

# The distribution of wages and wage inequality

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## **Abstract**

Over 25 years (1988-2013) the composition of employment and the determinants of wages have changed notably in Portugal. In this essay, the individual records of Quadros de Pessoal/Relatório Único are used to identify the structural and compositional changes in the distribution of wages, in Portugal. The workers' education level was the variable that most decisively contributed to wage increases over this period. Aggregate compositional effects, influenced by changes in schooling, are seen to be more relevant than the aggregate of the structural effects, which are essentially determined by the secular productivity growth. The horizontal shift of the wage distribution over time did not, however, contaminate the wage inequality indicators, which have remained essentially constant. This indication, is largely due to the fact that worker skills heterogeneity, firm wage policies heterogeneity, and job title heterogeneity have remained surprisingly unchanged. The association between firms with generous wage policies and high-wage workers has weakened significantly over this period, contributing in muted way to lower wage dispersion. (JEL: J24, J31)

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## **What we do**

Over the past 25 years, more explicitly the period between 1988 and 2013, the Portuguese labour market underwent deep changes. These changes reflected, among other things, a marked improvement in schooling for those in employment, a growing proportion of women in work, and the ageing of the working population. This paper explores the wealth of information contained in the individual records of the Quadros de Pessoal/Relatório Único to characterise the changes taking place in wage distribution, with a distinction made between compositional changes, and structural changes in the factors that determine wages. Special emphasis will be given within this

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framework, to move in the indicators of wage inequality, with specific focus on the different reasons underlying wage variations.

## What has changed

Between 1988 and 2013, the average years of schooling for dependent employees went up dramatically. The baseline was embarrassingly low (six years of schooling) rising to ten years, a figure that was even so less than satisfactory (see Figure 1). This move reflects on-going changes in compulsory education and a growing feeling among families that formal education was a worthwhile investment.

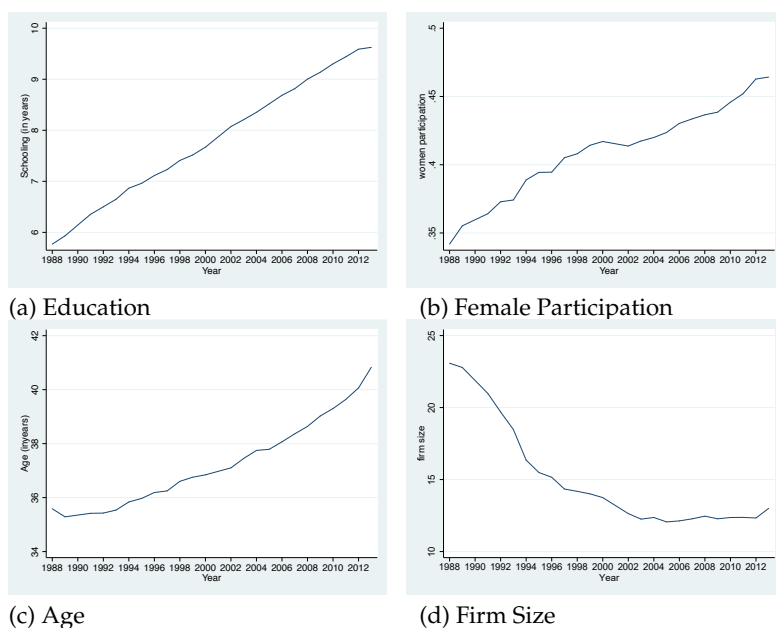


FIGURE 1: Portuguese Labour Market Trends

At the same time, and likely due to the increase in educational levels, there was a growing participation of women in the labor market, with the female participation rate increasing from 34.2 per cent to 46.4 per in 2013 (Figure 1).

Two elements here — a rise in the age when youngsters left formal education, and an increase in retirement age — played a part in the rapid ageing of the active population, with the average age moving from 35.5 to 40.8 years (Figure 1). In spite of such a clear rise in the average age of workers, employment stability, measured by job tenure, remained unchanged during this period, standing at around 9 years.

One trend that does not seem to have been highlighted enough is the steep fall in the average size of Portuguese firms, with the average number of workers per firm falling from 23 to 13 during the period under review (see Figure 1). The fall in firm size came about fundamentally between 1988 and 2000, with large firms shedding labour and the number of micro-firms rising substantially.

Figure 2 shows the dynamics of base wage distribution through a breakdown into minimum, median and mean wages. The most relevant feature of this is, quite clearly, the horizontal shift in the distribution. This can be summed up in the real rises in mean wage (56.3 per cent) and in median wage (51.5 per cent). The growing density close to the minimum wage stems on the one hand from the elimination of wages paid at a rate below the minimum, affecting very young people in work during 1987 and 1988 (Portugal and Cardoso (2006)) and, on the other hand, the growing incidence of the minimum wage influenced by nominal increases in the minimum wage above the aggregate figures for nominal wage increases (Martins and Portugal (2014)).

FIGURE 2: Evolution of the Wage Distribution (1988-2013)

Figure 3 also provides a dynamic indication of the shift in nominal wage change distribution for workers who hold a job in the same firm for two consecutive years (known as 'stayers'). The first point to make is the fact that nominal wage cuts are rare — indeed exceptional. This stems from the natural resistance among employers and workers alike to consider negative wage variation, but also, in a decisive way, of the prohibition (set down in the labour code) of any unilateral imposition of cuts in the base wage. The second

point is that the combination of recession and low inflation leads directly to a pronounced increase in the fraction of wage freezes. This has, in recent years, come in at figures close to 70 per cent. These observations overall illustrate the well attested downward nominal wage rigidity of the Portuguese labour market (Martins and Portugal (2014); Nunes (2016); Addison *et al.* (2017)).

### FIGURE 3: Nominal Wage Change Distribution

As a last point, summary indicators are presented for wage dispersion (Figure 4). The ratios between the total value of wages in relation to the 10th, 50th and 90th percentiles are surprisingly stable, contrary to international indicators. In fact, while on the left tail of the distribution, inequality in wages remained constant over the whole period under review, on the right tail there was the same uniform pattern, apart from the one-off increase in dispersion seen between 1989 and 1992.

In the following sections we will explore the factors contributing to changes in the wage distribution using quantile regression and high dimensional fixed effects regression to identify the sources of wage dispersion. First, however, before we move on to exploring these two lines of research, we will give a brief outline of the database that was used.

### About the data

This paper has drawn on the microeconomic data gathered by the Ministry of Labour and Social Security, which brings together data from all establishments who employ at least one dependent employee: this is known as the Quadros de Pessoal (up to 2009) and then the Relatório Único (from

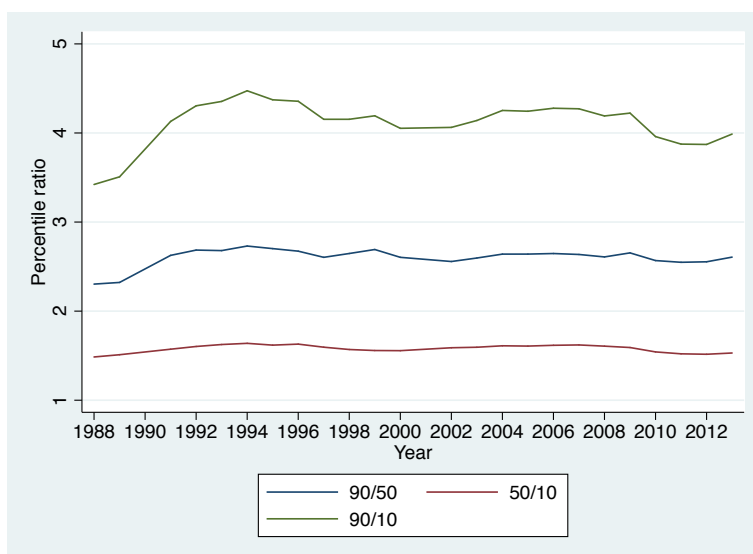


FIGURE 4: Wage Inequality

2010). The data obtained in these two reports is particularly precise and detailed when it comes to workers' wages. Initially the main purpose of the Quadros de Pessoal was to ensure that employers complied with wages reached through collective bargaining. In addition, it used to be a requirement for each employer to display the personnel tables in a public place. This was revoked in 2009, and a new directive allowed for the table to be shared digitally. Even today, in fact, the responsibility to "ensure that workers are provided with this information" remains in place.

Each individual worker is allocated a unique identifier, as well as each employer, every collective bargaining agreement and each distinct professional category. This allows us to track all workers systematically as they move along their career path. In addition to the detailed breakdown of wage components, the survey also collects social and demographic data on each worker, including age, gender, schooling, occupation, and job title. For firms, the survey collects data on the year the firm was founded, and includes sales revenue, size, location, and industry. This review will focus on full-time employees aged between 18 and 65, from all industries except the agricultural sector. Data is drawn therefore from 40,106,006 entries, relating to 4,918,285 employees and 611,765 firms.

## Wage Setting

The usual way to analyse wage levels is to use an equation that accounts for levels of education and labour market experience. This equation has been

adapted over the years from the now widely known equation initially derived by Mincer (1958). In this paper, we start off with an extended version of the Mincer equation to allow for differing wage levels according to gender (with a binary variable); the return on human capital specific to the firm; and wage level differentials linked to the size of the firm (through a logarithm of the number of employees).

The use of a linear regression model as a method to determine the factors linked to changes in wages levels has a number of drawbacks, however. To build a more complete picture, conventional regression analysis is not adequate to fully describe the wage distribution, since it is based on conditional means. In other words, in the regression model, the effect of a change in an explanatory variable, can always be shown as a horizontal shift of the distribution of a dependent variable. This statistical model is in fact unnecessarily restrictive, and in some cases inadequate, if the effect of an independent variable does not remain uniform across the distribution of wages. It is more useful to employ a more flexible model, which, in this case, is the quantile regression. This allows us to take into consideration the whole distribution rather than basing conclusions on the conditional mean.

Table 1 shows the results of estimating quantile regression corresponding to the 20th, 50th, and 80th percentiles for 1988 and for 2013. The indicator for gender discrimination is not homogenous across the wage distribution, with the gap more pronounced at higher wage levels. In this way, the difference between wages for men and women found on the 20th percentile is 18.2 log points (in 1998), which jumps to 24 log points when comparing wage quantiles corresponding to the 80th percentile. At the (conditional) median, men benefit by 20.9 log points.

One notable finding uncovered in the regression study is the indication that return on investment in formal education is significantly higher on the right tail of the distribution of wages. On percentile 20, an additional year of formal education leads to a rise in wages of 4.9 per cent, and at percentile 80 a rise of 8.3 per cent. This result suggests a strong complementarity between wages and education (Campos and Reis (2017)). The sequence of coefficients in the regression for the age variable, which is a proxy for the employee work experience, is similar to that seen for education. This also indicates that there is a complementarity between experience and more productive jobs. In terms of job tenure and firm size, the effects are relatively uniform across all distribution markers<sup>1</sup>.

From 1988 to 2013, the main drivers influencing wages remained the same when it comes to education and length of service, but there is a drop in influence exerted by the firm size (across the whole distribution) and age

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1. Another way to interpret this uniformity across distribution is to consider the fact that there is no heteroscedasticity (inconstant variance) associated with these variables.

Year Percentile	20	1988 50	80	20	2013 50	80
Male	0.182	0.209	0.240	0.170	0.251	0.339
Age	0.035	0.042	0.055	0.018	0.033	0.048
Age Squared	-0.000	-0.000	-0.001	-0.000	-0.000	-0.000
Tenure	0.001	0.001	0.001	0.001	0.002	0.001
Tenure Squared	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
Firm Size (logs)	0.068	0.073	0.075	0.037	0.049	0.054
Education	0.049	0.067	0.083	0.048	0.073	0.089
Constant	-1.737	-1.826	-1.961	-1.150	-1.636	-1.902

TABLE 1. Quantile Regression

(especially in the left tail) and the gender gap is more pronounced (particularly in the right tail). The change seen in the return on work experience is especially troubling as it may indicate lower levels of investment in job training for less qualified workers.

To better understand the changes in distribution of wages it is important to distinguish the effect of changes in the characteristics of workers and firms (composition effect) and the effect of changes in the regression coefficient (structural effect). In the linear regression models, this breakdown has most commonly been achieved using the Oaxaca-Blinder methodology. In the context of quantile regression models, the method proposed by Machado and Mata (2005) provides an elegant solution allowing for an aggregate breakdown between compositional and structural changes, and for a flexible way to identify the most decisive variables in the aggregate breakdown.

Table 2 shows the evolution of the compositional and structural effects for 1988 and 2013. It is very clear that compositional changes had a far more decisive impact on wage distribution than changes seen in the regression coefficients across the percentiles observed. In short, 33.3 log points (39.3 per cent) of the 42.7 log points (53.3 per cent) in the rise in median wage are due to changes in characteristics, and the remaining 9.4 log points (9.9 per cent) are

due to changes in coefficients<sup>2</sup>. The significance of aggregated composition effects rises for higher percentiles.

	1988 (1)	2013 (2)	(2)-(1)	Composition Effect (4)	Structural Effect (5)
Quantile 20	-0.346	0.040	0.387	0.251	0.135
Quantile 50	-0.018	0.409	0.427	0.333	0.094
Quantile 80	0.420	0.925	0.505	0.409	0.096

TABLE 2. Machado and Mata Decomposition

In order to get a fuller picture of the drivers behind changes in the wage distribution, we need to consider a higher number of percentiles. Figure 5 is based on 99 regressions, corresponding to percentiles 1 to 99. This shows two wage distributions: what prevailed in 2013 and what would have prevailed if the characteristics had been the same as in 1988. In line with the results set out in Table 2, we can see a clear shift between the counterfactual distribution and the actual results, and this reflects an improvement in productive characteristics observed over 25 years. Figure 5 also presents two distributions: what prevailed in 1988 and what would have prevailed in 1998 with the same characteristics but this time applying coefficients from the regression survey of 2013. It is very clear that the change that occurred in relation to wage structures show definite improvements in wages, particularly for workers in lower income brackets.

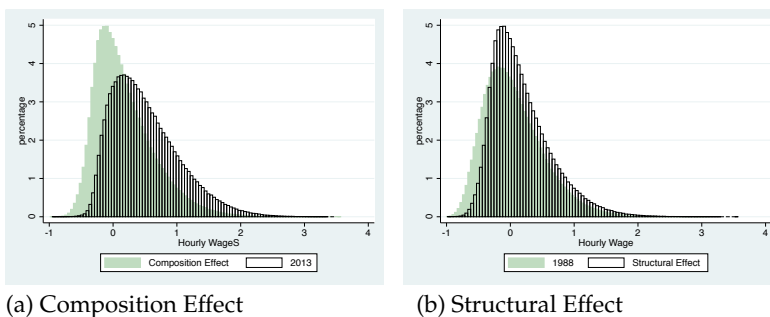


FIGURE 5: Changes in the wage distribution - part I

2. The conversion of logarithm points into percentages is calculated using the generic formula  $(exp(x) - 1) * 100$ .



Finally, we looked at isolating the effects of higher education for workers and changes seen in the returns to labour market experience. Figure 6 compares the distribution in wages in 2013 with what would have been seen had the education levels matched those of 1988. The striking resemblance between Figure 5, which aggregates all compositional effects, and Figure 6 suggests that the additional years in formal education have been the most decisive factor in shaping the pattern of wage distribution. In fact, the increase in formal education is responsible for around 75 per cent of a rise in wages. Figure 6 shows the effect of the drop in the returns to labour market experience. Here we compare the distribution of wages seen in 1988 and the distribution of wages that would have been seen had the return on work experience been the same as in 2013. From this comparison we can see very clearly that the value placed on work experience for less qualified workers has dropped significantly, either because of a cut in investment in training or because the labour market no longer values these attributes in workers.



FIGURE 6: Changes in the wage distribution - part II

### On the factors underlying wage variation

The longitudinal data base (i.e. the records of workers spanning over various periods) makes it possible to raise questions which would not otherwise be feasible. In particular, the repetition of observations covering workers, firms and job titles will make it possible to obtain permanent effects. In essence, the sources of wage variation will be obtained through to three questions: Who is the worker? Where does he work? What does he do?

The worker dimension condenses the human capital which leads to higher or lower wages. The firm dimension summarizes the generosity of the firm wage policy. The job title dimension accounts for different remunerations that persist over time between occupations or tasks. Identification of these effects (known as fixed effects) is obtained from repeated observations of the worker, the firm and the job title and from the mobility of workers entering and exiting firms and job titles. No particular interpretational problems are

posed by the specification of a high dimensional fixed effect regression model (Guimarães and Portugal (2010)). All that is needed is to consider a Mincer regression extended to include 4918285 dummies identifying workers, 611,765 identifying firms and 127,021 identifying job titles<sup>3</sup>.

In this context, heterogeneity of workers accounts for 49.2 per cent of the wage variance, whereas firm heterogeneity for 24 per cent and job title heterogeneity for 9.7 per cent<sup>4</sup>. This breakdown is similar to that obtained by Torres *et al.* (2013).

The correlation between the fixed effects of workers and of firms was estimated at 0.25, indicating that better paid workers (with greater human capital) tend to work in high paying firms (positive assortative matching). This association is fundamentally determined by the observed component of the worker (education, experience, tenure, and gender), where the correlation is 0.29, while the correlation with the unobserved part is 0.05.

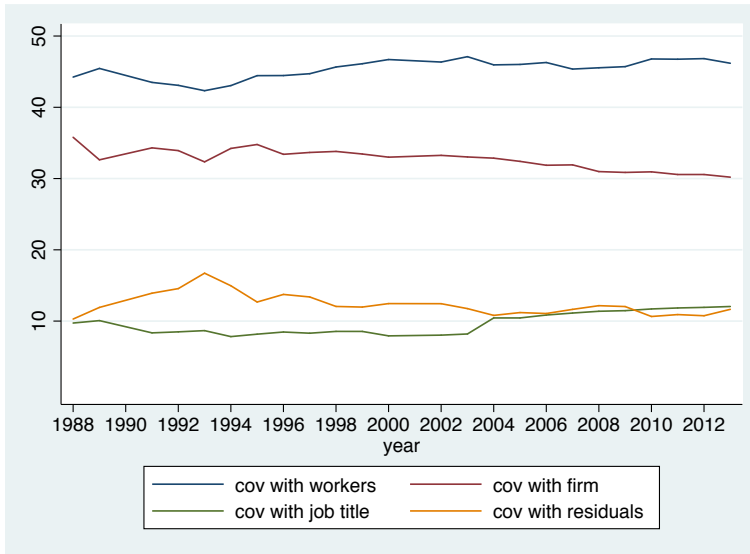


FIGURE 7: Wage Variance Decomposition

When the same breakdown of variance on an annual basis is established, it can be seen that the contribution of the main components in the variance of wages is basically constant over the period under review (Figure 7). The component with a marked trend is the correlation between workers and firms fixed effects. This drops by nearly 20 p.p., mainly from 1992 onwards (Figure

3. In practice, the regression model includes time-varying coefficients for gender, education and firm size as well as the three high dimensional fixed effects.

4. The expression used for this effect was  $Var(Y = X + Z + W) = Cov(Y, X) + Cov(Y, Z) + Cov(Y, W)$ .

8). It implies a fall in wage inequality, in marked contrast to the empirical evidence for Germany (Card *et al.* (2013)). It is clear that there is a significant weakening in the association of high paying firms and the level of human capital among workers (the evolution over time is given by Figure 9).

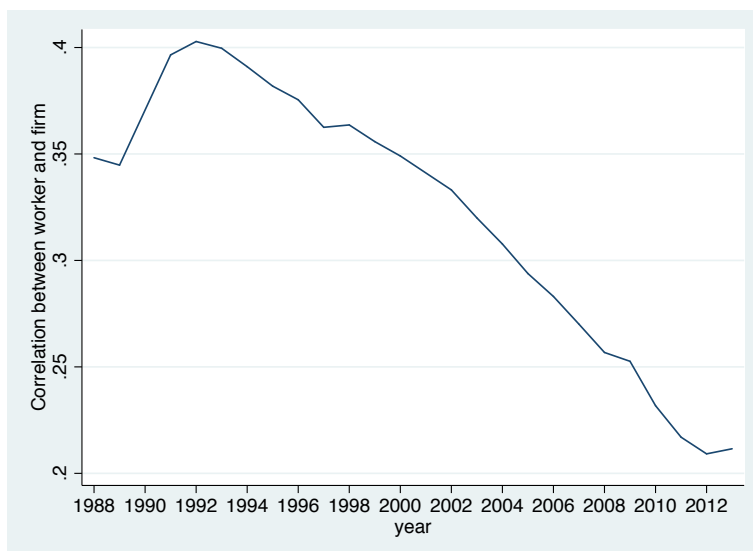


FIGURE 8: Correlation between Worker and Firm Fixed Effect

FIGURE 9: Matching between workers and firms

## Summing Up

Over the 25 years from 1988 to 2013, the wage distribution of workers underwent profound changes. The most important of these was, as might be expected, the overall rise in wages, with the median wage increase reaching 53.3 per cent. Improvements in workers' qualifications accounted for 78 per cent of the increase, with structural changes in the determination of wages accounting for the remaining 22 per cent. The most decisive factor underlying the wage increase was a pronounced improvement in workers' education levels. According to our calculations, the raising of the school levels accounts for around three-quarters of the overall wage increase. Against this backdrop, there are indications that the second engine driving the production of human capital, on job training, slowed markedly during the period under review, mainly for those workers who are less qualified and collect lower wages.

Which of the questions below is the most important to best estimate individual's wages? Who are they? Where do they work? What do they do? The information on the worker is in fact the most relevant, since it explains around 50 per cent of the wage variation, though the information on the firm and the job is also important, since this explains a quarter and a tenth (for the firm and the job) of the wage variation.

It is not possible to establish a clear trend for wage dispersion when we consider each wage component separately. It is not surprising, then, that the indicators of wage dispersion have remained constant for the past 20 years. The correlation between the fixed effect of the worker and the fixed effect of the firm, however, has been weakening, which in turn has led to less wage inequality. This finding is in contradiction with most economic literature, and in fact indicates that the sorting of workers among firms is increasingly less determined by the complementarity between the worker's human capital and the productivity of the firm.

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