunt, *Nature or Nurture? Explaining English Wheat Yields in the Agricultural Revolution* (Oct. 1997)

20 Paul A. David, *Path Dependence and the Quest for Historical Economics: One More Chorus of the Ballad of QWERTY* (Nov. 1997)

[Continued inside the back cover]

EXPLORING CHANGES IN EARNINGS INEQUALITY DURING INDUSTRIALIZATION: BARCELONA, 1856–1905*

NATALIA MORA-SITJA

University of Oxford

Nuffield College
Oxford
OX1 1NF
United Kingdom

natalia.morasitja@nuffield.ox.ac.uk

* Earlier versions of this work were presented at different universities (Oxford, Cambridge, Pompeu Fabra, Barcelona, Zaragoza, British Columbia and LSE) and meetings (the World Cliometrics congress in Venice, the TARGET group meeting in Vancouver and the EHS Annual Conference in Leicester); I want to thank all those who attended for their useful comments, and especially Tim Leunig and Tommy Murphy for their detailed suggestions. I am particularly indebted to Jane Humphries for her encouragement and continuous checking of my work. Remaining errors are all my own.

Abstract

This paper provides estimates of wage dispersion in nineteenth-century Barcelona and documents the compression of the pay distribution between 1856 and 1905. A decomposition of inequality changes by sector and gender leads to two conclusions. First, that most of the changes occurred within each industry, of which the textile industry stands out; and second, that although traditional analyses of changes in earnings inequality tend to ignore female labour and earnings arising from piecework, these seem to be, together with the new factory discipline, the key factors in explaining shifts in earnings inequality in industrializing societies.

Introduction

Economic historians have shown increasing interest on the evolution of income inequality, especially since the influential article by Simon Kuznets on economic growth and inequality.[1] Kuznets' well-known hypothesis is that inequality follows an inverted U-shape: it grows in the initial stages of economic growth, when urbanization and industrialization increase more rapidly; it then becomes stabilized for a while, and it narrows in the later phases. The literature on changes in inequality during the nineteenth century, mainly related to Britain and the United States, reflects the directive power of this model. Thus it focuses on measuring the upward and downward trends as well as timing the inflection point, relying usually on a few benchmark years and on the use of often-different definitions of inequality.[2]

Inequality has also been central to the debate on the evolution of living standards during industrialization, especially as measures of well-being were refined to include more aspects of workers' welfare. The most common indicators used within this context are wage inequality and earnings inequality. They too seem to have increased in early stages of industrialization and decreased later at the end of the nineteenth century.[3] In evaluating the causes of changes in inequality, several factors arise as candidates: technological change, urbanization, migration or education levels amongst the most common, being the ones that classically underpin economic growth. However, there are other key structural transformations during industrialization that despite being covered by a large literature, have received little attention within the debate on inequality. I can think of at least two: changes in the organization of work and women's participation in the labour market. The first refers to several innovations that took place in the workplace in the transition to the factory system, namely the higher division of labour and the introduction of factory discipline. The second points to the increasing participation of women in the labour market and the intensive use of women's work in some manufactures, especially the textile industry.

This paper will evaluate the influence of these two transformations on earnings inequality by analysing earnings inequality amongst manual workers in

---

[1] Kuznets (1955).

[2] Indicators of inequality have included wealth, earnings, income derived from tax records, wealth or the skilled/unskilled pay ratio. Williamson (1985) assesses most of them. Examples of criticisms to his methodology and conclusions can be found in Feinstein (1988) and Jackson (1987).

[3] Williamson (1985).

Barcelona in 1856 and 1905, and by exploring changes in the wage structure of the urban economy at a time when, due to supply and demand changes, it was likely to show high variability. The importance of Catalonia as an industrial centre has been underlined elsewhere: in the mid nineteenth century, Catalan industry accounted for a fourth of Spanish industry, and for two thirds in the case of textiles. Twenty percent of Catalan industrial workers were in Barcelona, the industrial, commercial and financial capital of the region. The Catalan leading role in Spanish industrialization has made it the ideal location in which to test industrialization theories for the Spanish case. The debate on inequality, however, has been weak amongst Spanish economic historians due to the lack of suitable data, and the literature on this issue is limited. Rosés addressed these questions both in his PhD dissertation on the early phase of Catalan industrialization (1998*b*) and in an unpublished paper (1999) that seem to be the only available systematic approach to studying Catalan inequality so far. Rosés analyses the second third of the nineteenth century (1830–1860), the decades during which the take-off of industrialization in Catalonia took place, and shows how all available wage ratios for different types of workers (skilled/unskilled, men/women, industrial/agrarian) rose during this period, generating increasing inequality. This increase in inequality, Rosés argues, was demand-driven: by showing evidence on capital-skill complementarity and employment data that points to some skills upgrading among the workforce, Rosés hypothesis is that skill biased technological change was the force driving the rise in inequality. Though this paper deals with a different period (1856–1905), Rosés' hypotheses will be revisited in the conclusions of the paper to draw a global picture of industrialization and inequality in Catalonia.

The paper, therefore, provides new empirical evidence on earnings inequality in Catalonia; but it also puts forward new hypotheses on the impact that changes in the organisation of work and in women's participation patterns had on inequality measures during industrialization, and these can be extended to any other national or regional context.

I. The causes of inequality: A demand and supply analysis

This section of the paper aims at providing a simplified overview of what changes were likely to affect wage inequality and in what direction. To do this, I follow a simple demand and supply analysis, and depart from the premise that wage differentials (skill premia) reflect the interaction between the relative demand for a set of skills and their relative availability. Table 1 is a summary of the forces that will interact to determine inequality.

Table 1. Demand and supply factors affecting inequality

Demand-side	Supply-side
Technological change • If skill-biased (+) • If unskill-biased (–)	Human capital formation (–)
Trade/Market • Depends on whether demand increases in skill-intensive sectors (+) or not (–)	Migration • Unskilled immigrants (+) • Skilled immigrants (–)
Institutional factors (e.g. trade unions), generally (–)	

The first and most direct factor influencing inequality (or skill premia) is technological change. New machinery and new production techniques demand new skills and generate a demand for a new type of labour, whose wages will increase relative to the rest of the workforce unless the supply of workers with these specific skills increases in parallel. In the twentieth century, there is a wide consensus that technology has been skill-complementary (technical change was accompanied by an increasing demand for skills).[4] However, the debate on the nature of technological change in the nineteenth century is far from being settled,[5] and the question remains much more open. If, as many scholars propose, technical change during the First Industrial Revolution was indeed un-

[4] See for example Acemoglu (1998).

[5] Examples supporting the hypothesis that the Industrial Revolution was deskilling can be found in Attack, Bateman and Margo (2004) or Goldin and Sokoloff (1982). On the other hand, others have argued that new techniques introduced during the Industrial Revolution relied on and required a pool of skilled labour. See for example Bessen (2000) and Bessen (2003) for the United States, Rosés (1998*b*) for Catalonia, and Boot (1995) and Harley (1974) for Britain. This list is not exhaustive, the debate is too long to be discussed here and I evaluate this literature extensively in my PhD dissertation.

skilled-biased, then it would have contributed to a decrease in inequality, by increasing the demand for unskilled workers and consequently their wages. Similarly, on the demand-side, and even without technological change, there can be an increasing/decreasing demand for skills if some skill/unskilled-intensive sectors increase their weight in the economy due to an increase in the demand for their products. In this case the structural change arising from new trade opportunities, for example, would alter the relative demand for skills.

Another factor, this one on the supply side of the labour market, which can clearly influence inequality, is human capital. Broadly understood, human capital refers to those skills derived from formal education, apprenticeships, on-the-job-learning and experience levels that can be used in the workplace. Human capital levels rarely decrease. An increase in human capital will, ceteris paribus, reduce the skill premium, and that is why there is a negative sign in the table. But wage differentials can widen even within a context of increasing human capital levels: the United States, for example, have witnessed both an increase in the supply of educated workers and an increase in inequality since the 1940s, the reason being that skill-biased technological change has increased the demand for skilled workers above the increase in its supply.[6] Therefore, it is the rate of growth of human capital relative to the growth of the demand for skills that determines whether wage differentials widen or narrow.

There is still another factor on the supply side of much relevance in determining skill differentials, and linked to demographic change: migration. The nineteenth century (and for the Spanish case the second half especially) witnessed a huge increase of migratory flows: from Europe to the New World, and within Europe, from the rural zones to the cities. It has been usually argued that these flows brought into the industrial districts of countries worldwide a huge pool of unskilled workers, and contributed to widen inequalities in those receiving regions. However, I will argue here that there can be migratory movements of skilled workers, and in this case migration could act as a factor pushing inequality downwards.

Finally, there can be institutional factors that also affect wage differentials. The list of potential candidates is long: barriers to entry to certain professions, such as guild regulations, can be an obstacle to acquire some skills and can therefore increase wage differentials. Minimum wage setting, on the other hand, can reduce wage inequalities by truncating the lower part of the distribution. Trade unions, who intervene in the process of wage setting, tend to reduce wage

[6] Acemoglu (2002).

inequality within the occupations they represent, both because they try to benefit all their members in order to retain them, and because wage setting is agreed by establishing wages for groups of workers, instead of remunerating individual characteristics and skills.

It is the interaction of the factors mentioned here that determines the outcome in terms of wage differentials.[7] There can be, for example, an *acceleration hypothesis*, that states that there is a discontinuity in the growth rate of the demand for skills not matched by the supply, and this widens inequality. This discontinuity could come from more rapid skill-biased technological change or from changes in international trade, amongst others. Alternatively, there could be a steady demand for skills, and a decrease in the relative supply of skills due to, for example, increasing unskilled immigration. Furthermore, technology and human capital formation can grow in parallel by reinforcing each other. Increasing demand for skills and increasing skill premia provide incentives for education, but increasing supply of skills can also provide incentives for skill biased technological change, to take advantage of the available pool of skills. Wage differentials are, therefore, the result of a complex interaction of other factors. I will explore some of these factors for the Catalan case in the next sections, by providing first empirical analysis on inequality changes, and second putting forward some hypotheses on their likely causes.

[7] A summary of the theories determining skill premia can be found in Acemoglu (2002). The paragraph that follows summarizes arguments of this article.

II. Sources and methodology

The empirical analysis in this paper is based on two sources familiar to Spanish historians, descriptive of the condition of the working class in Barcelona in the second half of the nineteenth century. The first is the 'Statistical Survey of the working class in Barcelona', carried out by Ildefons Cerdà in 1856. This is the first comprehensive survey on the standard of living of the working class in Barcelona. Cerdà, best known for his role as town planner, conceived the Survey as a tool for urban reform, and included it in his 'General Theory of Urbanization'.[8] Cerdà developed his study in two steps. First he listed, by sub-occupations, the data gathered in his research, and then he carried out various statistical analyses to summarize his results. Whereas the first part of his work has received no major criticisms, the reports he then wrote on the basis of his data have been regarded as biased and as distorting the information previously provided.[9] The information used here is extracted from his unprocessed data, the notes listed under each occupation known as *Indicador Alfabético*.

The survey refers to nearly 54,000 workers, nearly half of the population of Barcelona at the time and more than 70% of its manufacturing workforce. The Survey lists the number of wage earners in different occupations and for different categories, and provides their daily wages, the number of days a year worked, and whether they worked on a daily wage or piecework basis. The fact that information on wages is incomplete in some cases, restricts the size of the sample studied to approximately 36,000 workers in 1856.

The second source I use is one promoted by the Town Hall of the City of Barcelona and included in their Statistical Yearbook in 1905, the 'Working Class Census'. This information is the result of questionnaires sent to the manufacturing firms of Barcelona. The survey covers 144,000 workers, but has less information than a 1856 source. It does not list, for example, whether earnings

---

[8] The survey is a product of the conflicts of that period, characterized by general instability governing both the economic and political spheres. The conflicts between labour and capital had been escalating, and workers' demands could more effectively put pressure on the authorities. Several strikes and lockouts led the government to create a commission in Barcelona to intermediate in the conflict, and one of the commissioners was Ildefons Cerdà, who adopted the role of data collector. The purpose of the survey was to provide an account of the earnings and expenditures of waged workers, in order to demonstrate the hard times workers were going through, and to justify their complaints and demands.

[9] Borderías and Guallar (2001) show that Cerdà's tables are biased, and suggest that researchers use instead the *Indicador Alfabético* (Alphabetic indicator) where Cerdà first listed his data. This paper is based on this *Indicador Alfabético*.

are derived from piecework or daily wages, although on the other hand it provides for many cases the number of hours worked. The survey provides two different lists: one with the numbers of workers in each occupation, and another with the wages in each occupation. But the two lists of occupations do not always match. In some cases, for example, the number of workers is given for a general category (for example, toys) and the wages within this category are detailed depending on the more specific task performed (such as tinplate toys, tin toys, ironmongery etc.). I have applied different averaging procedures to correct for this lack of information[10], but could not avoid losing accuracy in the weighting of wages for some occupations. The resulting database is reduced this way to around 108,000 workers.

The surveys have some weak points. The main one, that is not easy to overcome, is that observations are not individual, but aggregate. This means that estimates of the range of earnings are going to be biased downwards, or in other words, they will underestimate inequality. This bias could be bigger for the 1905 survey, in which due to the problems outlined above the resulting information is more aggregate, which means some wage variation within occupations is lost.[11] This also means that if a decrease in inequality in time is found, it will probably overestimate the actual one. As we shall see, this will be the case. It turns out that earnings inequality decreased considerably between these two benchmarks, so much so that although the data analysis provided probably overestimates this decline, a fall of some magnitude is likely to have occurred. But given these probable biases, it should be pointed out before turning to the main empirical analysis that the aim of the paper is to evaluate the changes and the relative contribution of different factors, not absolute inequality values.

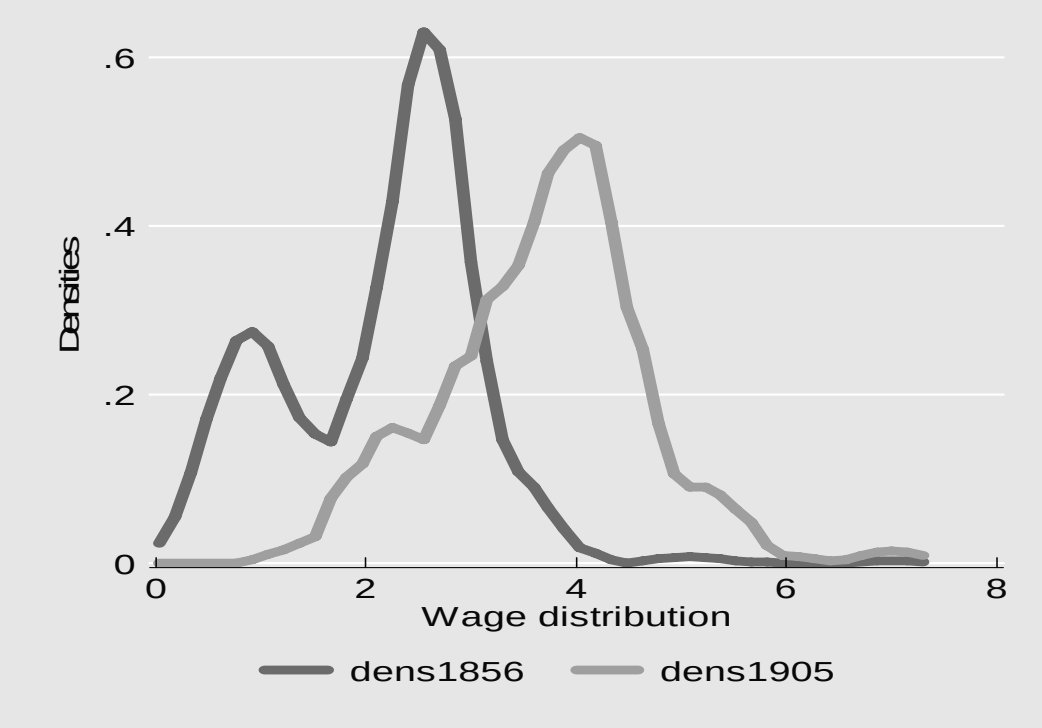
Figure 1 shows the distribution of earnings in both years. The first we see is a clear bimodal pattern in 1856, which fades out in 1905. Later in the paper we

[10] A detailed appendix on construction of the data is available on request. For the 1905 Census, I basically elaborated two different databases. In the first one, a 'conservative' version, I only recorded and used those wages that were clearly assigned to an occupation, without making further assumptions on the data. This conservative version covered 44,180 workers. The second version is the one used in this paper, in which some wages are averaged within categories to cover the lack of correspondence between the wages list and the occupations list provided in the original source. This version covers 107,998 workers. Sensitivity analysis shows that the difference in inequality resulting from using the first or the second version is of 1.74%, small enough to justify the use of the second and largest version of the database.

[11] Although we cannot deny that part of the overall inequality decrease is due to the higher level of aggregation in 1905, a test to identify a relationship between changes in the level of aggregation across sectors and changes in inequality measures across sectors between 1856 and 1905 showed no correlation between these two sets of variables.

will argue that the first mode reflects the female wage distribution, which in 1905 merges with the male one. The graph also shows a shift to the right of the overall distribution, which results in a higher average wage, expressed in nominal daily wages. If everyone worked the same numbers of days a year, using daily or annual wages to measure inequality would make no difference. However, the 1856 survey provides number of days a year worked in each occupation, and this differs across sectors. I have carried out a sensitivity analysis and the difference between the inequality index arising from daily earnings and that arising from annual earnings is 1%, small enough to allow us to proceed to the analysis using daily wages (given there is no data on working days per year and occupation in the 1905 Survey). Additionally, the deflator for the price index between these two years is almost one, so conclusions would not change much if we referred to real wages.[12]

Figure 1. Earnings inequality in Barcelona, 1856–1905



NOTES: See text for sources. The graph plots a Kernel density function estimation.

Table 2 shows computed classical measures of inequality, all of them pointing to a considerable decrease in inequality. How do these measures compare to

[12] The finding would change, though, if we consider that the consumption baskets for different socioeconomic groups might differ, in the way shown by Williamson (1976).

those of other nineteenth-century economies? It is difficult to find appropriate comparisons, for the samples used differ across studies. Williamson, for example, estimates a Gini index for non-agricultural workers in Britain of 0.36 and 0.33 for 1851 and 1901 respectively. These figures, however, include professionals and civil servants, and both rural and urban workers, which might explain the more unequal distribution of earnings.[13] My figures clearly underestimate economy-wide inequality, since they refer only to the dispersion of earnings amongst non-agricultural manual workers.

Table 2. Earnings inequality measures

	1856	1905
Gini index	0.249	0.143
Income in top decile	16.0%	14.0%
Income in bottom decile	2.0%	5.4%
Top 5 %	9.1%	7.6%
Bottom 5%	3.2%	2.4%
Decile dispersion ratio (Income in top decile/income in bottom decile)	8	2.59

Of the measures shown above, there is wide consensus that the Gini index is the more complete since it takes into account the entire distribution, whereas the percentile measures ignore the distribution of earnings in the middle ranges. However, the Gini index also has some limitations, the most important of which is that the Gini index for a population is not a linear function of the Gini indexes of its subgroups if these subgroups overlap in the earnings distribution, as it happens with sectors (or with gender). In other words, the Gini index is not decomposable. The alternatives are the so-called generalized entropy measures, of which the best known are the Theil indexes. These indexes, while keeping the same properties as the Gini index, allow estimation of how much inequality is explained by inequality within groups and how much by inequality between groups. I turn to these indexes to decompose inequality into its component sources. More specifically, this paper uses the so called Theil's L index or

[13] Williamson (1980)

mean log deviation measure, the most commonly used in the literature. Its formula can be expressed as follows:

$$I_0 = \frac{1}{N}\sum_{i=1}^{n} \ln\left(\frac{\bar{y}}{y_i}\right)$$

where N is the total size of the population, y_i is the income of an individual and $\bar{y}$ is the average income of the population.

One of the properties of these indicators, as already said, is that they can be decomposed as a function of some subgroups characteristics. Subgroups can be defined according to occupation, age, or gender, amongst others. Let yk be the average income of a subgroup, n_k the population in the subgroup, and I_0^k the inequality index for the subgroup, then,

$$I_0 = \sum_{k=1}^{n}\left(\frac{n_k}{N}\right)I_0^k + \sum_{k=1}^{n}\frac{n_k}{N}\ln\left(\frac{n_k / N}{y_k / \bar{y}}\right)$$

The first term represents the within-group inequality, and the second term the between-group inequality. The aggregate inequality value depends only on the subgroup mean incomes, population sizes and inequality values, and this enables the inequality trend to be assigned to changes in these factors.[14] Summarizing the change in total inequality (ΔI) is the sum of the following:

[14] For a complete development of the decomposition, see Mookherjee and Shorrocks (1982). Steckel and Moehling (2001), use this same decomposition technique.

(1) $\sum_{k=1}^{n} \bar{v}_k \Delta I_0^k$ changes in within subgroup inequality, with constant population weights, where $v_k = n_k / N$

(2) $\sum_{k=1}^{n} \bar{I}_0^k \Delta v_k$ changes in population shares on the within subgroup component

(3) $\sum_{k=1}^{n} (\overline{\lambda_k} - \overline{\log \lambda_k}) \Delta v_k$ changes in population shares on the between subgroup component, where $\lambda_k = y_k / \bar{y}$

(4) $\sum_{k=1}^{n} (\overline{\theta_k} - \overline{v_k}) \Delta \log y_k$ relative changes in the subgroup means, where $\theta_k = v_k \lambda_k$, the income share of subgroup k

Δ represents the change in the variables from year t to t+1,
$\bar{v}_k = \frac{1}{2}[v_k(t) + v_k(t+1)]$, and $\bar{I}_0^k$, $\overline{\log \lambda_k}$ are similarly defined.

The first term, intra-occupational inequality, refers to the diversity of wages within each sector. If over time wages become less spread out in one of the sub-groups, a sector for example, this would contribute to reduce inequality in the economy, other things equal. The second term, inter-occupational inequality, refers to inequality between subgroups, that is, it ignores the spectrum of wages within each subgroup and looks at differences in average wages across sub-groups. If the average wage in the lowest paid sector, for example, decreases, inequality will increase, ceteris paribus. Finally, we can also measure the effect of population shares both in intra and inter-occupational income inequality. That is, a transfer of workers from a sector with lower wage dispersion to another with a wider wage spectrum would increase inequality. Having established the approach I will take to quantify changes in earnings, I will proceed to apply the analysis using two different categories: by sectors and by gender.

III. The contribution by sectors to changes in earnings inequality

Table 3 summarizes for each sector in both 1856 and 1905 three main variables: the weight of the sector, expressed by the share of total population working in it; the relative mean income of the sector (that is the ratio of the average wage of the sector and the average wage in the economy); and, the indicator of inequality within each sector, measured by Theil's L index.

Table 3. Main indicators by sector, Barcelona 1856–1905

	Build	Chem	Metal	Print	Serv	Text	Others
Population shares ($v_k = n_k / n$), in percentage							
1856	8.8%	1.2%	4.1%	0.9%	31.0%	49.1%	4.9%
1905	16.0%	2.3%	9.3%	5.2%	16.9%	38.0%	12.4%
Relative mean income ($\lambda_k = y_k / \bar{y}$)							
1856	1.37	0.95	1.27	1.35	0.82	0.95	1.11
1905	1.09	0.94	1.04	1.16	1.05	0.91	1.04
Within sector inequality (I_0^k)							
1856	0.036	0.087	0.040	0.002	0.079	0.160	0.084
1905	0.016	0.016	0.015	0.018	0.049	0.045	0.032

Note: Inequality is given by Theil's L index, higher values indicating more inequality. If relative mean income equals 1 it means that the average income in a sector equals the average income in the economy.

There are three main features summarized in the table. The first is that, with the exception of the printing sector, there is a decrease in inequality within all sectors. The second is that, with the exception of the textile sector, there is a trend of convergence to the average wage. The third, not so directly observable, is that the weight of the sector is positively and significantly correlated with inequality (R = 0.62). That is, bigger sectors are more unequal, and they also have lower relative wages (R = –0.55).[15] The evolution of the structure of the

[15] Williamson (1985), p. 38, in contrast, finds positive correlation between average earnings and earnings inequality.

economy can be easily described. By the end of the nineteenth century the textile sector, which had been growing since the beginning of the century, started to give way to other sectors. The economy diversified, and sectors like the metallurgic or chemical industries, growth poles for future industrialization, began to increase in relative importance.

But how did these structural changes affect wage dispersion, and how did the wage distribution within each sector vary? Following the development of the decomposition method for generalized-entropy measures, Table 4 shows in percentage terms the contribution of inter and intra-occupational inequality changes to the total change in inequality, as well as the contribution of each sector for the case of changes within trades.

The most important feature is that nearly 83% of the inequality change can be attributed to the reduction of inequality within sectors, and in this the textile sector stands out clearly. The textile industry was the biggest and most unequal sector in 1856: its loss of weight within the economy and the wage compression experienced during the second half of the nineteenth century are crucial for the overall decrease in inequality in the economy.

Table 4. Decomposing inequality trends by sector

Intra-sector inequality		82.94%
Building	0.67%	
Chemical	0.71%	
Metallurgy	0.27%	
Printing	–0.99%	
Services	17.25%	
Textiles	64.82%	
Others	0.20%	
Inter-sector inequality		17.06%
TOTAL inequality change		100%

It is possible to test empirically the influence on between-sectors relative wage changes of different factors within the supply and demand framework. Using data on wages in the United States in the second half of the twentieth-century, Katz and Murphy developed a partial equilibrium model that allowed them to test whether data were consistent with stable factor demand; in other words, they analysed whether changes in wages could be explained solely by

supply shifts.[16] Consider a production function involving K types of labour inputs (which correspond to different sectors). The factor demand function is

$L_t = D(W_t, Z_t)$ where:
$L_t = K \times 1$ vector of labor inputs employed in the market in year t
$W_t = K \times 1$ vector of market prices (wages) for these inputs in year t
$Z_t = m \times 1$ vector of demand shift variables in year t, including effects of technology and product demand shifts.

The model tests whether wage changes are solely generated by relative supply shifts arising from changing demographics and human capital formation. With stable relative factor demand (Z fixed), an increase in the relative supply of a group (this group being a labour input, in this case the number of workers in each sector) must lead to a reduction in the relative wage of that group. Changes in factor supplies and changes in wages must negatively co-vary:

$$(W_t - W_{t+1})'(L_t - L_{t+1}) \leq 0$$

The variables here refer to relative wage changes as a function of relative supply and relative factor demand shifts, and therefore the framework abstracts from changes in absolute wages arising from factor-neutral technological change and from neutral demand shifts linked to the scale of the economy.[17] The inner product of changes in relative wages with changes in relative quantities for the different sectors in Barcelona is –0.044, hence consistent with the stable demand hypothesis. The analysis, however, sheds little light on inequality changes within sectors, in spite of this being the most important explanatory element of wage inequality. Even if we could say that supply shifts (in the form of increasing supply of workers in the highest paid sectors) accounted for the change in inter-sectorial inequality, this would only be explaining 17% of the inequality decrease.

To understand changes within sectors we need to concentrate on the textile sector, which itself explains nearly 60% of the inequality decrease. Given that the relative wage in this sector decreased over these 50 years, the deskilling of the labour force due to technological innovations may have played a role in ho-

[16] The following model is fully developed in Katz and Murphy (1992).

[17] Katz and Murphy (1992), p. 48. To do so a relative wage measure is used (actual wages deflated by a wage index $N'W_t$, where N is the $(K \times 1)$ vector of average employment shares over the entire sample for the K labor inputs) and a relative supply measure (actual supplies L_t, deflated by the total supply of labor in the economy measured in efficiency units $\Omega' L$, where Ω' is the $(K \times 1)$ vector of average relative wages over the entire sample).

mogenizing wages. Evidence from La España Industrial, the most important Catalan textile firm, suggests this was the case. The firm undertook by the end of the 1880s a complete technological renovation, which affected especially the spinning section of the factory and was characterized by the massive introduction of ring-spinning. This reduced skill and strength requirements and increased the demand for female workers.[18] Wages in the factory remained fairly stable except for occasional increases that mainly affected unskilled workers,[19] these reflected surely the increasing demand for this type of labour. Thus, technological and organizational changes affected changes in labour demand that can explain the wage compression in the textile sector and indeed most of the homogenization of wages within the working class.

Besides these factors, there are also supply-side explanations, which relate to broader economic trends. The two most important supply shifts come from migration and from human capital formation. Over fifty years, Barcelona's population multiplied by five, mainly due to immigration. In 1900, nearly 60% of the population of the city was born in another province.[20] On one hand it is usually argued that immigrants to industrial cities were unskilled workers, which would have pushed the unskilled wage downwards and therefore increased the skill-unskilled wage ratio, another measure of wage dispersion. On the other hand, decreasing relative wages is predicted by basic economic theory. It is suggested that wages adjust to short-run supply and demand conditions and provide market signals that induce education or training to take place, leading to a convergent process. With time, those skills in greatest demand by the growing sectors of the economy might have been acquired by an increasing number of people, among whom migrants could be counted, both through education and through on-the-job training. Barcelona's industrial growth and the shift towards centralization of textile production occurred at the expense of many proto-industrial districts that had flourished in the initial stages of industrialization under the protection of the putting-out system, but which could no longer compete with factory production. The deindustrialization of these areas released thousands of workers who had been trained in textile production processes and who were left

[18] Enrech (1997) and Domenech (2005), 'Labour market adjustment to economic downturns'. Again, this helps explain the increase in the gender gap outlined in the previous section of this paper.

[19] Enrech (1997), p. 151.

[20] 1900 Population Census.

without a job.[21] As Rosés has already pointed out, the transmission of skills from proto-industry to the factory system has not received adequate attention, and too much weight has been placed on the supply of cheap and unskilled labour.[22] In the latter part of the century, however, rural zones with no textile tradition started nurturing Barcelona with migrants, and the ratio of skilled to unskilled workers might have decreased. This view, as we shall see in the next sections, is supported by data on literacy rates.

Finally, there are institutional factors that we cannot ignore, such as the role of trade unions in compressing wage distributions.[23] During the last third of the nineteenth century the labour movement became increasingly powerful in Barcelona. In 1870, a general congress in Barcelona set up the Spanish Regional Federation of the International Workingmen's Association, which adopted as statutes those of the Jura Federation (drawn up by Bakunin), a proof that anarcho-syndicalism was deep-rooted in Catalan society. The organisation was forced underground, and in the 1880s and 1890s the movement tended toward terrorism and insurrections, so that Barcelona was known by the end of the century as the 'city of bombs' and the 'rose of fire'. In parallel with these events more moderate forms of syndicalism were also beginning to grow. A last question, then, would be whether labour organizations helped to make the mass of workers more uniform, or whether exogenous tendencies towards the homogenization of the labour force could have given a boost to the formation of a working class more culturally and politically united, and could therefore explain the power of labour movement at the turn of the twentieth-century.

---

[21] I have described in Mora-Sitja (2002), pp. 25–34, the manufacturing origin of urban immigrants in Barcelona at the beginning of the nineteenth century, and for the late nineteenth century Camps (1995) has found similar results. This was not a characteristic exclusive to Catalonia. In Germany, for example, a prominent feature of areas of heavy emigration was also a well-developed cottage linen industry [Hatton and Williamson (1998), p. 16].

[22] Rosés (1998*a*), p. 27.

[23] Eichengreen (1987) studied labour earnings in Iowa in 1894 and found evidence of a union earnings premium. Additionally, his analysis shows that late-nineteenth century unionism tended to reduce wage dispersion. Similar results are found for the twentieth century.

IV. Accounting for gender in wage dispersion measures

The economic history literature on the gender gap has followed a path independent of the literature on inequality, which has usually focused exclusively on male earnings, generally due to the lack of rich enough available sources on women's wages.[24] Additionally, however, and in order to justify using men's earnings inequality as representative of the whole economy, historians argue that women's wages can be disregarded because female labour is secondary in the labour market and it is often low paid labour clustered around similar wage rates. Hunt, for example, looks at wage variation by focusing exclusively on male earnings and does not use women's earnings because 'the prevailing level of labour demand affected all local wages, and because everywhere women's and children's wages were considerably less than men's wages and were determined, in large part, by the maintenance of customary ratios between male and female pay'.[25] It is argued here that the labour force composition is heterogeneous not only in skill levels, but also in men and women's characteristics, and that labour demand and labour supply changes are likely to affect these groups' wages differently, and hence modify the overall wage structure. Table 5 shows male and female characteristics for 1856 and 1905. Women were always recorded as a minority within the working population, although observations probably underestimate the true involvement of women in the labour market. Women's share in the active population was roughly the same in 1856 and 1905, around 30%, which is a figure that is comparable to data for other European countries.[26] Women's and men's wages, on average, increased; and women's wages relative to men's increased as well. The reduction of the gender gap in manufacturing is a general phenomenon in other countries during this period.[27] One of the surprising things, however, is that at both points in time inequality amongst women was bigger than inequality amongst men, which calls for explanations of gender segregation and women's training and skills that al-

[24] For example, the classical Bowley study on British workers' standard of living, used subsequently to compute inequality [e.g. in Williamson (1985)], only provides information on male labour.

[25] Hunt (1986), p. 964.

[26] Bairoch (1969), pp. 136–7, 173–5 and 189–91 provides data on the percentage of women workers in different activity branches across Europe during the nineteenth-century. Women were only a majority in domestic service.

[27] Goldin (1990), p. 62.

low for this heterogeneity in women's experiences and casts doubts on studies of inequality that ignore female earnings.[28]

Table 5. Main indicators by gender, Barcelona 1856–1905

	Men	Women	Total (all)
Working population shares, in percentage			
1856	68.3%	31.7%	100.0%
1905	71.1%	28.9%	100.0%
Relative mean income ($\lambda_k = y_k / \overline{y}$) [in brackets daily wages in pesetas]			
1856	1.21 [2.61]	0.53 [1.14]	1 [2.15]
1905	1.09 [4.02]	0.77 [2.85]	1 [3.68]
Within gender inequality (I_0^k)			
1856	0.028	0.147	0.132
1905	0.014	0.055	0.037
	Gender gap	**Female/male wages ratio**	
1856	0.56	0.44	
1905	0.29	0.71	

Notes: Inequality is measured by the Theil's L index, higher values meaning more inequality. Wages are pesetas per day of work.

Table 6 decomposes the observed decrease in inequality between 1856 and 1905. The first contribution, which accounts for a 43% of the total decrease in inequality, is the decrease in inequality within groups. Of these, the most important is the wage compression amongst women. The second contribution is the narrowing of the gender gap, which accounts for a 57% of the total decrease in inequality.

Table 6. Decomposing inequality trends by gender

Within gender inequality		**43%**
Men	9.39%	
Women	33.60%	
Gender gap		**57%**
Total inequality change		**100%**

[28] This echoes Humphries (1991) criticism of the lack of integration of research on women and mainstream discussions.

We see, therefore, that during these decades women's wage structure underwent more significant changes than men's. These changes may be due to several factors, the most important one being a shift of female labour from part-time to full-time work. There are no data on changes in hours worked per day, but an indirect approach to this shift is to consider the transition from outworkers doing piecework to labourers in factories working for a daily wage. In 1856, 72% of workingwomen were engaged in piecework. In 1905 information is much more incomplete, but the estimate is that the number of women engaged in piecework ranged between 40% and 60% of the female labour force. Additionally, even amongst piecework labourers, there was a tendency to move the workplace from the house to the factory, under direct supervision of the managers who exercised control over the hours worked. This explains both the wage compression amongst women and the narrowing of the gender gap. Pieceworkers at home (even those working under the same piece rates regime) were likely to experience higher variation in their earnings due to the flexibility of working hours. Women tend to combine housework with outwork, and different family needs across individuals can lead to very different outcomes in terms of hours worked, and therefore in earnings. The homogenization of daily working hours amongst women explains the reduction in earnings inequality within the female labour force.[29]

Two alternative (although not mutually exclusive) explanations help us understand the decrease in the gender gap. The first refers to the fact that women constituted a much higher proportion of all piece rate workers than men. In 1856 only 35% of men were paid according to piece rates. This, combined with the fact that, for both sexes, earnings arising from piecework were lower than those derived from daily wages, reinforces the hypothesis that the female shift towards the factory and a daily wages regime, equivalent to a shift from part-time to full-time labour, accounts for much of the decrease in the gender gap. I will further explore this hypothesis in the next section with an Oaxaca type decomposition. The main intuition behind this thesis is that outworkers tended to earn less than workers at the factories, most probably because they worked a fewer number of hours a day. In mid-nineteenth-century Britain, a Parliamentary investigator reported that women handloom weavers working in shops

[29] The argument that factory discipline increased work effort is an old one, see Pollard (1963). In Clark (1994), there is evidence from different firms in Britain showing that factory discipline introduced a premium on weekly earnings. And, what is even more relevant for the arguments put forward in this paper, the 'discipline premium' was much higher for women than for men. See Clark (1994), p. 145.

earned nearly 30% more than those working at home, and he attributed this difference to the difference in hours worked. Women at home, he said, tended to be married and combined weaving with domestic duties.[30] The data in the survey give some evidence that allows us to tentatively measure how the role of household care eroded women's earnings, and how the transition to the factory could have helped women's wages to catch up with men's. The 1856 Survey clearly distinguishes, for the case of weavers, male and female outworkers from those working at the factory. Female handloom weavers and Jacquard adapted loom weavers earned 75% and 43% more respectively than their counterparts working at home, whereas male weavers at the factory only earned 18% more than those working at home. In other words, this means that the gender gap for the same task was higher within the household than at the factory, and this difference probably represents the weight of female household responsibilities.

The second explanation relates to changes in the overall wage structure and to what extent they can influence the gender gap. I will explore whether what changed was women's position in the labour market (their type of employment and characteristics), or was it instead the remuneration associated with male characteristics (e.g. the wage premium associated with employment in male sectors).

IV.1. The transition from 'part-time' to 'full-time'

There is not much empirical evidence on number of hours worked by men and women in the nineteenth century, nor on individual workers' characteristics. It is, therefore, nearly impossible to study whether hourly rates corresponded to productivity rates, and thus conclusively find out whether discrimination took place. Using the 1856 survey and the additional information it provides on different types of workers, I have performed an Oaxaca decomposition of wage determinants to identify some of the sources of the gender wage differentials. Consider the following regression equation:

(1) $Yi = \beta_{ji} X_{ji}$

where i denotes two groups, i.e. males (m) and females (f), β is the vector of parameters (including the constant term) and X are the independent variables included in the regression.

[30] Quoted in Burnette (1997), p. 263.

We know that fitted regression lines go through the point of means:

(2) $\overline{Y}_m = \beta_m \overline{X}_m$

(3) $\overline{Y}_f = \beta_f \overline{X}_f$

Therefore the difference in average wage rates would be:

(4) $\overline{Y}_m - \overline{Y}_f = \beta_m \overline{X}_m - \beta_f \overline{X}_f$

If we substitute $\beta f = \beta m - (\beta m - \beta f)$, we can rewrite equation (4) in the following manner:

(5) $\overline{Y}_m - \overline{Y}_f = \beta_m (\overline{X}_m - \overline{X} f) + (\beta_m - \beta_f) \overline{X}_f$

The first term of the right side of the equation is telling us how much of the wage differences is explained by different characteristics between men and women, whereas the second term, which multiplies women's characteristics by the difference in the coefficients, is pointing at the discrimination that might exist against women, reflected in a different treatment to similar characteristics. This term is the 'discriminatory' component. However, it is not the purpose of this paper to study gender discrimination. What we here call the *discriminatory* component corresponds in fact to an *unexplained* component. Since we do not have information on workers' other characteristics (such as human capital, be it education or job experience), or on productivity, we cannot claim that discrimination took place.

The only non-categorical variable available and included in the regression is the number of days worked per year for different occupations. Although our analysis will be based on daily wages (wage rate per day worked), it is important to take into account that the figure of annual working days eventually determines the annual earnings for each worker: given a daily wage, the more days a labourer can work, the higher his annual income will be. The number of working days is a proxy for regularity, and varies with industries. It is logical to think that a worker will find it more desirable to work in an industry that operates for most of the year. That is, regularity is an amenity, and it is therefore reasonable to expect it to be negatively correlated with wages. In other words, higher wages should compensate for fewer working days. The coefficient on the regression is indeed negative.

A second variable of importance is qualification. The survey divides the working population into masters, journeymen, assistants and apprentices, the latter working without economic reward. If qualification corresponds to higher productivity and/or higher responsibility, wages should increase with skills. The

regression uses a dummy for masters, and journeymen are the excluded category.

The third variable analysed is the pay basis. It has already been mentioned that although many workers would earn their pay indiscriminately from piecework or daily wages, for many of them the pay basis was always constant. Did this make a difference to their earnings? The use of piece rates was dominant in those occupations where productivity was clearly measurable and monitoring difficult, especially if some work was undertaken at home. The paradigmatic sector, in this case, is the textile industry: in Barcelona, according to the survey, 85% of those workers paid by piece rate worked in the textile industry. The use of piece rates has clear advantages for firms: first, they do not need to pay for training (workers bear the costs of learning through lower wages), and second, they do not have an incentive to resist workers preferences for flexibility, since these will not have any cost for the firm.[31] It is the advantage of flexibility that should make us think that workers consider piecework as an advantage, and are therefore more inclined to accept a wage reduction in exchange for that. Table 4 shows that, indeed, the coefficient for piecework labour is negative, indicating that those being paid at a daily basis earned more than those working for piece rates.

Finally, a last variable has been included that measures a feature of the industry, whether men and women worked together or not. There are not many reasons to think, in principle, that this would influence wages, except for the fact that women's work in the past has been linked to non-skilled work, and this would reduce wages. However, the variable is relevant in the context of a debate around whether women's work could be perceived by men as a threat. Borderías and López Guallar, in their criticism of Cerdà's use of data, pointed out that highest wages for males were found not in those occupations exclusive to men, but in those where men were in charge of the main tasks and women of those secondary.[32] Still, when controlled for the other variables, male wages in those occupations where men and women worked together are lower, while women clearly benefited from working in a mixed environment. This will be relevant to evaluate to what extent employment segregation was responsible for the gender gap.

31 Leunig (2003).

32 Borderías and López Guallar (2001), p. 38.

Table 7. What determines men and women's wage rates differences?

	Characteristics		**Coefficients**		**Explained by characteristics**	**Unexplained by characteristics**
	$\bar{X}_m$	$\bar{X}_f$	β_m	β_f	$(\bar{X}_m - \bar{X}_f)\beta_m$	$(\beta_m - \beta_f)\bar{X}_f$
Constant	1	1	4.170	5.040		
Working days/year	258.28	241.75	–0.008	–0.015	–9.72%	105.05%
Master	0.74	0.96	0.452	0.200	–8.10%	19.84%
Earnings p/work	0.35	0.72	–0.075	–0.572	2.23%	29.15%
Mixed work	0.32	0.40	–0.075	1.120	0.61%	–39.07%
Daily wages	2.59	1.36	1.23 (100%)		–14.98%	114.98%

Note: There are 17,894 valid observations for men and 5,888 for women. All coefficients are statistically significant at a 99% confidence level. The Chow-test also shows that coefficients between the two regressions are significantly different from each other. The constant and the 'working days/year' are somehow overlapping in the overall explanation of discrimination, although it is interesting to see in the parsimonious regression that there is a trade-off between 'regularity' and 'daily wages', for which I keep the coefficients separate. Daily wages are ptas/day. Discrepancy in average wages with Table 5 is due to the fact that the sample here analysed is smaller since it includes only those observations for which all variables in the regression are available.

What we first see in the decomposition analysis is that most of the differences between men and women's wages remain in the unexplained (often called 'discriminatory') component. Only the fact that women get higher wages in mixed occupations gives some advantage to women. General discrimination against women is captured by the sum of the constant and working days coefficients, since eventually the latter specifies how much less women earn per working day controlling for the rest of variables. With regard to qualification, we see that although the percentage of masters amongst women is higher than amongst men (96% to 74%), and although in both cases being a master implies a higher wage with respect to other qualifications, this skill premium is much lower for women. But perhaps the most interesting finding is the penalty in terms of earnings of women engaged in piecework, since this arises both from the fact that piecework generates lower earnings for women, and that women are a higher proportion (72% in comparison to 35% of men) working under a

regime of piece rates, which supports the hypothesis that the transition from piecework to daily wages might have played a big role in reducing the gender gap.

There is evidence (other than that found in the surveys) on the decline of piecework and its intensive use of female labour. Table 8 shows data on the organization of work in the most important Catalan textile firm, La España Industrial. Workers are classified according to their pay basis, whether piece rates or daily wages, and the decline of piecework over these 50 years stands out clearly. All piecework workers in La España Industrial were, according to Enrech (1997), women, and women's involvement in piecework declined particularly in the spinning section of the factory.

Table 8. Pay basis at a big textile factory: La España Industrial

	1857	**1867**	**1877**	**1887**	**1897**	**1907**
Daily wages	47%	50%	45%	50%	62%	67%
Piece rates	53%	50%	55%	50%	38%	33%
N workers	1,217	1,398	1,548	1,055	1,032	1,075

NOTES: Data from C. Enrech (1997), pp. 132 and 152.

In Table 7, only the fact that women get higher wages in mixed occupations gives some advantage to women. We can analyse, therefore, whether in the 50 years here studied employment segregation decreased, for that could be a factor increasing women's wages relative to men's.

IV.2. Wage structure, segregation and the gender gap

Blau and Kahn (1996), in an influential article, emphasize the role of the wage structure as a factor influencing the gender gap across countries for the second half of the twentieth-century. Their main argument is that given a set of male and female workers' characteristics, if the array of prices set for various labour market skills differs, this can have important consequences for the gender gap. Imagine we face, for example, the same degree of gender occupational segregation in two countries. If in one of them the wage premium associated with employment in male sectors is bigger, so will be the gender gap. Skill prices can be affected by relative supplies, by technological changes or, as Blau and Kahn emphasize, by wage setting institutions (such as minimum wage legislation). I will consider these factors in the next section. First, though, we want to get a

better insight on the sources of gender wage differentials. We have already seen that working patterns and regularity account for much of the reduction of wage inequality amongst men and women, and are also responsible for part of the decrease of the gender gap. We now want to know to what extent changes in the overall wage structure might have influenced the gender gap, or whether the main explanatory factors lay in gender-related variables, such as segregation or gender differences in human capital.

It is argued that one of the sources of the gender gap is not only that within any sector women are doing the lower paid jobs (*vertical segregation*) but that women tend to concentrate in low paid industrial sectors (*horizontal segregation*). The two surveys of the working class provide indications of the sectors each occupation belongs too. I have opted for a seven sectors classification which includes the building industry, the chemical industries, the metallurgic sector, the printing trades, services (incomplete since they do not include domestic service), textiles (including tasks which are auxiliary to textiles, such as bleaching) and others, which gather a group of small sectors that range from paper industries to luxury trades.

Table 9 shows us that segregation decreased between the two benchmarks here studied. On the one hand in 1856, for example, there were no women working in the building, chemical or printing sectors, but in 1905 there were some female workers in these sectors. On the other hand, women were overrepresented in the textile industry or the services in 1856, which also turned out to be the sectors with lower wages, but their weight in these sectors had decreased by 1905. Indeed, the segregation or dissimilarity index shows that there was a considerable decrease in employment segregation.[33] And for those cases where we can compare the gender gap between the two benchmarks, we see a clear upwards trend of the female/male earnings ratio.

[33] The segregation index looks at how the distribution of men and women across sectors or industries differs. The index (S) ranges from 0 to 100, 100 being maximum segregation (there are no mixed sectors in the economy). See for example Humphries (1987) for further information and the degree of segregation in the nineteenth century. Following Humphries, we can also decompose changes in the segregation index in a structural effect (segregation resulting from increasing relative numbers in predominantly male or female industries), composition effect (an increase in segregation within industries with the industrial structure remaining unchanged) or an interaction effect (simultaneous changes) [see Humphries (1987), Appendix B for details]. The analysis for the Catalan case shows that interaction effects dominated.

Table 9. Horizontal segregation and the gender gap

	1856			1905		
Sectors	**% men**	**% women**	**gap**	**% men**	**% women**	**gap**
Building	100.00%	0.00%		99.24%	0.76%	0.48
Chemical	100.00%	0.00%		90.47%	9.53%	0.43
Metallurgic	94.65%	5.35%	0.59	95.96%	4.04%	0.50
Printing	100.00%	0.00%		80.12%	19.88%	0.26
Services	63.68%	36.32%	0.49	76.89%	23.11%	0.49
Textiles	13.94%	86.06%	0.57	43.90%	56.10%	0.21
Others	98.58%	1.42%	0.51	86.68%	13.32%	0.50
Segregation index	74.91			53.03		

Literacy rates also reveal how women's position in the labour market might have improved in the second half of the nineteenth century. Since 1860, the Spanish Census questionnaires included a question on literacy. Respondents could state whether they were able to read and write (literate), to only read but not write (semi-literate), or none of the above (illiterate). Table 10 shows literacy rates for all the population and for men and women in different Census years, calculated as follows:

$$Literacy\_rate_i = \frac{N_{literate,i} + 0.5 * N_{semi-literate,i}}{N_i} * 100$$

And the gender gap in literacy is derived from the following expression:

$$Literacy\_gap = 1 - \frac{Literacy\_rate_{women}}{Literacy\_rate_{men}}$$

Table 10. Literacy rates in the city of Barcelona

Literacy rates	**1860**	**1877**	**1887**	**1900**
Population	40.81%	51.57%	57.78%	50.37%
Men	54.90%	63.71%	68.53%	57.73%
Women	26.75%	40.22%	48.06%	43.64%
Literacy gender gap	0.51	0.37	0.30	0.24

The table shows a continuous increase of literacy rates up to 1887 for all groups, and a decrease between 1887 and 1900. This latter fall of literacy rates can be explained by the increasing inflow of immigrants with higher illiteracy

rates at the turn of the century from Spanish rural zones. Between 1860 and 1900, the years closest to the ones here analysed, literacy increased by 25% for the whole population. Furthermore, women's literacy rates converged to those of men and the gender gap in literacy decreased monotonically from 0.51 in 1860 to a low of 0.24 in 1900 (notice that in Table 3 we showed how the gender wage gap decreased from 0.56 in 1856 to 0.29 in 1905). If we assume, therefore, that literacy is a proxy for human capital and can therefore explain wage outcomes, we observe that while literacy increased considerably both for men and women in the second half of the nineteenth century, women's progress was more remarkable, which reinforces the hypothesis above that gender-related characteristics gave women a better position in the labour market.

The main conclusions with regard to gender, therefore, are that changes in the type of women's employment, their further involvement in different sectors of the economy previously confined to men, the decrease in both vertical and horizontal segregation, and the narrowing of the literacy gap account for the decrease in the gender gap that took place in the fifty years here analysed. Although this paper is concerned with changes in inequality and its causes, it also sheds light on the origins of the gender gap, by providing evidence of the higher involvement of women in outwork and piecework and the lower earnings it caused.

Including women's earnings in the measurement of inequality not only allows us to look at the evolution of female workers' experiences within the context of the whole economy, but also improves the estimate of true wage dispersion. This has implications for other inequality studies that do not take into account female earnings. Excluding women from the analysis would have underestimated inequality in the economy (measured by the Gini index) by more than 20%. Similarly, the analysis above has shown that it is important to take into account earnings arising from piecework, for the nineteenth century witnessed a transition to the factory and to daily wages that had profound effects not only on workers' wages and earnings inequality, but also on the supply of labour.[34]

[34] It is not the purpose of this paper to further explore this issue, but it is worth noting that the arguments put forward here support the idea of a shift towards a more work-intensive economy, similar to the one that characterized the Industrious Revolution in the previous centuries, which could boost demand in the economy.

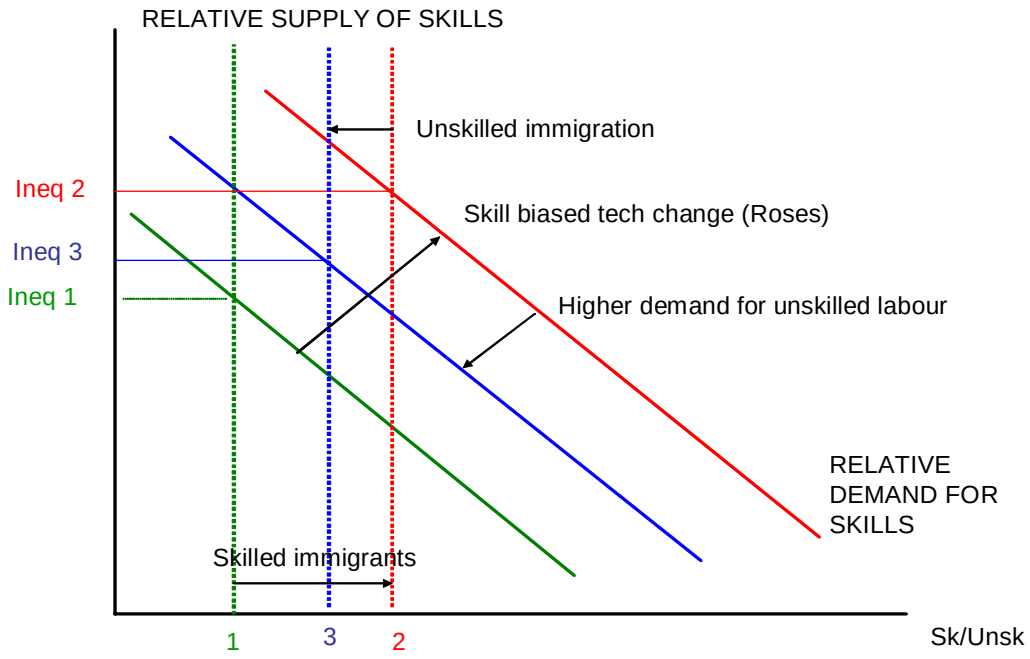
V. Conclusions: Explaining the rise and fall of wage inequality in Barcelona

By looking at two snapshots in time, this paper provides the first available estimates of wage dispersion in nineteenth-century Barcelona taking into account the entire distribution, and documents the compression of the pay distribution between 1856 and 1905. By using univariant measures of inequality that provide more information than the traditional Gini indexes, inequality changes are decomposed both by sector and by gender. It has been argued and documented that although traditional analyses of changes in earnings inequality tend to ignore female labour and earnings arising from piecework, these nonetheless seem to be key factors in explaining shifts in earnings inequality in industrializing societies. The sector analysis showed that most of the changes occurred within each industry, of which the textile industry stands out.

This paper started mentioning the Kuznets curve and its influence on studies on income inequality during industrialization. Is there evidence to talk about a Kuznets curve in Catalonia? To the extent that Kuznets' analysis of development included both rural and urban zones, the data analysed in this paper does not suffice to test Kuznets' theory. However, if we include the results of Rosés (1998*b* and 1999) for an earlier period, we can identify a rise and fall of wage inequality in the nineteenth century Catalan economy.

Figure 2 describes how supply and demand changes interacted in the Catalan economy to result in an initial period (1830–1860) of increasing inequality and a second phase of wage compression until the beginning of the twentieth century. The graph plots the ratio of skilled/unskilled wages (a summary indicator of inequality) over the relative supply of skilled and unskilled labour, which for simplicity here we can assume inelastic. In t = 1 (e.g. 1830), the skill premium is represented by Ineq1. Rosés' findings suggest that the three decades that follow were characterized by skill-biased technological change (technological implementations that increased the demand for skilled labour) that shifted the demand curve upwards. Additionally, on the supply side, evidence from marriage registers suggests that immigrants to Barcelona could have been contributing to increase the pool of skilled labour, but not enough to neutralize the effect of skilled biased technological change, which dominates and exerts upward pressure on skill premia, that rose to Ineq2.

Figure 2. Inequality and labour supply and demand in Catalonia, 1830–1905



After t = 2 (between 1856 and 1905) there is evidence, especially for the textile sector, of unskilled-biased technological change, that increased the demand for unskilled workers. This would suffice to explain the decrease in inequality we observe, together with organizational changes (and the transition from piece-work to daily wages) that reinforce this trend. Evidence on the supply side is more ambiguous. On one hand, literacy rates, if accepted as a proxy for human capital, would point at an increase in the supply of skilled labour. On the other hand evidence on immigrants in Barcelona in the last decades of the nineteenth century seems to suggest that the pool of skills amongst immigrants could be declining. The first scenario would suppose a shift to the right of the supply curve (not depicted in Figure 2) that would only reinforce the result of decreasing inequality. But decreasing inequality can also be the outcome if we include the second scenario in Fig. 2 and assume a decrease in the availability of skills in the population outbalanced by the demand changes.

The Catalan economy, therefore, witnessed an increase and subsequent decrease of wage inequality driven by labour demand changes and, more specifically, by the type of technological and organizational developments in the textile industry. Future research should determine whether this was a key factor in stimulating the rise of the working class and could therefore explain the power of the labour movement in Barcelona at the turn of the twentieth century.

References

Acemoglu, D., 'Technical change, inequality and the labor market', *Journal of Economic Literature*, XL (2002), pp. 7–72.

Acemoglu, D., 'Why do new technologies complement skills? Directed technical change and wage inequality ', *The Quarterly Journal of Economics*, 113 (1998), pp. 1055–1089.

Atack, J., Bateman, A. and Margo, R., 'Skill intensity and rising wage dispersion in nineteenth-century American manufacturing', *Journal of Economic History*, 64, 1 (2004), pp. 172–92.

Anuario estadístico de la Ciudad de Barcelona, Ayuntamiento de Barcelona (Barcelona, 1905).

Bairoch, P., *La Population active et sa Structure* (Brussels, 1969).

Bessen, J., 'The skills of the unskilled in the American industrial revolution', *Unpublished Working Paper* (September 2000).

Bessen, J., 'Technology and learning by factory workers: The stretch-out at Lowell, 1842', *The Journal of Economic History*, 63, 1 (2003), pp. 33–64.

Blau, F., and Kahn, L.M., 'Wage structure and gender earnings differentials: An international comparison', *Economica*, 63, n.250 (1996), Supplement: Economic Policy and Income Distribution, S29–S62.

Boot, H.M., 'How skilled were the Lancashire cotton factory workers in 1833? *Economic History Review* 48 (1995), pp. 283–303.

Borderías, C. and López Guallar, P., *La teoría del salario obrero y la subestimación del trabajo femenino en Ildefonso Cerdà* (Barcelona, 2001).

Brenner, Y.S., Kaelble, H. and Thomas, M., *Income distribution in historical perspective* (Cambridge, 1991).

Burnette, J., 'An investigation of the female–male wage gap during the Industrial Revolution in Britain', *Economic History Review*, 50, 2 (1997), pp. 257–281.

Camps, E., *La formación del mercado de trabajo industrial en la Catalunya del siglo XIX* (Madrid, 1995).

Cerdà, I., *Teoría general de la ubanización*, vol. III, (Madrid, 1968).

Clark, G., 'Factory discipline', *The Journal of Economic History*, 54, 1 (1994), pp. 128–163.

Domènech, J., 'Labour market adjustment to economic downturns in the Catalan textile industry, 1880–1910. Did employers breach implicit contracts?', *Economic History Working Papers*, No. 88/05 (2005), London School of Economics.

Eichengreen, B., ‘The impact of late nineteenth-century unions on labor earnings and hours: Iowa in 1894’, *Industrial and Labor Relations Review*, 40, 4 (1987), pp. 501–515.

Eichengreen, B. and Gemery, H.A., ‘The earnings of skilled and unskilled immigrants at the end of the nineteenth century’, *The of Economic History*, 46, 2 (1986), pp. 441–454.

Enrech, C., ‘La reforma de la organización del trabajo en “La España Industrial” a finales del siglo XIX’, *Sociología del Trabajo*, 29 (1997), pp. 135–156.

Feinstein, C., ‘The rise and fall of the Williamson Curve’, *The Journal of Economic History*, 48, 3 (1988), pp. 699–729.

Goldin, C., *Understanding the Gender Gap. An Economic History of American Women* (Oxford, 1990).

Goldin, C., and Sokoloff, K., ‘Women, children and industrialization in the early republic: Evidence from the manufacturing censuses’, *The Journal of Economic History*, 42, 4 (1982), pp. 741–774.

Harley, C.K., ‘Skilled labor and the choice of technique in Edwardian industry’, *Explorations in Economic History*, 11, 4 (1974), 391–414.

Hatton, T.J. and Williamson, J.G., *The Age of Mass Migration. Causes and Economic Impact* (Oxford, 1998).

Herscovici, S., ‘The Distribution of wealth in nineteenth-century Boston: Inequality among natives and immigrants, 1860’, *Explorations in Economic History*, 30 (1993), pp. 321–335.

Humphries, J., ‘ “… The most free from objection…” The sexual division of labor and women’s work in nineteenth-century England’, *Journal of Economic History*, 47, 4 (1987), pp. 929–49.

Humphries, J., ‘ “Lurking in the wings…”: Women in the historiography of the Industrial Revolution’, *Business and Economic History*, 20 (1991), pp. 32–44.

Hunt, E. H., ‘Industrialization and regional inequality: Wages in Britain, 1760–1914’, *Journal of Economic History*, 46, 4 (1986), pp. 935–66.

Jackson, R.V., ‘The structure of pay in nineteenth-century Britain’, *Economic History Review*, XL, 4 (1987), pp. 561–570.

Katz, L.F. and Murphy, K.M., ‘Changes in relative wages, 1963–1987: Supply and demand factors’, *The Quarterly Journal of Economics*, 107, 1 (Feb., 1992), pp. 35–78.

Kuznets, S., ‘Economic growth and income inequality’, *The American Economic Review*, 45, 1 (Mar., 1955), pp. 1–28.

Leunig, T., 'Piece rates and learning: understanding work and production in the New England textile industry a century ago', *LSE Working Paper* (2003).
Lindert, P. and Williamson, J.G., 'English workers' *Living Standards during the Industrial Revolution: A New Look*.
Mookherjee, D. and Shorrocks, A.F., 'A decomposition analysis of the trend in U.K. income inequality', *The Economic Journal*, 92 (1982), pp. 886–902.
Mora-Sitjà, N., 'Labour and wages in pre-industrial Catalonia', Discussion Papers in Economic and Social History, University of Oxford, 45 (May 2002).
Pollard, S., 'Factory discipline in the Industrial Revolution', *The Economic History Review*, 16, 2 (1963), pp. 254–271.
Rosés, J.R., 'Explaining the upswing of the kuznets curve during the Early Industrialization (Catalonia, 1830–1861)', Unpublished manuscript, prepared for the III Conference of the EHES in Lisboa (1999).
Rosés, J.R., 'Measuring the contribution of human capital to the development of the Catalan factory system (1830–61), *European Review of Economic History*, 2, 1 (1998*a*), pp. 25–48.
Rosés, J.R., *The Early Phase of Catalan Industrialisation, 1830–1861*, PhD dissertation, European University Institute (Florence, 1998*b*).
Scholliers, P., 'Industrial wage differentials in nineteenth-century Belgium', in Brenner, Y.S., Kaelble, H. and Thomas, M. (eds.), *Income distribution in Historical Perspective* (Cambridge, 1991), pp. 96–116.
Steckel, R.H., and Moehling, C., 'Rising inequality: Trends in the distribution of wealth in industrializing New England', *The Journal of Economic History*, 61, 1 (March 2001), pp. 160–183.
Williamson, J.G., 'American prices and urban inequality since 1820', *Journal of Economic History*, XXXVI, 2 (June 1976), pp. 303–333.
Williamson, J.G., 'Earnings inequality in nineteenth-century Britain', *The Journal of Economic History*, XL, 3 (1980), pp. 457–475.
Williamson, J.G., *Did British Capitalism Breed Inequality?* (Boston, 1985).
Williamson, J.G., 'Globalization and inequality then and now: the late nineteenth and late twentieth centuries compared', NBER Working Paper 5491 (March 1996).

[Continued from inside front cover]

21 Hans-Joachim Voth, *Time and Work in Eighteenth-Century London* (Dec. 1997)

22 Tim Leunig, *New Answers to Old Questions: Transport Costs and The Slow Adoption of Ring Spinning in Lancashire* (Feb. 1998)

23 Paul A. David, *From Keeping 'Nature's Secrets' to the Institutionalization of 'Open Science'* (July 2001)

24 Federico Varese and Meir Yaish, *Altruism: The Importance of Being Asked. The Rescue of Jews in Nazi Europe* (May 1998)

25 Avner Offer, *Epidemics of Abundance: Overeating and Slimming in the USA and Britain since the 1950s* (Nov. 1998)

26 David Stead, *An Arduous and Unprofitable Undertaking: The Enclosure of Stanton Harcourt, Oxfordshire* (November 1998)

27 Oliver Grant, *The Diffusion of the Herringbone Parlour: A Case Study in the History of Agricultural Technology* (December 1998)

28 Antonia Taddei, *London Clubs in the Late Nineteenth Century* (April 1999)

29 Liam Brunt, *Estimating English Wheat Production in the Industrial Revolution* (June 1999)

30 Matthew Braham, *Volunteers for Development: A Test of the Post-Materialism Hypothesis in Britain, c.1965–1987* (June 1999)

31 Paul A. David and Gavin Wright, *General Purpose Technologies and Surges in Productivity: Historical Reflections on the Future of the ICT Revolution* (September 1999)

32 Liam Brunt, *An Arbitrage Model of Crop Rotation* (September 1999)

33 Paul A. David and Gavin Wright, *Early Twentieth Century Productivity Growth Dynamics: An Inquiry into the Economic History of 'Our Ignorance'* (October 1999)

34 Avner Offer, *Economic Welfare Measurements and Human Well-Being* (January 2000). Rev. version, March 2000.

35 Liam Brunt, *'Where there's Muck, There's Brass.' The Market for Manure in the Industrial Revolution* (February 2000).

36 Alasdair Crockett, *Variations in Churchgoing Rates in England in 1851: Supply-Side Deficiency or Demand-Led Decline?* (August 2000).

37 Martin West, *State Intervention in English Education, 1833–1891: A Public Goods and Agency Approach* (October 2000).

38 George Speight, *Who Bought the Inter-War Semi? The Socio-Economic Characteristics of New-House Buyers in the 1930s* (December 2000)

39 Peter Temin, *A Market Economy in the Early Roman Empire* (March 2001)

40 Michael Biggs, *Positive Feedback in Collective Mobilization: The American Strike Wave of 1886* (April 2001)

41 Charles H. Feinstein and Mark Thomas, *A Plea for Errors* (July 2001)

42 Walter Eltis, *Lord Overstone and the Establishment of British Nineteenth-Century Monetary Orthodoxy* (December 2001)

43 A. B. Atkinson, *Top Incomes in the United Kingdom over the Twentieth Century* (February 2002)

44 Avner Offer, *Why has the Public Sector Grown so Large in Market Societies? The Political Economy of Prudence in the UK, c.1870–2000* (March 2002)

45 Natàlia Mora Sitjà, *Labour and Wages in Pre-Industrial Catalonia* (May 2002)

46 Elaine S. Tan, *'The Bull is Half the Herd': Property Rights and Enclosures in England, 1750–1850* (June 2002)

47 Oliver Wavell Grant, *Productivity in German Agriculture: Estimates of Agricultural Productivity from Regional Accounts for 21 German Regions: 1880/4, 1893/7 and 1905/9* (August 2002)

48 Oliver Wavell Grant, *Does Industrialization Push up Inequality? New Evidence on the Kuznets Cure from Nineteenth-Century Prussian Tax Statistics* (September 2002)

49 Alexandre Debs, *The Source of Walras's Idealist Bias: A Review of Koppl's Solution to the Walras Paradox* (January 2003)

50 Robert Dryburgh, *'Individual, Illegal, and Unjust Purposes': Overseers, Incentives, and the Old Poor Law in Bolton, 1820–1837* (March 2003)

51 David R. Stead, *Risk and Risk Management in English Agriculture, c.1750–1850* (October 2003)

52. Pablo Astorga, Ame R. Bergés, and Valpy FitzGerald, *Productivity Growth in Latin America during the Twentieth Century* (December 2003)

53. Teresa da Silva Lopes, *Evolution of Corporate Governance in Global Industries: The Case of Multinationals in Alcoholic Beverages* (February 2004)

54 Pablo Astorga, Ame R. Bergés, and Valpy FitzGerald, *The Standard of Living in Latin America during the Twentieth Century* (March 2004)

55 Regina Grafe, *Popish Habits vs. Nutritional Need: Fasting and Fish Consumption in Iberia in the Early Modern Period* (May 2004)

56 Nicholas Dimsdale: *Unemployment and Real Wages in Weimar Germany* (October 2004)

57 Pablo Astorga, Ame R. Bergés, and Valpy FitzGerald, *The Standard of Living in Latin America During the Twentieth Century* (March 2005)

58 Richard H. Steckel, *Fluctuations in a Dreadful Childhood: Synthetic Longitudinal Height Data, Relative Prices, and Weather in the Short-Term Health of American Slaves* (April 2005)

59 Federico Varese, *How Mafias Migrate: The Case of the `Ndrangheta in Northern Italy* (July 2005)

60 Avner Offer, *The Markup For Lemons: Quality And Uncertainty in American and British Used-Car Markets c.1953–1973* (September 2005)

61 Natalia Mora-Sitja, *Exploring Changes in Earnings Inequality during Industrialization: Barcelona, 1856–1905* (April 2006)

University of Oxford
Discussion Papers in
Economic and Social History

are edited by:

Jane Humphries
All Souls College, Oxford, OX1 4AL

Avner Offer
All Souls College, Oxford, OX1 4AL

Papers may be downloaded from
http://www.nuff.ox.ac.uk/Economics/History/