ANALYZING SEMIPARAMETRICALLY THE TRENDS IN THE GENDER PAY GAP - THE EXAMPLE OF SPAIN

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De conformidad con la base quinta de la convocatoria del Programa de Estímulo a la Investigación, este trabajo ha sido sometido a evaluación externa anónima de especialistas cualificados a fin de contrastar su nivel técnico.

Analyzing Semiparametrically the Trends in the Gender Pay Gap - The Example of Spain

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Abstract:

This article studies the trend in wage discrimination in Spain during the period 1995-2002. We first introduce a novel approach to the analysis of wage discrimination with methods which are rather robust to model (mis-)specification. To that end we apply semiparametric methods to the decomposition of wage differentials between men and women based on classical approaches. We extend the methodology to further decompositions and semiparametric quantile estimation, and discuss sample selection bias correction. In addition, to study inequality, some descriptive analysis is presented again using sophisticated nonparametric techniques.

Key words: wage differentials, quantile regression, semiparemtric model, gender pay gap, Oaxaca-Blinder decomposition.

JEL classification: C14, J16

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1- INTRODUCTION

For the past thirty years much attention has been paid to wage discrimination; in the US the focus has been more on discrimination due to race, while in Europe it has been mainly on gender discrimination. This article concentrates on the latter, investigating trends in the gender pay gap in Spain from the nineties to the beginning of the new millennium. We consider Spain to be a particularly interesting country in terms of wage discrimination (by gender) for several reasons.

The labor market in Spain has changed enormously from economic, legislative and social viewpoints in the last 30 years, since the advent of democracy in 1975. Apart from the transition to democracy, another driving force behind the changes in the labor market in Spain was the country's entry into the European Union in 1986. Changes had to be made in the 80s prior to enter into the EU, and further important changes took place throughout the 90s.

Furthermore, Spain has experienced considerable economic growth over the last thirty years. The economy boomed from 1986 to 1990, averaging 5% annual growth. After a Europe-wide recession in the early 1990s, the Spanish economy resumed moderate growth in 1994, which has continued up to the present thanks to the advantages provided by enormous quantities of economic aid from the EU. Spain has had one of the highest growth rates of any EU country in recent years with per-capita GDP growth of 3.6%, bringing per-capita income to 27,542 dollars in 2006. Unemployment in the Spanish labor market in the late 70s was at a level close to full employment. In 1976 the rate was 4.72% for men, and 4.94% for women. Unemployment increased sharply in the 80s, especially among women, and peaked in the early 90s at 22.87% for men and 29.53% for women. The situation began to improve in the second half of the 90s, but to a lesser degree for women. At the end of this period women were in a more precarious situation than men. In 2004 the unemployment rate was 7.76% for men but twice as high for women at 14.55%.

Many changes in legislation governing the treatment of men and women were introduced between the 70s and the 90s. There has been existing the general belief that one of the fundamental characteristics of the Spanish labor market was, and maybe is, the persistent, strong wage discrimination due to gender; for a similar job, men are clearly paid more than women. The equality principle was enshrined in Article 14 of the Spanish Constitution of

1978, which clearly prohibited discrimination on grounds of gender. The Workers' Statute Act of 1995 contains a number of rules on the equal treatment of men and women. Wage equality for work of equal value was established in Article 28. Moreover, the 3rd Plan for Equal Opportunities for Men and Women (1997-2000) recognized the need to incorporate more women into remunerated labor, the persistence of unjustifiable wage inequalities for women already working, and the existence of large-scale segregation of female employment. To palliate this unequal situation, a number of actions were taken under the Plan to provide women with real access to employment with full social and economic rights by encouraging structural changes and transformations that favored this purpose, with special emphasis on the reconciliation of family and working life.

As well as national legislation, there is a large body of European legislation with on equal treatment and labor market access of women and men. Among the legislative advances that deserve to be pointed out is the inclusion of the principle of non-discrimination on grounds of gender as one of the objectives of the EU. In 1997 the Member States jointly decided to implement a new strategy for employment in which equal opportunities should be an important, explicit component since it is one of the four pillars of the guidelines for employment in the Union. Partly, this has been done quite successfully such that the wage-gap has been converging, i.e. decreasing (especially) in the Mediterranean EU countries which today have a smaller gap than the other members, see OCDE (2002). Since 2006 a common anti-discrimination legislation is in force in most EU Member states including Spain. However, all this has had a positive impact mainly on possible discrimination in the public sector where today, we can hardly find a pay-gap anymore in Spain.

Another point worth highlighting is that considerable social changes took place over the period under study, such as the emancipation of women and their massive incorporation into the labor market (there was a great increase of the rate of female participation in the labor force among the 25-54 age group, with an employment rate up from 28.38 in 1976 to 40.97 in 1995) and also an increase in the level of education of women. Over the last 30 years Spanish women have dedicated much more time to studying (at present the percentage of women studying at university is higher than that of men), which is one reason why women enter the labor market later. Another demographic outcome worth describing is that women are marrying later, which considerably delayed the age at which they have their first child. This has allowed women to achieve some success as a labor force on the one hand and reduced the fertility rate to the lowest level in the history of Spain and one of the lowest in the world.

As mentioned above, all these elements entailed a massive incorporation of woman into the labor market. Albeit for different reasons, the market has not been able to absorb all this increase in the number of women who want to work, resulting in "an excess of female labor supply" on the labor market. This translates to some degree into a situation of discrimination against women on the labor market: their unemployment rates are higher than those of men in most sectors, the jobs that women take do not involve the same degree of responsibility or decision-making power as those of men, and women's participation is limited to a few sectors of the economy. In contrast to this bad news the wage gap has been seen to narrow steadily in recent years (see Palacio and Simón, 2006 and Simón, 2007). Nevertheless, in spite of this clear reduction, various jobs show that the wage gap remains notable, as mentioned above, mainly in the private sector on which we therefore will concentrate. Some papers that deserve to be mentioned here are Garcia et al (2001), Simón (2000), Fernandez et al (2000), Aláez et al (2000), Pérez and Hidalgo (2000), Amuedo-Dorantes and De la Rica (2006), and De la Rica, Dolado, and Llorens (2007), among many others. However, they all differ clearly from ours in their methods.

The main purpose of this paper are twofold: First we analyze the evolution of the gender wage gap over that time and the various factors that produce them. To that end we present a new semiparametric version of Oaxaca-Blinder method. The structure of the rest of the paper is as follows. The next section introduces our method for measuring sources and degrees of discrimination. Section 3 describes the data used and the trends in wage gaps between men and women through the estimation of density functions. Section 4 presents the main econometric results obtained and evaluates the trend in wage gaps. Section 5 concludes.

2. METHODOLOGY

There are several possible causes of the aforesaid wage gap. On the one hand there is labor segregation, due to which women are paid poorly because they are employed in bad jobs. On the other hand it can be seen that employers offer different wages for workers with very similar abilities. This wage dispersion within a company is less accentuated when sectorial collective bargaining is strongest and when wage limits are fixed by the government or by agreements between unions and employers' associations.

Typically, the analysis of wage discrimination employs either the method attributed to Oaxaca (1973) or the one introduced by Juhn, Murphy and Pierce (1991). The difference lies basically in the way in which the discrimination is identified or, in other words, how wage differences are decomposed and interpreted. In this study we have opted for the first of these methods for several reasons. Apart from the fact that it is easier to interpret, it is not clear how our semiparametric extensions can be incorporated in Juhn et al (1991).

The wage decomposition of Oaxaca-Blinder (1973) has been widely used to analyze wage discrimination by reasons of gender. This method allows the gap between the average wages of men and women to be separated into two parts. The first is explained by the difference between the observed productive characteristics of each group and the second lies in differences in the structure of the model, and is therefore not explained. This non explained part is usually considered as the wage discrimination by gender in the labor market.

We proceed below with the details of this procedure. Based on the Mincer wage equation model (1958) the reference equation is

$$\log W_i = X_i \beta + U_i \quad , \tag{1}$$

where "i" stands for an individual worker, W_i is the wage of that worker and X_i is a set of observable characteristics of that worker which linearly influence the logarithmic wage. Finally, U_i is the error term and β the vector of parameters. When we distinguish between men and women, we obtain:

$$\log W_i^m = X_i^m \beta^m + U_i^m \quad \text{and} \quad \log W_i^w = X_i^w \beta^w + U_i^w . \tag{2}$$

The superscript "w" refers to women and "m" to men. With help of this system of equations the decomposition of the wage gap between men and women according to Oaxaca-Blinder (1973) can be formulated as

$$\log \overline{W^m} - \log \overline{W^w} = \left(\overline{X^m} - \overline{X^w}\right)\beta^m + \left[\overline{X^w}\left(\beta^m - \beta^w\right)\right], \tag{3}$$

where the first summand on the right-hand side describes that part of the (average) gap between men and women which is explained and the second term represents the part that is not explained, and therefore the discrimination.

However, this method has limitations. First of all, it simplifies the level of disaggregation of wage discrimination since it depends on two factors: the choice of the wage structure in which there is no discrimination and the explanatory variables used in the regression. The disadvantage of the Oaxaca's approach, which considers that in the absence of wage discrimination the wage structure of men and women remains unchanged, lies in the assumption that employers create discriminating practices against women or demonstrate favorable attitudes toward men. Subsequent works, e.g. Cotton (1988) and Neumark (1988), develop methods of wage decomposition that allow the part of the discrimination due to the advantage which men may have and the disadvantage that women may have to be identified. The use of a particular model structure (i.e. neglecting possible differences in model structure for men and women), be it male or female, leads to extreme results, whereas the methods proposed by Cotton and Neumark allow more moderate estimations of the discrimination effects (Oaxaca and Ransom, 1994). It is also necessary to indicate that the selection of the variables used in the regression is crucial to avoid over- or underestimation of the discrimination effect.

A second problem of the method presented above lies in the fact that it provides information only on the conditional mean, which implies that the size of the wage gap and the weights of the factors that make it up are constant throughout the wage scale. To avoid this problem, different examples which analyse the wage gap between men and women by means of quantiles have been developed. Relevant papers include Buchinsky (1998), Pereira and Martins (2000), Melly (2005), Garcia et al (2001) and Sakellariou (2004) among others. Another way of avoiding the limitation indicated in this paragraph is the approach proposed by Di Nardo et al (1996), which analyses the wage distribution using non-parametric techniques.

The third limitation, which has so far been analyzed least, is based on the specification that is made with the wage equation. The previous approaches establish a parametric linear regression of the wage equation, although there is no theoretical or practical reason that justifies such a simple functional form. The choice of the parametric model depends, in most cases, on different factors. On the one hand, there may be a theory that recommends such a parameterization, and on the other hand there may be empirical evidence from the analysis of similar data. If the linear parametric model is chosen in an approximately correct form, the paradigm of the probability (Fisher, 1922) provides estimators with good statistical properties. Unfortunately, if the information that we have a priori is not very abundant the risk of incorrect specification is substantial, and in that case the statistical properties of the estimators obtained under the probability paradigm are very poor, so the conclusions of the analysis may be incorrect. In earlier studies on wage discrimination little attention has been paid to the specification of the relationship between the endogenous factor and its explanatory variables. Much more flexible methods of estimation can be used. Instead of supposing that the regression function belongs to a function space characterized by a rather small number of parameters, we assume that it is an element in a bigger function space, like for example that one of sufficiently often differentiable functions. We use semi-parametric estimation techniques which combine flexibility and the possibility of modelling. A good introduction and summary can be found in Härdle, Müller, Sperlich, and Werwatz (2004), Linton and Härdle (1994) and, with special emphasis on its relevant use in micro-econometric analysis, in Powell (1994).

Since the two first limitations have received a lot of attention already, in this work we present an approach that offers an alternative to the classical specification of the regression equation. In this article we use a new semiparametric estimator of the wage gap between men and women. We obtain the extension of equation (1) to a semiparametric environment with

$$\log W_i = X_i\beta + g(Z_i) + U_i, \quad (4)$$

where Z_i is a vector of explanatory variables, whose functional relation with the endogenous variable is not known, and $g(\ )$ is a non-parametric function that has to be estimated. It is even possible to specify the above equation distinguishing between men and women, so that we get the following system of equations:

$$\log W_i^m = X_i^m \beta^m + g^m\left(Z^m\right) + U_i^m , \qquad \log W_i^w = X_i^w \beta^w + g^w\left(Z^w\right) + U_i^w . \tag{5}$$

Like Oaxaca-Blinder, we express the difference between the average values of the two equations for 2002 as

$$\log\overline{W_{02}^m} - \log\overline{W_{02}^w} = \left(\overline{X_{02}^m} - \overline{X_{02}^w}\right)\beta_{02}^m + \left(\overline{g_{02}^m\left(Z_{02}^m\right)} - \overline{g_{02}^m\left(Z_{02}^w\right)}\right) + \left[\overline{X_{02}^w}\left(\beta_{02}^m - \beta_{02}^w\right) + \left(\overline{g_{02}^m\left(Z_{02}^w\right)} - \overline{g_{02}^w\left(Z_{02}^w\right)}\right)\right], \tag{6}$$

which allows us to obtain a first approximation of the wage discrimination that exists in certain countries. This total difference can be decomposed into two elements. The first two summands, also called "the explained part" are quite simply the wage gap due to personal characteristics (or endowments), which are measured for men and for women in the same way, e.g. age, experience, level of studies, etc. The third and fourth summands, the elements in brackets, represent the non explained part, and they reflect the wage difference which is caused by unobserved but different "wage structures" between the two genders.

The adaptation of the model of Oaxaca-Blinder for the inter temporal comparison of wage disparities shows the advantage of using different wage structures for an arbitrary country in two different time periods. Starting with equation (6) for a country in the two time periods 2002 and 1995, the difference in wage discrimination between these two periods can be written as:

$$\begin{aligned} D_{02} - D_{95} = {} & \underbrace{\left(\nabla\overline{X_{02}} - \nabla\overline{X_{95}}\right)\beta_{02}^m + \nabla\overline{g_{02}^m\left(Z_{02}\right)} - \nabla\overline{g_{02}^m\left(Z_{95}\right)}}_{\text{effect of the observed characteristics}} + \underbrace{\nabla\overline{X_{95}}\left(\beta_{02}^m - \beta_{95}^m\right) + \nabla\overline{g_{02}^m\left(Z_{95}\right)} - \nabla\overline{g_{95}^m\left(Z_{95}\right)}}_{\text{effect of the observed prices}} \\ & + \underbrace{\left(\overline{X_{02}^w} - \overline{X_{95}^w}\right)\nabla\beta_{02} + \nabla\overline{g_{02}\left(Z_{02}^w\right)} - \nabla\overline{g_{02}\left(Z_{95}^w\right)}}_{\text{effect of the feminine characteristics}} + \underbrace{\overline{X_{95}^w}\left(\nabla\beta_{02} - \nabla\beta_{95}\right) + \nabla\overline{g_{02}\left(Z_{95}^w\right)} - \nabla\overline{g_{95}\left(Z_{95}^w\right)}}_{\text{effect of the differences in the observed price}}, \end{aligned} \tag{7}$$

with the differential $\nabla\overline{X_{02}} = \overline{X_{02}^m} - \overline{X_{02}^w}$ (8)

and similarly defined $\nabla\overline{X_{95}}, \nabla\beta_{95}, \nabla\beta_{02}$. Wage differences are expressed by $D_{02} = \log\overline{W_{02}^m} - \log\overline{W_{02}^w}$, same for D_{95}. Furthermore we use $\nabla\overline{g_{02}^m\left(Z_{02}\right)} = \overline{g_{02}^m\left(Z_{02}^m\right)} - \overline{g_{02}^m\left(Z_{02}^w\right)}$ and $\nabla\overline{g_{02}\left(Z_{02}^w\right)} = \overline{g_{02}^m\left(Z_{02}^w\right)} - \overline{g_{02}^w\left(Z_{02}^w\right)}$, etc. Recalling this decomposition, the differences between these two time periods are caused by 4 factors:

The first reflects the differences which can be observed between the individual qualities (endowments) of men and women in the two periods. The second reflects the differences in valuations (or prices) of those individual characteristics at the two different times. The third represents the differences in individual characteristics of women between the two periods. The fourth characterizes the differences in valuations (or prices) that are observed for the same characteristics between men and women.

Several criticisms can be levelled at this approach. One such criticism lies in the fact that it does not consider a much more complex approach to wage discrimination such as the one developed by Juhn et al. (1991, 1993) or by Oaxaca, see Cotton (1988). In this case the starting equation for the year 2002 is

$$D_{02} = \ln \overline{W_{02}^{m}} - \ln \overline{W_{02}^{w}} = \left(\overline{X_{02}^{m}} - \overline{X_{02}^{w}} \right) \beta_{02}^{*} + \overline{X_{02}^{m}} \left(\beta_{02}^{m} - \beta_{02}^{*} \right) + \overline{X_{02}^{w}} \left(\beta_{02}^{*} - \beta_{02}^{w} \right), \tag{9}$$

where β_{02}^{*} is the wage structure in the absence of discrimination in the year 02. The semiparametric extension, starting from equation (9), is then

$$\begin{aligned} D_{02} &= \ln \overline{W_{02}^{m}} - \ln \overline{W_{02}^{w}} = \left(\overline{X_{02}^{m}} - \overline{X_{02}^{w}} \right) \beta_{02}^{*} + \left(\overline{g_{02}^{*}\left(Z_{02}^{m}\right)} - \overline{g_{02}^{*}\left(Z_{02}^{w}\right)} \right) + \\ &+ \overline{X_{02}^{m}} \left(\beta_{02}^{m} - \beta_{02}^{*} \right) + \left(\overline{g_{02}^{m}\left(Z_{02}^{m}\right)} - \overline{g_{02}^{*}\left(Z_{02}^{m}\right)} \right) + \overline{X_{02}^{w}} \left(\beta_{02}^{*} - \beta_{02}^{w} \right) + \left(\overline{g_{02}^{*}\left(Z_{02}^{w}\right)} - \overline{g_{02}^{w}\left(Z_{02}^{w}\right)} \right) \end{aligned} . \tag{10}$$

A limitation of the mean regression approach that underlies the above method is that it provides little indication as to what is happening to the gender pay gap at different points of the wage distribution. For the case of having a pure parametric specification, Koenker and Basset (1978) and Buchinsky (1994, 1998) introduce a GMM estimator to obtain the regression parameters of interest. For the purely non-parametric setting readers are referred to the approaches taken by Yu and Jones (1998) and Hall et al (1999), who propose the estimation of the conditional distribution function. For the selection of the optimal bandwidth in the estimation procedure see Ruppert (1997). For semiparametric quantile regression Cole and Green (1992) and Stengos and Sun (2006) develop an estimation method for the parametric part as well as for the non-parametric one. Lee (2003) estimates the parametric part in an efficient way, whereas Yu (1999) proposes a two-stage estimation method. For quantiles, the semiparametric specification of equation (4) for men in 2002 is given by:

$$Q_\theta\left(\ln W_{02}^{w} \middle| X_{02}^{m}, Z_{02}^{m}\right) = X_{02}^{m}\beta_\theta^{m} + g_\theta^{m}\left(Z_{02}^{m}\right), \tag{11}$$

where $Q_\theta(\ )$ represents the quantile of order "θ" of the wage density function conditioned by X_{02}^{m} and Z_{02}^{m}.

In Section 4 we therefore consider not only the semiparametric regression analysis and decomposition introduced above (compare equation (7)) but also the extension that solves the two problems discussed: on the one hand we use a non-discriminatory structure as presented in equation (10) and on the other hand we apply the semiparametric extension to quantile regression.

Our quantile regression approach uses equation (11) and the work of Machado and Mata (2004), who propose a decomposition process that combines quantile regression and the bootstrap method. First, quantile regression is used to obtain estimates of the conditional quantiles given by (11). The second idea involved in this technique is the Theorem of probability integral transformation from elementary statistics: If the random variable U has a uniform distribution on [0,1], then $F^{-1}(U)$ has distribution F. Therefore, for any given X_i, Z_i and the random variable $\theta \approx U[0,1]$, $X_i^{m}\beta_\theta^{m} + g_\theta^{m}\left(Z_i^{m}\right)$ has the same distribution as $\ln W_\theta^{w} \middle| X_\theta^{m}, Z_\theta^{m}$. If $X_\theta^{m}, Z_\theta^{m}$ is fixed and we take random variables from X, Z of the population, $X_i^{m}\beta_\theta^{m} + g_\theta^{m}\left(Z_i^{m}\right)$ has the same distribution as $\ln W_\theta^{w}$. The estimation process is formally represented by the following steps:

- Generate a random sample of size j with uniform distribution on [0,1]: $u_1,...,u_j$
- Estimate for each gender j different coefficients and non-parametric functions of the quantile regression: $\widehat{\beta}_{ui}^{m}, \widehat{g}_{ui}^{m}(\ ), \widehat{\beta}_{ui}^{w}, \widehat{g}_{ui}^{w}(\ )$, i=1,....,j
- Generate for each gender a random sample of size j with replacement from the values of X, Z, denoted by $\left\{\widetilde{X}_i^{m}, \widetilde{Z}_i^{m}\right\}_{i=1}^{j}$ and $\left\{\widetilde{X}_i^{w}, \widetilde{Z}_i^{w}\right\}_{i=1}^{j}$
- Obtain $\left\{\ln \widetilde{W}_i^{m} = \widetilde{X}_i^{m}\widehat{\beta}_{u_i}^{m} + \widehat{g}_{u_i}^{m}\left(\widetilde{Z}_i^{m}\right)\right\}_{i=1}^{j}$ and $\left\{\ln \widetilde{W}_i^{w} = \widetilde{X}_i^{w}\widehat{\beta}_{u_i}^{w} + \widehat{g}_{u_i}^{w}\left(\widetilde{Z}_i^{w}\right)\right\}_{i=1}^{j}$ as a random sample of size j from the marginal distributions of the wage ln *W* in accordance with equation (11)

- Generate a random sample of the "counter-factual" distribution. $\left\{\ln \widetilde{W}_i^{cf} = \widetilde{X}_i^m \widehat{\beta}_{u_i}^w + \widehat{g}_{u_i}^w\left(\widetilde{Z}_i^m\right)\right\}_{i=1}^j$ is a random sample of the wage distribution that will exist for women if all explanatory variables are distributed as they are for men.

Now the wage gap between the genders can be decomposed into the contribution of the coefficients and the contribution of the "covariates" using the technique of Machado and Mata (2004) who analyse changes in wage density. To simplify the comparisons of the decomposition of Oaxaca, we can decompose the quantiles in the wage distribution:

$$Q_\theta\left(\ln W^m\right) - Q_\theta\left(\ln W^w\right) = \left[Q_\theta\left(\ln \widetilde{W}^m\right) - Q_\theta\left(\ln \widetilde{W}^{cf}\right)\right] + \left[Q_\theta\left(\ln \widetilde{W}^{cf}\right) - Q_\theta\left(\ln \widetilde{W}^w\right)\right] + residual\,. \quad (12)$$

The first term on the right hand side is the contribution of the parameters to the wage gap between the $\theta -$th quantile for men and the $\theta -$th quantile for women. The second is the contribution of the explanatory variables. The residual contains the simulation errors that appear when many simulations are carried out. Assuming that the quantile equation (11) is correctly specified, the error term disappears (asymptotically) in (12).

A further criticism (see Garcia et al (2001) for a more recent discussion) concerns the problem of endogenous selection of women in the labor force. Assuming the availability of additional information about the labor participation of individuals, summarized in a vector of covariates T, we can apply for example the method of Heckman (1980) to our specification. For women in 2002 we would obtain the following simultaneous equation system:
$\ln \overline{W_{02}^w} = \overline{X_{02}^w}\beta_{02}^m + \overline{g_{02}^w\left(Z_{02}^w\right)} + \sigma_{02}^w\lambda\left(\overline{X_{02}^w}\alpha_{02}^w + \overline{m_{02}^w\left(Z_{02}^w\right)} + \overline{h_{02}^w\left(T_{02}^w\right)}\right) + U_{02}^w$ is selected if $\mathrm{I}^* > 0$ with $\mathrm{I}^* = \overline{X_{02}^w}\alpha_{02}^w + \overline{m_{02}^w\left(Z_{02}^w\right)} + \overline{h_{02}^w\left(T_{02}^w\right)} + V_{02}$, where $\overline{h_{02}^w\left(T_{02}^w\right)}$ is a nonparametric function and the residual terms V_{02} and U_{02} have joint normal distribution, whereas $\lambda(\ )$ is the inverse Mills ratio. Statistically, this correction "only" implies the inclusion of a new element in our regression equation but, at the same time, it assumes availability of information summarized in covariate vector T. When this fact is considered, the extension to our semiparametric specification causes no problems for identification or for estimation.

A different semiparametric estimator for regression data with selection bias problems is proposed by Li and Wooldridge (2002). Their approach could also be extended to our model (almost) straightforwardly.

In our application we disregard this extension due to several problems. One is that for Spain in 2002 we expect the selection biases for women not to be significantly different from the selection bias for men. Another reason is that we could not find a good instrument T. "Good" means that for any available T this extension increases the variances of our estimates unacceptably without significantly changing the estimation results. Actually, in semiparametrics we often face the problem that minor corrections for possible biases increase the variance so much that in the end one loses out when looking at the mean squared error – the most relevant criterion for the quality of statistical inference. We also found that most of the papers on the gender pay gap did not correct for a possible selection bias: they either argue that it is negligible or simply ignore it without discussion. We agree with all the papers that say that if significant selection biases exist they are expected to be (much) larger for women then for men. A careful study of the formulae discussed above reveals that all numerical results on the gender pay gap can then be considered as lower bounds of the actual gender pay gap. Bearing this in mind, Section 4 shows that – data permitting – a correction for this possible selection bias would not change our findings qualitatively but only quantitatively. This also holds true for our finding that the gender pay gap has decreased from 1995 to 2002, because the much higher female labor participation in 2002 also leads to a smaller selection bias (compared to 1995) resulting in a sharper lower bound than for 1995.

3. DATA AND DESCRIPTIVE STATISTICS

The data used in this paper come from the *Structure of Earnings Survey* (SES) conducted by Instituto Nacional de Estadistica (the Spanish National Institute of Statistics), which employs a method similar to that used in surveys of wage structures in other European countries. The SES consists of a two-level sampling of Spanish companies (stratified sampling in the first stage for local units, and systematic sampling for the selection of workers at those units). For 1995 there was a sample of 161423 workers, and for 2002 the total sample was of 161370 including only those who had full-time contracts and branches that existed in both years (branches C to K, see Table 1, loosing only some still pretty small and recent branches). This survey collects information on non-self-employed workers who work at establishments with at least 10 workers and covers a wide range of private sectors (industry, construction, commerce, the hotel & catering business, transport, financial intermediation, etc.) excluding the primary sector.

A special circumstance of the SES is that, due to its general character, it shows observations on different workers from the same workplace. This gives its data the nature of matched company/worker data, which is recommendable especially for the analysis of wage determination and therefore particularly interesting for the study in question here. We once more emphasize that we concentrate on discrimination in the private sector for reasons discussed in the introduction, compare Aláez and Ullíbarri (2001) also for the limitations arising. Finally, we believe that the considered years are comparable as they do not show major differences concerning the business cycle, a possible source of distortion when comparing wage discrimination (Alaéz and Ullíbarri, 2000).

Table 1: Explanation of variables

Wage	Gross hourly earnings form employment
Ln(wage)	The natural logarithm of wage
Expr	Lenght of service in the actual enterprise, number of years
Age	Number of years of the employee
Intern. Market	Dummy: 1 if products are mostly sold outside Spain
(Loc-national Market)	Dummy:1 if products are mostly sold in local or national market
Enterprise size 1	Dummy: 1 if between 16 and 25 employees in the enterprise
Enterprise size 2	Dummy: 1 if 25 or more employees in the enterprise
(Enterprise size 0)	Dummy: 1 if less than 16 employees
Ed. level 1	Dummy: 1 if high school or apprenticeship level studies are held
Ed. Level 2	Dummy: 1 if university studies are held
(Ed. Level 0)	Dummy: 1 if primary studies are held
Long term	Dummy: 1 if contract is long-term
(Short term)	Dummy:1 if contract is short-term
C	Mining and quarrying industry
D	Manufacturing industry
E	Energy
F	Construction
G	Wholesale and retail trade, repair of motor vehicles
H	Accommodation and food service activities
I	Transportation and storage
J	Finance and insurance
(K)	Renting and other auxiliary activities

In brackets the option used of reference in the different regressions

Table 1 summarizes the variables we include in our model. The notion of “loyalty” might be more appropriate than “experience” to describe what is actually measured. However, it must be noted that interruptions are not counted, so this variable really reflects working time.

Second, for Spain the difference between experience in a particular job and loyalty to the firm is often negligible since Spain has the lowest mobility of any industrialized country in the world. Third, in Spain loyalty is typically more important for salary purposes than what is commonly understood as "experience". Finally, note that by law (in force for the whole period of interest) women can return to their job (at least at the same level) after a maternity break of up to three years. To our knowledge, women in Spain often make use of this opportunity and typically do not use this break to change firms afterwards.

Note further that the list of covariates in Table 1 is the result of a previous model selection not documented here. A less typical variable in this kind of studies is *intern. market*. It turned out to be clearly significant, it reflects that the company is under the pressure of global competition but is certainly also correlated with size. As shown in Section 4, these covariates give always an R square larger than 50% for both genders and periods studied.

3.1 DESCRIPTIVE STATISTICS OF THE LOG WAGES

The study of wage data is based on two elements: first, descriptive statistics give information about position, dispersion and form of distribution (among other things), and second, we have a nonparametric visual tool of great potential in the density function. Instead of using the frequency histogram, nonparametric kernel density estimation can be carried out as in the paper by Melly (2005), see below.

The logarithm of the hourly wage is used as the wage concept. It is calculated as the annual gross income divided by the number of hours worked in the year. Table 2 shows the descriptive statistics of the dependent variable for 2002 and 1995. Measurements of position, the mean and the median reflect higher values for men in both years.

Table 2: Descriptive statistics of ln(wage/hour) in 2002 and 1995

	2002		1995	
	Male	Female	Male	Female
Number of data	120317	41053	126743	34680
Min	-1.3325	-0.2794	-1.0076	-3.409
Max	5.3772	5.0052	4.864	4.2527
Mean	2.2963	2.0577	2.1328	1.7774
Median	2.2728	2.0204	2.1219	1.7665
Standard deviation	0.6344	0.5855	0.6138	0.6367

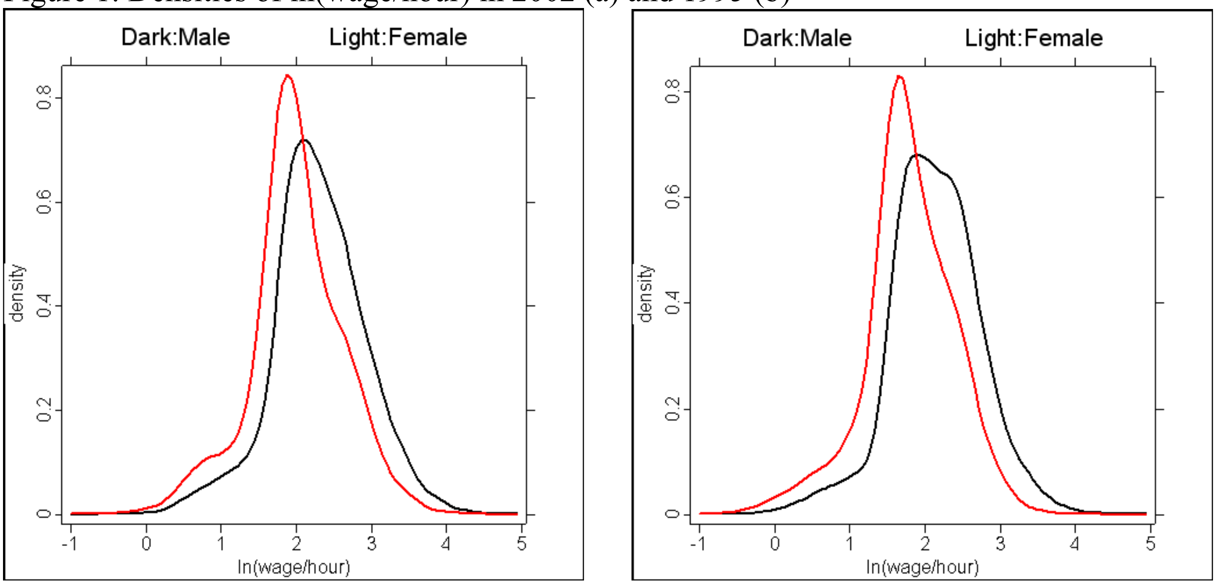
The nonparametric density estimator consists of estimating f(x) without assuming that it belongs to a pre-established parametric family. Parzen (1961) and Rosenblatt (1970) propose a density estimator given by:

$$\hat{f}_h(x) = \frac{1}{nh}\sum_{i=1}^{n} K\left(\frac{x - X_i}{h}\right) \tag{13}$$

with n being the total number of data available. Here, h is the width of the window and K( ) is a kernel function. For more details of the nonparametric method see Härdle et al (2004).

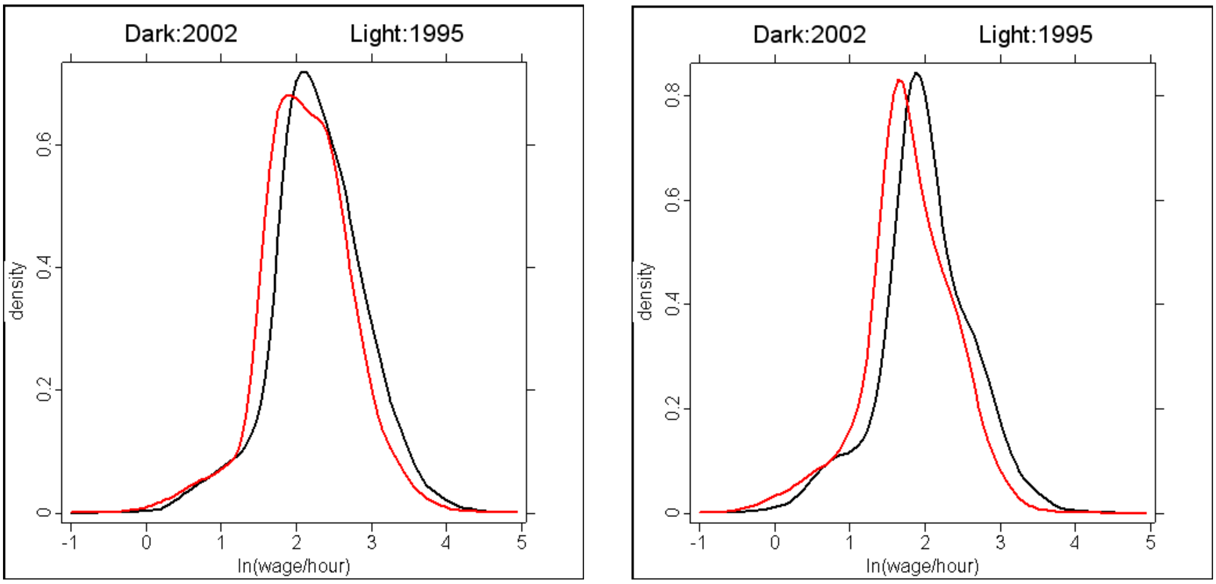
Figures 1 and 2 show the results obtained for the density functions of the wage/hour in logarithm for men and women separately for two different time periods (1995 and 2002) and their changes over time. As expected for a distribution of the log of wages, we can consider these functions as almost symmetric. Figures 1(a) and 1(b) for 1995 and 2002 seem to show that women tend to be located more on the left-hand side. Nevertheless, as the wage increases, this function always appears below that of men. Turning to the trend in wages in these two years, graphs 2(a) and 2(b) show that there was a general increase in the wage for women, but no clear increase for men. The mode of the density function for women is located further to the right in 2002 than in 1995, but for men it seems that no similar growth took place. Unquestionably, the mean increased between 1995 and 2002 with emphasis on the case of women.

Figure 1: Densities of ln(wage/hour) in 2002 (a) and 1995 (b)



(a) (b)

Figure 2: Densities of ln(wage/hour), evolution:02 – 95 of male (a) and female (b)



(a) (b)

4. MAIN RESULTS

We study the gender pay gap in three steps. We start with a comparison of the joint distributions of log wages and their continuous covariates for men and women. Next we carry out a regression analysis and the resulting wage gap decomposition, as introduced in Section 2. Finally, we do the semiparametric quantile analysis which was also introduced in Section 2.

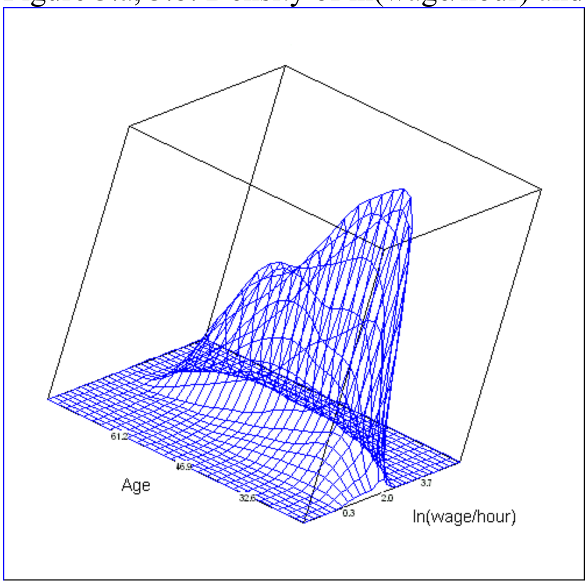
4.1 A DISTRIBUTION BASED COMPARISON OF WAGES

When no particular structure is considered, the most rudimentary, most flexible model that comes to mind is the joint distribution of variables in terms of their density. As the counterpart for the mixture of continuous and discrete data is much more complicate we restrict ourselves here to illustrating the relationship between log wages and age and years of experience, respectively. To that end we use an extension of the nonparametric density estimator given in the previous section. If we have two variables (x,y) for n observations, an estimator of f(x, y) can be calculated using the expression:

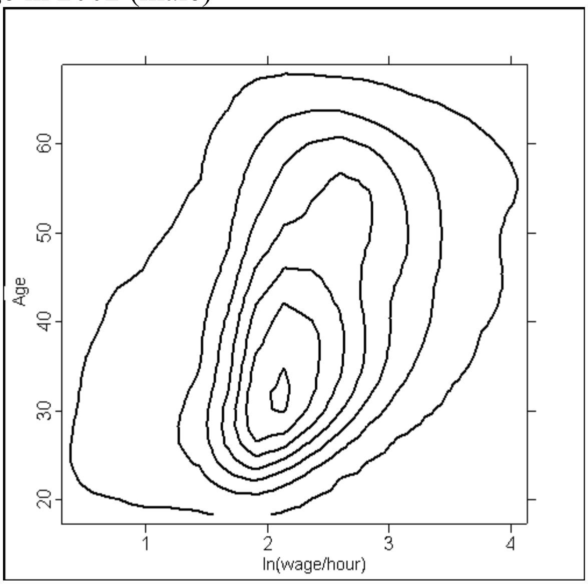
$$\widehat{f}_h(x,y)=\frac{1}{nh_xh_y}\sum_{i=1}^{n}K_x\left(\frac{x-X_i}{h_x}\right)K_y\left(\frac{y-Y_i}{h_y}\right) \tag{14}$$

with h and K being as defined above. Graphs 3 - 6 show the results for the two-dimensional functions for wage-age and wage-experience in 2002. In Graphs 3.a and 3.b a cross line perpendicular to any point on the year axis gives a conditional distribution of the wage for a certain age. Keeping this point in mind, contours are observed that run from north to south with a slight leftward tendency, which implies that wage distribution depends on age distribution for male and female workers. With regard to years of experience, Graphs 6.a and 6.b of the two-dimensional density function show a situation very similar to the one for age, though in this case a slight diagonal tendency is observed in the contour, which again reflects a positive relationship between the distributions of these two variables.

Figure 3.a, 3.b: Density of ln(wage/hour) and Age in 2002 (male)

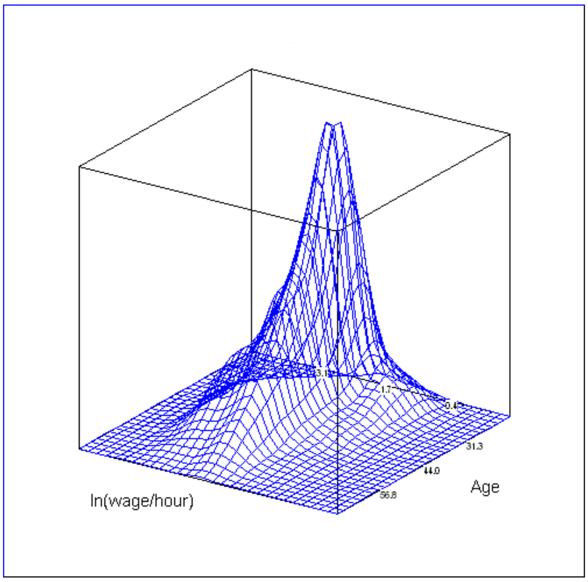


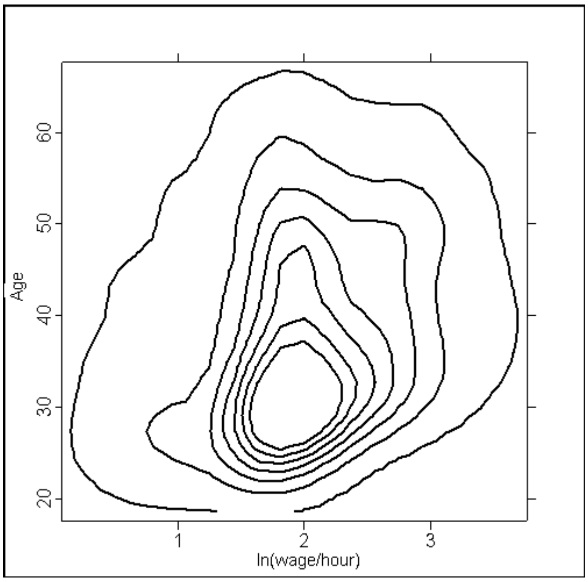
(a)



(b)

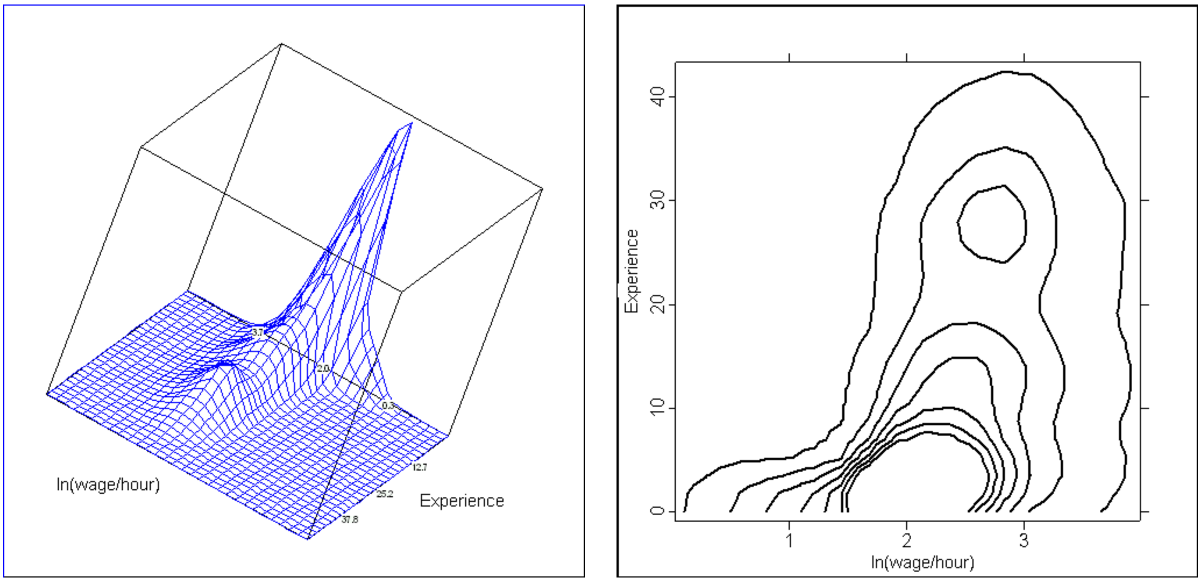
Figure 4.a, 4.b: Density of ln(wage/hour) and Age in 2002 (female)





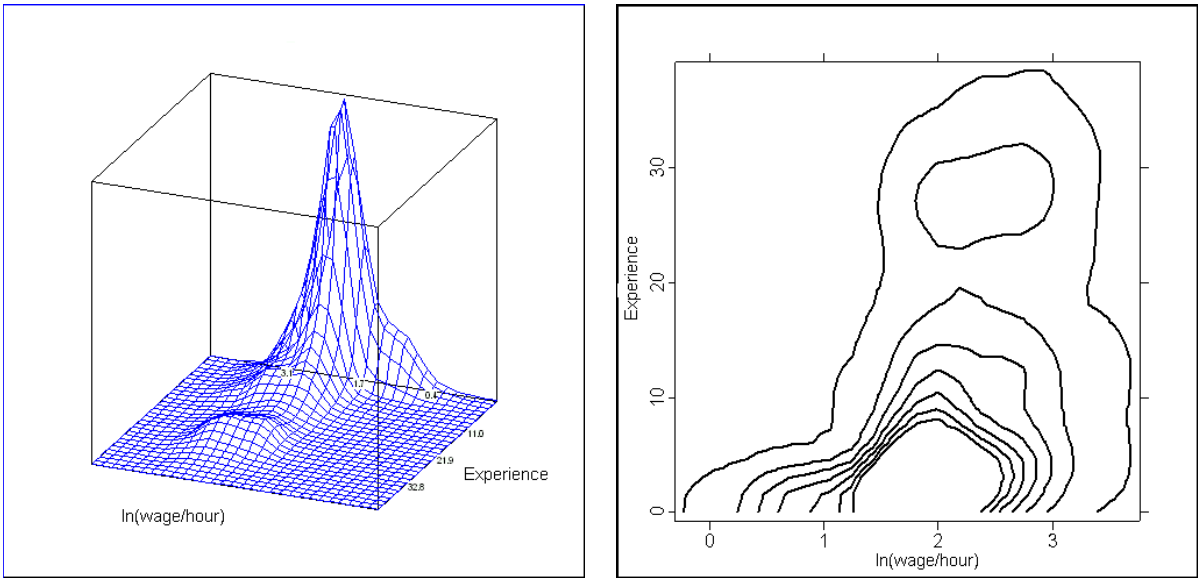
(a) (b)

Figure 5.a, 5.b: Density of ln(wage/hour) and Experience in 2002 (male)



(a) (b)

Figure 6.a, 6.b: Density of ln(wage/hour) and Experience in 2002 (female)



(a) (b)

4.2 REGRESSION RESULTS

Before beginning to apply the more sophisticated semiparametric approach, we tested the validity of the alternative (fully) parametric analysis. We adapted the nonparametric test of Härdle, Mammen and Müller (1998) to compare the fully parametric regression model with our semiparametric alternative. For more details on semi- and nonparametric specification tests, see also Härdle et al (2004). We rejected the parametric null hypothesis for the log wage equation for both years and both genders at the 10% rejection level.

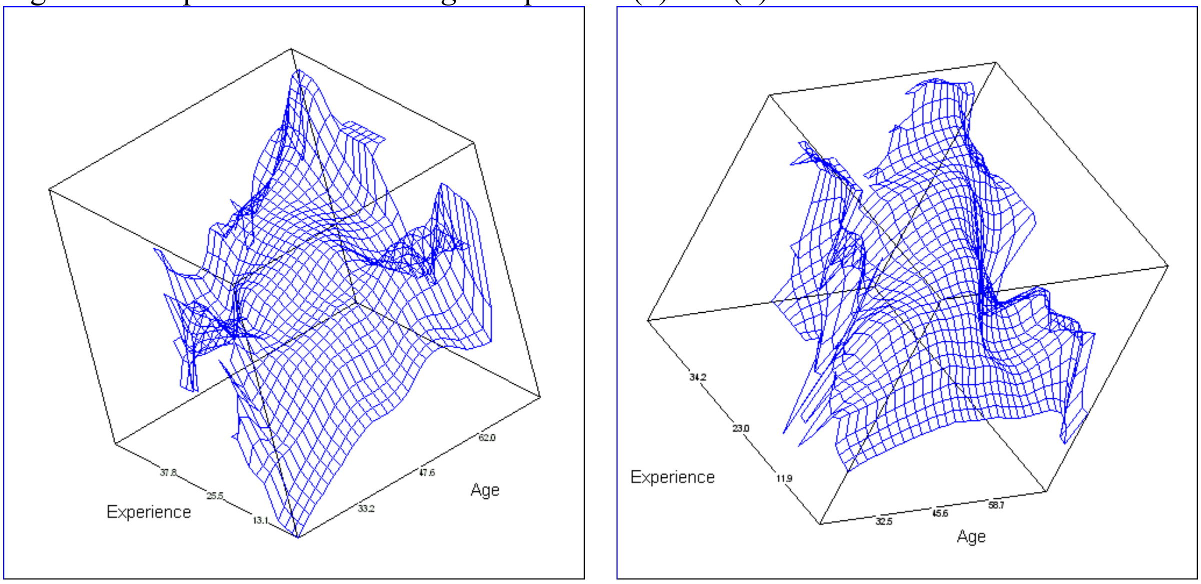
Now let us turn to the results obtained with the method presented in Section 2. As all covariates are dummies except Experience and Age, only these two enter into the nonparametric part. Our first step consists of separately estimating equation (5) for both the years in question. Table 3 shows the semiparametric estimates. Most of the parameter estimates are significant. It must be emphasized that the results obtained are in agreement with other studies on wage determination. The variables that positively influence the wage of a worker are: belonging to a large company, having university education, and having a long-term contract. In terms of sectors, energy supply (E) and the financial sector (J) influence wages strongly positively, whereas the influence of being in the hotel and catering business (H) is clearly negative.

Table 3: Coefficient estimates and goodness of fit measure

Year	2002				1995			
	Male		Female		Male		Female	
	Param	s.e.	Param	s.e.	Param.	s.e.	Param.	s.e.
Intern. market	0.0767	0.0002	0.0890	0.0002	0.0755	0.0001	-0.0534	0.0004
Company size1	0.0827	0.0002	0.0420	0.0003	0.0748	0.0002	0.0508	0.0005
Company size2	0.2446	0.0002	0.1103	0.0002	0.2533	0.0002	0.176	0.0004
Educ. Level 1	0.1687	0.0002	0.1629	0.0002	0.1553	0.0001	0.2035	0.0003
Educ. Level 2	0.5483	0.0003	0.4928	0.0002	0.6871	0.0003	0.5865	0.0009
Long term	0.3429	0.0002	0.3663	0.0002	0.2993	0.0003	0.2368	0.0005
C	0.2183	0.0015	0.0965	0.0040	0.0537	0.0016	0.2394	0.0127
D	0.0393	0.0004	0.0271	0.0003	-0.0081	0.0006	-0.1219	0.0009
E	0.3393	0.0013	0.3772	0.0018	0.2765	0.0014	0.1852	0.0045
F	0.1209	0.0006	0.1249	0.0016	0.0577	0.0008	0.0801	0.0030
G	0.0151	0.0007	-0.0310	0.0004	-0.0400	0.0008	-0.2278	0.0012
H	-0.1451	0.0011	-0.0241	0.0005	-0.1226	0.0013	-0.1112	0.0013
I	0.1141	0.0007	0.1542	0.0007	0.0891	0.0009	0.0501	0.0018
J	0.3406	0.0009	0.3370	0.0006	0.2635	0.0009	0.2147	0.0014
R^2	0.5331		0.5205		0.5198		0.4825	
Mean(y)	2.2987		2.0577		2.1406		1.7774	

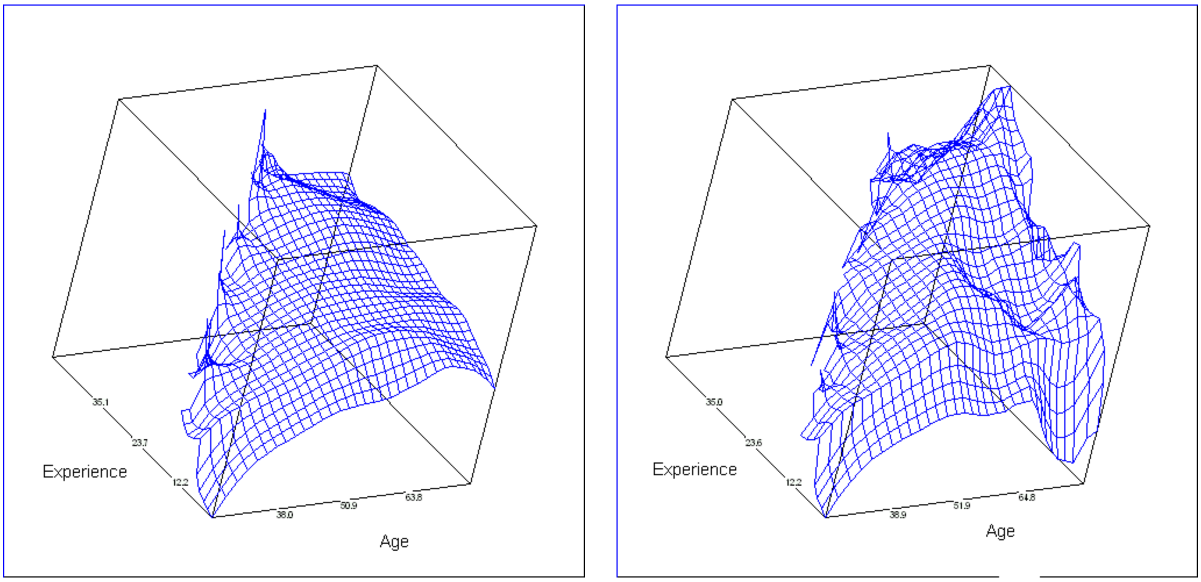
With respect to the nonparametric functions, Figures 7 and 8 show that covariate Experience is highly related to wages, independently of type and years, whereas we no major conclusions can be drawn for studies concerning the relation of endogenous variables with age. The plots of the estimated functions g( ) are quite wiggly as we have undersmoothed somewhat. This is recommended in semiparametric models to get unbiased estimates in the parametric part (coefficient estimates).

Figure 7: Nonparametric function *g* of equations (5) and (6). Year 2002



(a) male (b) female

Figure 8: Nonparametric function *g* of equations (5) and (6). Year 1995



(a) male (b) female

To study actual wage discrimination, Table 4 shows the decomposition for 2002 with equation (6). As can be seen there, the wage gap between men and women is 0.2386 logarithmic points (i.e. on average men earn about 24% more), most of which is due to elements that cannot be explained. Moreover, in the explained part we see that as a result of their endowments women should actually earn basically the same on average. In other words, the discrimination (unexplained part) is still evident (i.e. men earn about 19.4% more than identically qualified women) than it appears to be when just looking at raw data. In view of the value of all components, we must state that there was still a high degree of wage discrimination in Spain in 2002. For the sake of brevity we skip the presentation of the same study for 1995 when the gaps were even much larger, and turn directly to the comparison.

Table 4: Decomposition of Gender Pay Gap in Spain, 2002

Description	Estimates
Observed change	0. 2386
Due to:	
Observed endowments	0. 0431
Unexplained	0. 1944

So our next question is: has the situation at least improved compared to 1995, and if so by how much? Table 5 shows the results of the decomposition of the trend in the wage gap between 1995 and 2002. One of the main conclusions that can be drawn is that the wage gap dropped by 0.1167 logarithmic points between these years, from about 36% higher wages for men in 1995 to about 24% in 2002. At first glimpse this looks like good news, but if we look at the components, a remarkable fact is that more than half of the reduction is due to the reduction of the differences in observed characteristics between men and women and feminine endowments (with a value of -0.0447, and -0.0225 respectively). This implies that women considerably improved their characteristics (higher levels of study, more experience, acquisition of posts at better paying companies and with better contracts) compared to 1995 on the one hand, but also in comparison to men on the other hand. These results show that in the reference period women improved a great deal in relative terms compared to men and also in absolute terms according to an analysis of changes over time. That means that with respect to the valuation of these characteristics, given as "observed prices", the situation of wage discrimination in Spain has changed only slightly over these 8 years.

Table 5: Decomposition of the gender pay gap in Spain, 1995-2002

Description	Estimates
Observed change	-0.1167
Due to:	
Observed endowments	-0.0447
Observed prices	-0.0009
Effect of women’s endowments	-0.0255
Effect of differences in the observed price	-0.0486

A limitation of all the above analysis is that it is based on average values, which prevents us from observing the trend in wage gaps along with the distribution of wages. Table 6 shows the estimated wage differentials for quantiles 0.1, 0.25, 0.5, 0.75 and 0.9. All results are obtained using the estimation methods described in Section 2.

Table 6: Evolution of the decomposition of the Gender pay gap by quantile: 2002-1995

Quantiles	year	10th	25th	50th	75th	90th
Total observed gap	2002	0.2341	0.1795	0.2524	0.2603	0.2785
	1995	0.4169	0.2749	0.3554	0.3407	0.3457
Due to returns of endowments	2002	0.2165	0.2067	0.2254	0.2323	0.1698
	1995	0.3082	0.2664	0.3070	0.3367	0.3325
Due to endowments	2002	0.0112	-0.0289	-0.0144	0.0501	0.1032
	1995	0.0477	-0.0015	0.0901	0.0460	0.0642

We see that for the highest wages the drop in the wage gap between 1995 and 2002 is smaller than for the rest of the quantiles, fundamentally because in 1995 the wage gap between genders was not as high as for the lowest wages. This is easily seen in the 75th and 90th quantiles, which have a value of about 0.34 points in 1995 and about 0.27 in 2002. Note that, interestingly, in contrast to many other EU Member States (Arulampalam, Booth, and Bryan, 2005), where the total observed gap increases monotonously with the quantiles, in Spain we observe an asymmetric U-shape (with a minimum in the 25th quantile) in both years. The situation observed here once again, in which gender pay gaps are typically wider at the top of the wage distribution, is known as the "glass ceiling". When analyzing inequality between men and women, this metaphor typically describes the barrier to further advancement once women have attained a certain level. From there on they see their male counterparts promoted while they are not. The "sticky floor" is simply the opposite scenario of the "glass ceiling". Here the gaps widen at the bottom of the wage distribution. Booth, Francesconi, and Frank (2003) define this as the situation where men and women with identical endowments might be appointed to the same pay scale, but the women are appointed at the bottom and men further up the scale. The explanation for these two effects seems to be rather complex: it involves the interplay of several factors, and is beyond the scope of this paper. For further discussion, especially on the situation in Spain, see also De la Rica, Dolado, and Llorens (2007). Recall finally that due to the nature of our sample, the “sticky floor” effect observed here cannot be provoked by irregular immigrants or clandestine employment.

A look at the decomposition of the total observed gap confirms our general findings above, but now separated for the different quantiles. First, most of the wage gap for the distribution over the median is due to the valuation or "price" of the characteristics, and this does not change much over the years from 1995 to 2002. However, it seems that the gap has become significantly smaller, at least for the higher wage groups. As for endowments, the trend in the gap has experienced a dramatic change, switching from positive (in 1995) to negative (in 2002) for the 50^{th} quantile. For the 10^{th} and 75^{th} quantiles also the values have fallen to about half of the 1995 level. Only for the higher wages (75^{th} and 90^{th} quantile) does the wage gap increase from 1995 to 2002, and for the highest by even more than 50%.

5. CONCLUSIONS

This paper examines the structure of the wage gap for men and women in the private sectors in Spain during the period from 1995 to 2002. Among other findings, the (nonparametric) descriptive statistics study shows that though wages seem to have increased for both genders in the period of reference, the growth in women's earnings is especially strong. As for the trend in the wage gap, this article introduces flexible semiparametric extensions of the decomposition of Oaxaca and its (parametric) extensions. Our application of these new methods to Spain indicates a decrease in wage discrimination (by gender) over the period from 1995 to 2002. A similar result can be found in Palacio and Simón (2006) and Simón (2007). This decrease was basically due to the fact that women improved their personal characteristics in relative terms compared to men, and in terms of time from 1995 to 2002. In regard to the valuation (or pricing) of women's endowments, a major political challenge still remains. We should emphasize here once more that due to possible selection bias (full time workers in private companies with at least 10 employees) we have estimated the lower bound only; the actual discrimination might be even stronger. Extending our new methods of decomposition to quantile estimation following ideas proposed by Machado and Mata (2004), we have been able to study the trend in the wage gap along with the distribution of wages. We find that discrimination is much more serious in rather low and rather high paid jobs than for jobs with median wages.

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