The gender wage gap across cohorts: The role of education in twelve countries

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Abstract

Does the increase in tertiary education among women translate into commensurate female wages? Existing studies have shown that countries differ considerably in the gender wage gap. Using selected countries over 30 years, we study whether women's educational expansion has translated into a closing of the gender wage gap. As education is known to be very cohort dependent, in our view, a Age-Period-Cohort analysis is most appropriate. Applying such an analysis to the Luxembourg Income Study (LIS) data, we show that, while in terms of access to tertiary education women have caught up and in many countries even outperform men, substantial gender wage differences persist in all countries. Using the Blinder-Oaxaca decomposition, we demonstrate that the role of education in explaining the gender gap has been limited and even decreased over cohorts. We thus conclude that gender wage differences at levels far from gender equality will also persist in the future, even if the "rise of women" in terms of education continues.

Keywords: gender gap, education, wage, age-period-cohort analysis, Blinder-Oaxaca decomposition

Introduction

In many developed countries, female cohorts successively outnumbered men in terms of tertiary education. On average and different from earlier birth cohorts, women are now more likely to have a tertiary education than men (DiPrete and Buchman 2013; Becker, Hubbard, and Murphy 2010;

Breen, Luijkx, Müller and Pollak 2010; Buchmann and DiPrete, 2006; Grant and Behrman 2010; Wilson, Zozula and Gove 2011). With respect to education, the glass ceiling is broken. But does this increase in tertiary education translate into commensurate female wages? Does the "rise of women" and their catching up with men in terms of attainment of tertiary education also lead to a closing gender gap? Since education is the main determinant of one's occupational career (Treiman and Terrell 1975) and since educated women have a higher employment as well as shorter career interruptions than non-educated women, an expansion in women's education should close or at least narrow the gender gap.

Some studies indeed document a narrowing of the gender gap in terms of hourly earnings; but also a slowing down of this trend (Bernhardt, Morris, and Handcock 1995; England, Gornick & Shafer 2012; Fitzenberger and Wunderlich 2002; Fransen, Plantenga, and Vlasblom 2010). Consequently, important gaps remain. Apparently, education is a necessary but not sufficient condition. Existing studies have shown that countries differ considerably in the gender wage gap (Harkness 2010; England et al. 2012; Mandel 2012; Christofides et al. 2013). We argue here that the timing of the educational catch-up of women is relevant to understand why women caught up in terms of wages in some countries, but not in others.

In our view, a cohort-based analysis is most instrumental to study trends in the gender wage gap because education is known to be cohort sensitive. In addition, it is important to use an age period cohort (APC) analysis to control for period (e.g. policy reforms) or age effects (e.g. motherhood) that only accrue at a certain in a certain period or at a certain age. Eventually, cohort studies allow identifying cohort replacement mechanisms and predict future trends more accurately and net of compositional effects. If younger, more equal cohorts are shrinking relative to older ones, an overall slowing down of the declining gender gap may be observed although the cohort effects points towards a continuation of this process as younger cohorts replace older cohorts. Nevertheless, APC studies analyzing the gender gap are rare as long and well-harmonized times series data are required. The few existing studies confirm strong cohort effects in the gender wage gap (Campbell and Pearlman 2013). In addition, no cross-national cohort study decomposing the gender wage gap into different factors exists to data. We add to this literature with a comparative cohort study over 25 years decomposing the gender wage gap to identify the role of education using the Luxembourg Income Study (LIS), a recognized cross-national dataset where earnings, incomes and education are systematically harmonized.

Background

The closing or even reversal of the gender gap in education, or "the rise of women", as seminal book by DiPrete and Buchmann (2013) is titled, has occurred in most western countries in a similar time frame (Breen et al. 2010). Today, where women have caught up with men and even outperform them in terms of education, education is not the marking difference between women and men. This phenomenon, along with the steady, albeit slow, decline in the gender wage gap, led scholars to predict a closing in the gender wage gap (Blau and Kahn 1997). However, recent studies suggest, at least for the U.S., that the convergence of gender wage gap slowed down considerably (Blau and Kahn 2007, Campbell and Pearlman 2013). This is surprising since education has been considered to be an important reason for wage gaps, for example over racial, ethnic and migration lines (Black et al. 2006, Mandel and Semyonov 2017).

Two processes are relevant to evaluate the gender wage gap trends: not only educational expansion but also occupational transformations. Educational expansion has equipped women with better diplomas and degrees which should eradicate one reason for the "legitimate" part of the gender gap. In the presence of gender segregation across occupations, changes in the labour market structure additionally impact on the gender gap, which can be either reinforcing or impairing the gender equalizing trend. The strongest gender equalizing trend in the US occurred among the lowest educated, which can in part be attributed to the disappearance of relatively well-paid, typically male occupied jobs in manufacturing, while the gender gap in at the top of the occupational hierarchy remains the widest.

Therefore, our aim in this paper is to estimate the role of the educational gender gap in the pattern of the gender wage gap and to test these following *hypotheses* on a larger set of countries:

H1: The gender gap in education has declined over birth cohorts and has reversed for the most recent cohorts.

H2: The gender gap in wages has declined over birth cohorts.

H3: The gender wage gap has declined faster among low than among tertiary educated.

H4: As the gender gap in education has closed, also the role of education as a factor explaining the gender wage gap is declining over cohorts/with educational expansion.

Method

Age Period Cohort Gap/Oaxaca model (APC-GO)

The purpose of the Age-Period-Cohort Gap/Oaxaca model (APCGO) is to compute the change over cohort in the gap between two groups (e.g. gender) across birth cohorts in a dependent variable *y* (e.g. income). Data which are fitted to APCGO are structured in a Lexis table: an *age* by *period* table of (e.g. cross-sectional) data with a constant pace in age and in period (for instance 5 years age groups measured each fifth year). Each cell of the Lexis table is indexed by its age *a* and a period *p* and then pertain to cohorts $c = p - a$. In APCGO, we identify a vector of "net" gender gaps (measured by the classical Oaxaca "unexplained difference" of y by relevant covariates), where the gaps are indexed by cohorts. This cohort indexed gap is a γ_c vector showing the intensity of the gap (the average value of the vector coefficients), the trend (the general linear slope of coefficients across cohorts) and their fluctuations (their non-linear shape), to measure a possible closing gap from social generation to generation.

To do so, we apply a 2 steps method:

- On the base of Oaxaca-Blinder models of y by relevant control variables in each (age by period) cell of the initial Lexis table y_{apc}, we compute a matrix u_{apc} of "unexplained" differences, the "Oaxaca-Lexis-table" gender gap of income.
- We then decompose the Oaxaca-Lexis-table on the base of a specific trended APC model to obtain a measure of the cohort-specific non-explained gap in income.

The first step: Oaxaca Lexis table

In order to obtain the gender gaps in income (un-)explained by education (and other characteristics), we apply the Blinder-Oaxaca decomposition method (Blinder 1973; Oaxaca 1973; Jann 2008) to each cell of the initial Lexis table. If we consider incomes for male and female as a linear combination of endowments X plus errors.

$Y_1 = X_1b_1 + e_1$ for male

$Y_2 = X_2b_2 + e_2$ for female

In the two-fold decomposition, the mean outcome difference is the difference in the linear prediction at the group-specific means of the regressors of the difference R, which can, in the case of two groups, be decomposed as:

$R = x_1'b_1 - x_2'b_2$

$= (x_1-x_2)'b_2 + x_2'(b_1-b_2) + (x_1-x_2)'(b_1-b_2)$

$= E + C + CE$

Where E is the gap in 'endowments' ("explained"), C is gap in 'coefficients' ("unexplained" 1) and CE is the interaction of differences in endowments & coefficients ("unexplained" 2).

In the twofold Oaxaca Decomposition, U = C+CE are the unexplained difference.

This equation includes the explained part ("quantity effect"), in which we include education (less than secondary/secondary/higher), in a next step also living with a partner (yes/no), number of children (no children/1 child/2 or more children), and employment status (yes/no). The unexplained part comprises the effect of variables not observed in our model. We call u_{apc} this Oaxaca Lexis table allows us to explain the gap in the means of our outcome variables between women and men net of other differences.

The second step: APC-lag of the Oaxaca Lexis table

In the second step we are employing a cohort indexed measure of the gaps in the Oaxaca Lexis table. This step relies on an adaptation named APCL (lag) of our former APCD (detrended) model (refs.). The APCD, thought as a detector of cohort fluctuations in a Lexis table, delivers a trend zero vector of cohort fluctuations. The APCD is modified here to deliver a γ_c vector of intensity and trend in gap. After forty years of research, the last decade development in APC models produced important improvements. Even if some aspects are still debated (Luo et al. 2016), two aspects of APC debate are clearly stabilized today.

The first aspect of the APC debate is the identification of fluctuation: it is clear now that cohort fluctuations (def. the degree to which some cohorts did/do better than others after control of linear effects of age period and cohort) are (easily) identifiable with simple tools. This is the purpose of the APCD model[1] (Chauvel, 2013, Chauvel and Schröder. 2014, Chauvel et al., 2016), otherwise called ZLT (zero linear trend), that is a recent reformulation of the Holford model (1980). From a Lexis table of y_{apc} considered as a dependent variable that pertains to an individual *i* of age *a* in period *p*, and thus of cohort membership *c*, where c=p-a, APC-Detrended can extract

- a single constant β_0

[1] The APCD can be downloaded as a Stata ado file by typing "ssc install apcd" in Stata.

- a single two-dimensional linear (=hyperplane) trend that can be arbitrarily associated to age&period, age&cohort or period&cohort, but no decomposition can be directly interpreted as causally relevant [this is the term $\alpha_0 rescale(a) + \gamma_0 rescale(c)$]
- three vectors (age, period and cohort $\alpha_a, \pi_p, \gamma_c$) of fluctuations defined by zero sum and zero trend

$$y^{apc} = \alpha_a + \pi_p + \gamma_c + \alpha_0 rescale(a) + \gamma_0 rescale(c) + \beta_0 + \varepsilon \qquad \text{(APCD)}$$

$where\ the\ sums\ and\ trends\ of each\ set\ of\ coeffcients\ \ \alpha_a, \pi_p, \gamma_c\ are\ constrained\ to\ zero;$

$\alpha_0 and\ \gamma_0 absorb\ the\ age\ and\ the\ cohort\ trend\ respectively$

The APCD as such is not able to produce the solution we need, since the cohort vector expresses accelerations and decelerations of gender gaps once the general trend is suppressed.

The second aspect of the APC debate, which is paradoxically more difficult, pertains to the identification of trends. Due to the collinear relation a=p-c, the decomposition of age, period and cohort linear effects (the above mentioned hyperplane) has no general solution without the implementation of a constraint. Once it is done, this arbitrary choice lead to a unique APC trends decomposition. Some conventional APC models of the 1980s proposed to equate the first and the last coefficients of cohort, or to keep period trend as zero, for instance. Once a constraint is implemented, the model is identified, but it is impossible (or difficult) to propose a general non *ad hoc* justification of this choice. Strategies which are supposed to make no arbitrary choice in the constraints, for example the APC-IE intrinsic estimator, or the Hierarchic HAPC, actually hide such implicit arbitrary constraints. For instance, APC-IE is based on a principal component analysis to reduce the three dimensional indices a p c on a geometrically optimal two dimensional hyperplane; for multilevel strategies such as HAPC, random effects on period and cohort effects hide an implicit detrendisation of period and cohort.

These methods are even more problematic when dealing with the effect of education over age period and cohort. Due to their general inaptitude to relevantly decompose trends, they inadequately decompose the age effect of education as a strong, steady decline in education across life span – because the seniors are always older than juniors – This is obviously misleading if not absurd[2].

[2] See more in the annexes and replication files of ‘Problems with APC-IE and HAPC’ in the online annex of Chauvel and Schröder’s (2015) paper.

The constraints that are implement in APC mean specific baselines for comparisons of models, some baselines provide easy to understand models – APCD go with a baseline of zero linear trend in cohort – and others families of models provide unexpectable unexplainable baselines – like in APC-IE – that forbid comparison from one model to the other (Luo et al. 2016).

The new APC-lag approach, we propose another empirically relevant baseline: the "linear age effect". We expect in the APC decomposition of linear slope α (the average slope associated to age vector α_a) to be equal to the average trend α of longitudinal aging in the Oaxaca-Lexis table. Once this constraint is given, and period linear trend constrained to be zero, cohort effect will absorb the long term time transformations. This definition means a new, clear baseline where the linear slope of age trend measured by the α_a coefficients is designed to equate α, the average shift due to age in the Oaxaca Lexis table across cohorts o_{apc}. Consider this average shift α

$$\alpha = \sum \frac{\left(o_{(a+1,p+1,c)} - o_{apc}\right)}{(A-1)(P-1)}$$

Where α represents the average shift for a cohort c when it gets one age group older in the next period across the window of observation of a age groups and p periods. Once α is known, APC-Lag is identifiable:

$$o^{apc} = \alpha_a + \pi_p + \gamma_c + \varepsilon \qquad \text{(APCL)}$$

$$where \sum(\alpha_a) = 0 \;\; and \;\; \sum(\pi_p) = 0\,; Trend(\pi_p) = 0; Trend(\alpha_a) = \alpha$$

The formula of operator Trend for age coefficients is, when A is the number of age coefficients:

$$Trend(\alpha_a) = 12\,\frac{\sum(\alpha_a\,(2a - A - 1))}{(A-1)A(A+1)}$$

In the APC-Lag, γ_c absorbs the constant (larger when the gap is high), its trend shows the variation in the intensity of the gap by cohort for age and period controlled, and the fluctuations show possible non-linear accelerations or deceleration in the cohort trend. We verify on education (diploma attainment) that APCL provides a small linear age effect α and an easy to interpret vector of cohort coefficients.

The complete APCGO method cannot provide direct estimations for confidence intervals due to its complexity – relatively sophisticated succession of Oaxaca and APC methods. So a bootstrap solution is implemented on the complete process considered as a whole, including first the Oaxaca process on each cell of the initial Lexis table of y_{apc} to obtain the non-explained o_{apc} Oaxaca Lexis table, second the estimation of a linear age effect α of o_{apc}, and third of the APC-lag of the Oaxaca Lexis table.

Data and variables

Using data from the Luxembourg Income Study (LIS), we include the following twelve countries for which we dispose of sufficient waves and information on education: Germany (DE), Denmark (DK), Spain (ES), Finland (FI), France (FR), Israel (IL), Italy (IT), Luxembourg (LU), the Netherlands (NL), Norway (NO), the UK and the US. We dispose of a cross-sectional survey approximately each fifth year between 1985 and 2010, and construct 5-year birth cohorts between 1935 and 1980 restricting age to 25-59 years so that we can observe graduation from tertiary education and elderly are excluded. We focus on wages, which comprise paid employment income including basic wages, wage supplements, director wages and casually paid employment income but not self-employment income.

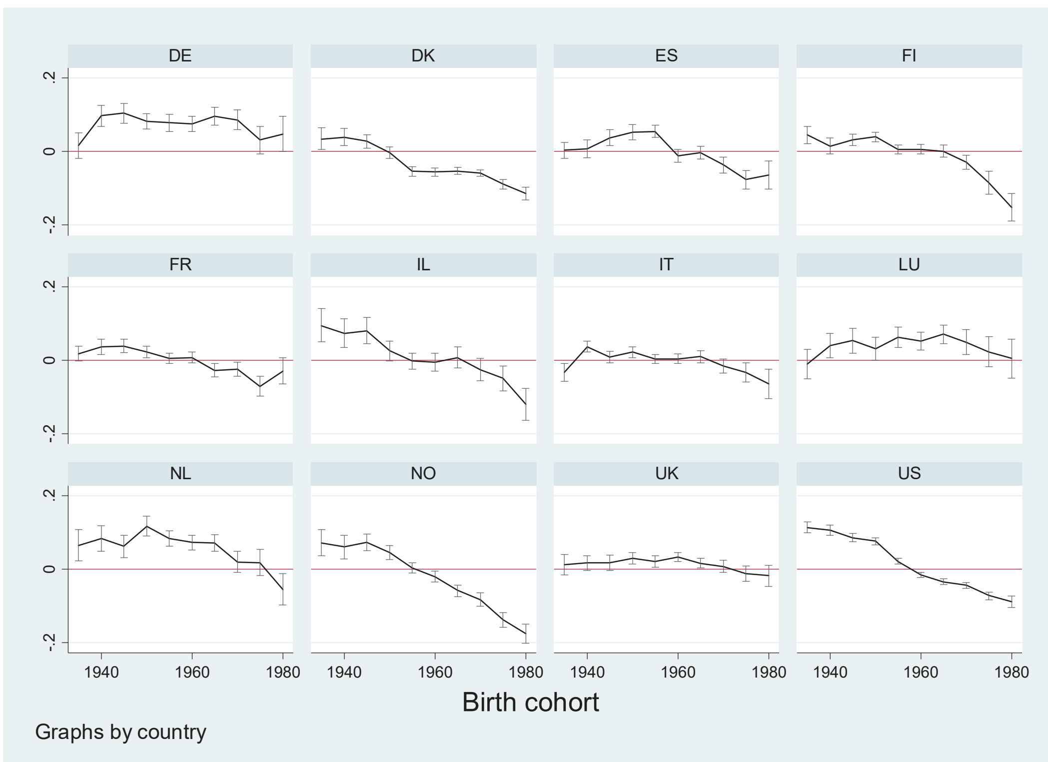
Then we apply the logitrank transformation as proposed by Chauvel (2016). Since gaps are trivially larger when income distributions are more unequal, logitrank offers a standardization strategy consistent with the Pareto characteristics of income distributions that suppresses the mechanical effect of increasing gaps with increasing inequalities. More importantly, it allows us to include zero wages. This is a substantial improvement relative to previous studies as the focus on hourly wages omits large parts of the female population and underestimating thus the true gender gap in wages.

We proceed as follows. Let $p \in [0;1]$ be the percentile rank of individual i in the income distribution, so that the logged odds of the percentile $\ln(p_i/(1-p_i)$ measures the relative social power of individual i ("Logitrank" (Copas, 1999), compare also to the log of Positional Status Index used by Rotman et al, 2015). Using the so-created rank positions enables us look at changes in the wage structure net of the Gini (Champernowne, 1953; Chauvel, 2016; Dagum, 1977; Fisk, 1961). We use the logit-rank of wages as dependent variable in our APC-GO model. In a first step, we include education (less than secondary/secondary/higher) in the Blinder-Oaxaca decomposition and in a next step also living with a partner (yes/no), number of children (no children/1 child/2 or more children), and employment status (yes/no). This allows us to explain the gap in the means of our outcome variables between women and men net of other differences.

Results

Our results confirm the shape of the educational expansion in the US and most other countries (Figure A1 in Annex), where the gender gap is now inversed. Figure 1 shows the difference of the levels of attainment of tertiary education between men and women across birth cohorts. The results indicate that the earliest timing of the rise of women occurred in Denmark, followed by Norway and the US, where the gender gap in attainment of tertiary education reversed already for cohorts born after 1950 and 1960 respectively. Women have not (significantly) surpassed men in three of the observed twelve countries (Germany, Luxembourg, UK). In the UK, however, women and men have historically had equal levels of tertiary education.

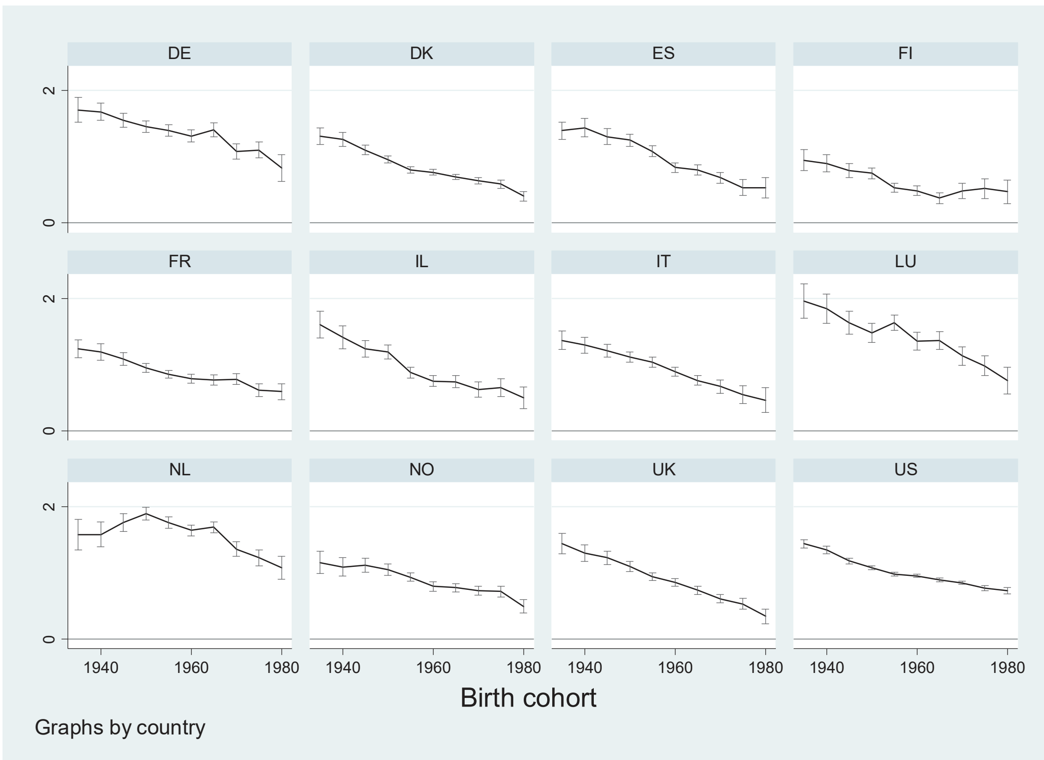
Figure 1. Gender gap in attainment of tertiary education, by birth cohort



Note: Zero denotes gender equality, negative values refer to male advantage. Source: LIS.

This general inversion in educational gap gives hopes of rapid socioeconomic convergence between women and men. Figure 2 showing the gender difference in logit-ranked wages confirms a clear cohort trends in all countries. In all countries, the gender wage gap decreased considerably. However, against the expectations, empirical results give a paradox picture: the gender gap in wages is much evident than those found in educational attainment and the convergence between women and men is much weaker. In some countries but clearer in Spain, Finland, France and the US, the decreasing trends appears to be slowing down or even stagnating since the last cohorts.

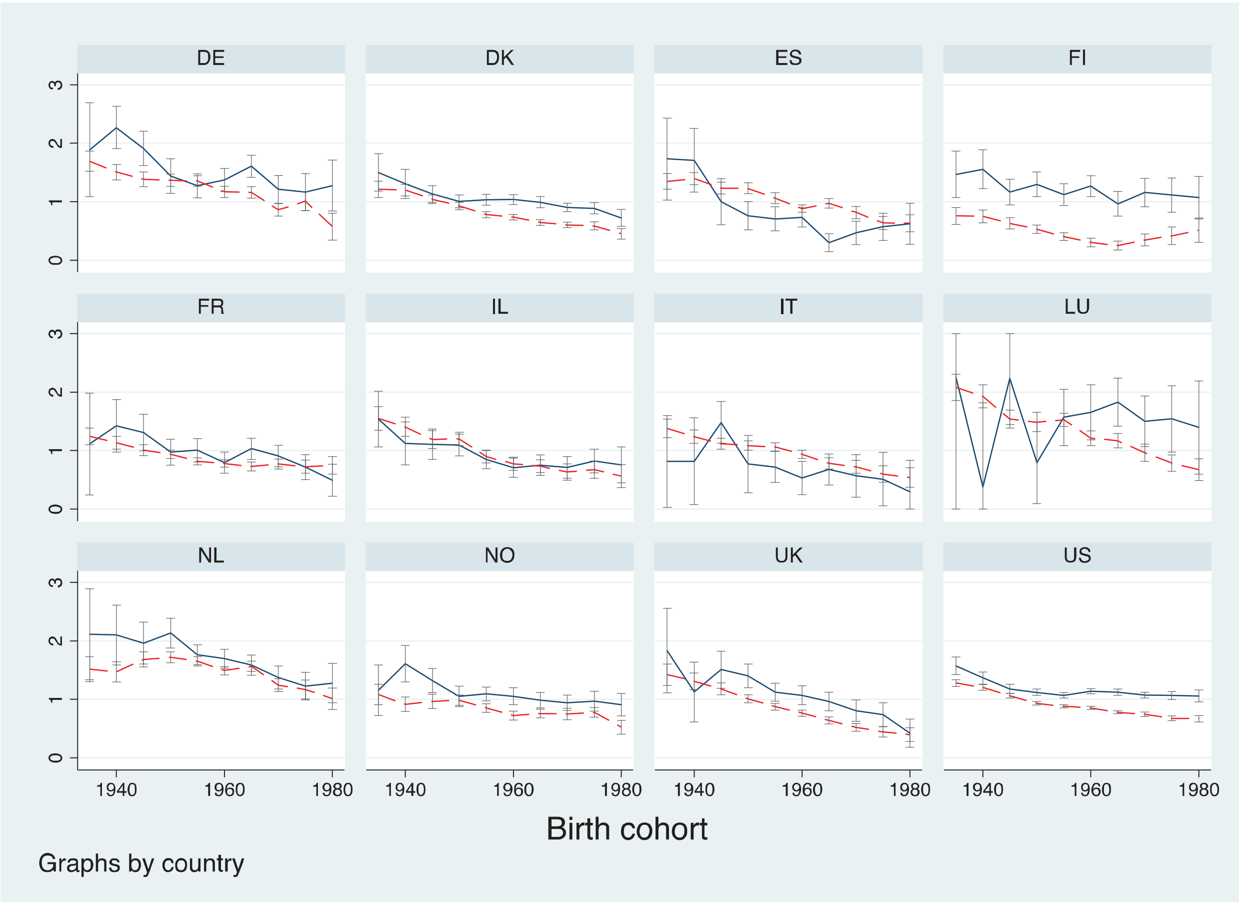
Figure 2: Gender gap in logitrank of wage, by birth cohort



Note: Zero denotes gender equality, negative values refer to male advantage. Source: LIS.

Regarding our second hypothesis H2, we expected that a smaller gender wage gap among low educated due to restructuring of the labour market. In Figure 3, we split the previous results by level of educational attainment. Indeed, we find significant differences in the gender wage gap between non-tertiary and tertiary educated in most countries. Systematically larger wage gaps among lower educated are prevalent in the Nordic and Anglo-American countries, most notably in Finland and the US but also in Denmark, Norway and the UK. Only in Spain, the gender gap among lower educated is significantly higher than among higher educated.

Figure 3. Gender wage gap among persons with non-tertiary (red, dashed) and tertiary (blue) educated, by birth cohort

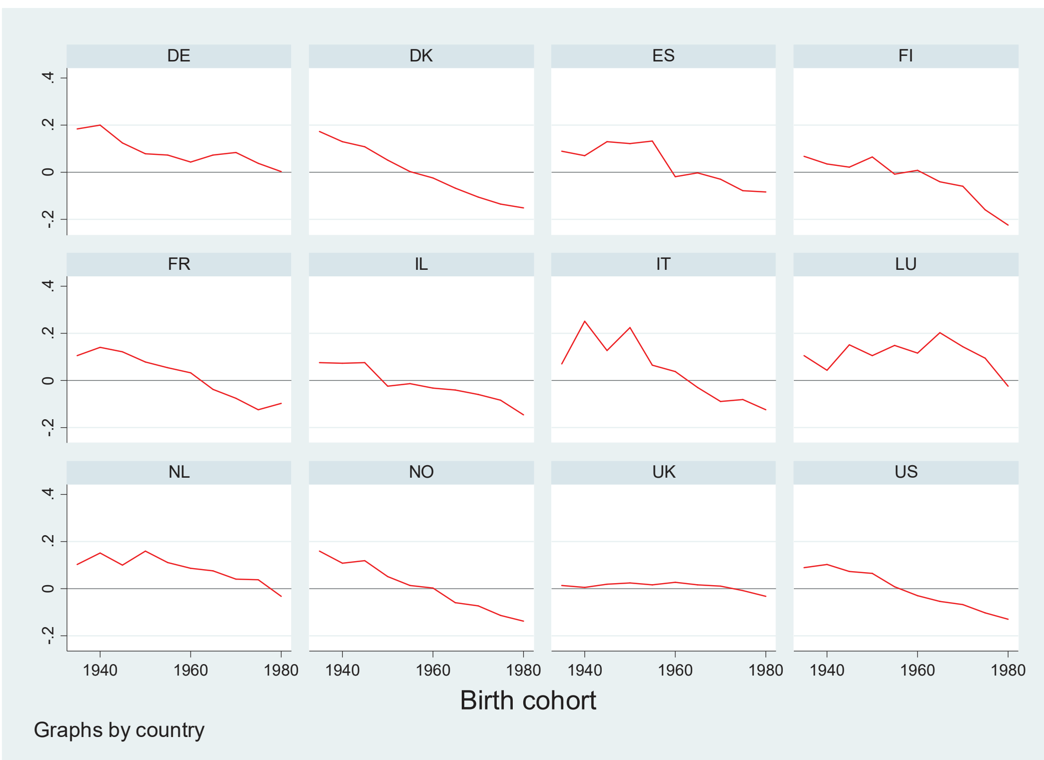


Note: Confidence interval for oldest three cohorts in Luxembourg continue beyond the graph and have been trimmed for better visualization of the results. Source: LIS.

A second observation that however contradicts our thesis is that the gender gap decreases stronger among the lower educated than among persons with tertiary education only in a few countries. This can be clearly observed in the US and in Luxembourg, but also in Germany and Italy. Here the thesis seems to hold true that steady disappearance of the relatively well-paid unskilled jobs that were typically occupied by men has contributed to the narrowing of the gender wage gap. The US results are confirmed in the literature discussed earlier. Luxembourg is another clear and interesting case as its economy was heavily based on coal and steel industry in the past but made a rapid transition towards a service economy abolishing an immense number of well-paid male breadwinner jobs. The educational expansion occurred, however, relatively late and female labour market participation rates were and still are relatively low, which may explain why the gender gap among higher educated did not converge in Luxembourg, in contrast to the stark decrease among the lower educated.

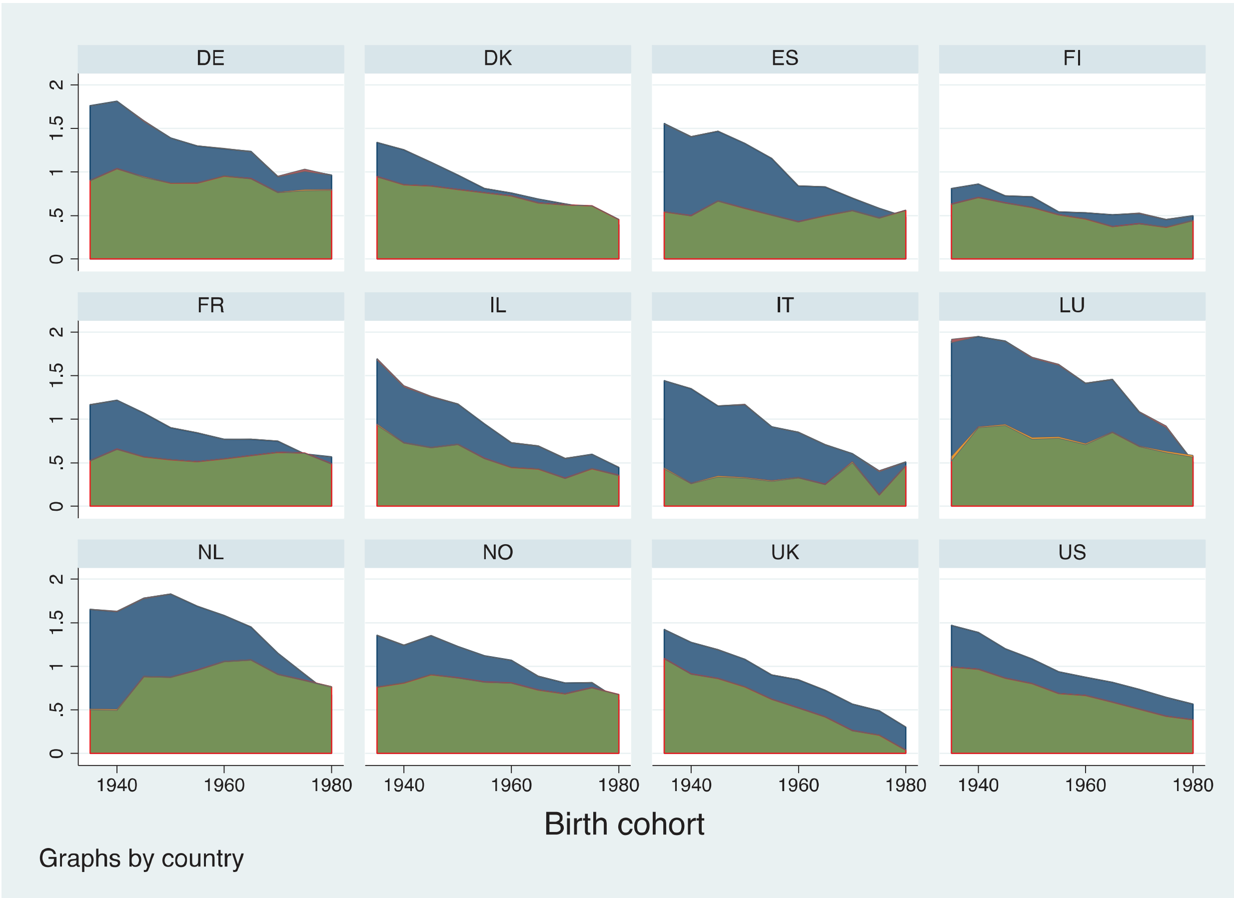
Moving to H3, our aim was to identify to what degree education can explain the gender gap in wages. To this end, we decomposed the gender wage gap in two steps: first, including only education (Figure 4) and second, including education as well as a larger set of control variables (Figure 5). Figure 4 reveals how much of the mean differences across gender is accounted for by group differences in education. We can see that, with the exception of the UK, the role of education is universally declining across cohorts. Over and above, it has even reversed in most countries. This implies that while women had lower wages than men but also had inferior levels of education in earlier cohorts, women in more recent cohorts are better educated but still have inferior levels of wages. In other words, if they had the same education as men, they should also have higher wages today.

Figure 4. The decomposed gender wage gap explained by education



Notes: The graph plots the APC modeled difference explained by education through country-year-cohort based Blinder-Oaxaca decomposition. Source: LIS.

Figure 5. Total (blue) and unexplained (green) gender wage gap



Notes: Blinder-Oaxaca decomposition of the gender wage gap controlling for education, number of children, and employment status. Source: LIS.

Next, we also account for group differences in the predictors education, living with partner, number of children and employment status in the Oaxaca-Blinder decomposition. The difference and how much of it remains unexplained are shown in Figure 5. The difference between the two curves shown indicates by definition how much of the mean differences across gender is accounted for by the set of predictors. To total differences indicates, again, that the overall gender gap is shrinking but that is is far from closing, while there seems to be a persisting unexplained part (except in the UK), no matter which and how many predictors we include. This points towards other explanations than those based on the predictors we include. In the Netherlands where part-time employment plays a crucial role, differences in work intensity between women and men could for instance be held responsible for an additional part of the differences. Country studies could investigate these explanations in further detail, which could not consistently be integrated in our comparative study.

Furthermore, important differences between the countries can be observed. In some countries, most notably Finland, much of the gender wage gap can be explained: the differences between women and men are due to differences in education, family patterns and employment status. In a few countries such as Germany and the UK, the differences in the above mentioned characteristics including education still explain a relevant part of the gender wage gap. Here, the gender gap may also potentially shrink in the future if women and men become more equal in these respects.

Conclusion

The common wisdom considers that gender equality in terms of education is the first or even the sole force able to promote gender equality in terms of wages. First, we notice significant general educational shifts in most of the twelve developed countries towards an relative improvement of women, leading, in most countries, even to an inversion from male to female domination in education in recent cohorts. However, this trend has not translated in a closing of the gender wage gap, which reaches and even stagnates at levels far from economic equalisation, even among the most recent cohorts. Second, we show that the pace of the narrowing gender wage gap differs in several countries for low and high educated with lower and/or decreasing levels of gender inequality among low educated.

Our aim was to identify the degree to which education and to a lesser extent other factors b can explain the gender wage gap. In Central and Southern European countries, a large part of the gender gap is due to gender differences in education, family patterns and employment status. Here we find that it is the converging profile of both genders leads to a declining gender gap. Nevertheless, in almost all countries, a large residual of unexplained differences persists.

More specifically we have shown that the role of education in determining the gender gap has been relatively small and decreased further across cohorts. This is an important result as it contradicts the wide belief that the rise of women in terms of education had led or could lead to a closing of the gender gap. This implies also that much of the gender gap is due to circumstances we are not able to include in our analysis without losing our contribution of providing a comparison over a long period of time and in a large number of countries. Future research could investigate such questions on a smaller set of countries where more detailed, well-harmonised data is available. Our central result is that education and economic inequality are two relatively independent dimensions of gender inequality, and the reduction of educational gaps is may be a necessary condition of economic equality, but it is not sufficient. In many countries, educational equality is reached and even exceeded (with women having a better education), but economic gaps remain strong, visible and durable, even for the very latest cohorts of young adults and thus for the future.

A merit of our study is to be able to include also women not in employment. Instead of focusing at hourly earnings, we have looked at income from paid employment and included also women with zero wages. This has the advantage to include changes in labour market behavior of women, joint choices in the household as well as labour market discrimination and represents in our view a wider, more realistic gender gap than looking only at (full-time) employed women, which would exclude a very large part of the female population.

Our study contributes to understanding the timing of the reduction of the gender gap in wages: it is strong and fast in Germany, Luxembourg and the UK, it is slower in France and the UK. In countries where the gaps where smaller for the 1940 birth cohort, the convergence is much slower with some stagnations. The importance of comparative birth cohort analysis can therefore not be overstated. The gendered trends in educational attainment that are central factors in the dynamics of stratification are diverse and their real impact is diverse as well. Thus, comparative research in this respect is vital for the stabilization of general results in social stratification.

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