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## Higher education expansion & labour income inequality in high-income countries: A gender-specific perspective

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# LIS

## Working Paper Series

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### Higher Education Expansion & Labour Income Inequality in High-income Countries: A Gender-specific Perspective

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# Higher Education Expansion & Labour Income Inequality in High-income Countries: A Gender-specific Perspective

Petra Sauer\*, Philippe Van Kerm†, Daniele Checchi‡

## Abstract

The expansion of higher education since the second half of the 20th century was particularly pronounced among women. In most high-income countries to date more women complete a tertiary level than men. But research on the implications of higher education expansion for labour income inequality has largely treated expansion as gender neutral. With this paper we build on prior studies that have ignored potentially differential effects by factoring in what it means for earnings inequality to increase tertiary education among women as compared to men. To this end we draw on harmonised data from the Luxembourg Income Study (LIS) for 27 countries and two time points, 1995 and 2015, and use the method of Recentered Influence Function (RIF) regression. We obtain three main insights from our study. First, no average distributive effect of higher education expansion exists. Second, the distributive effect is gender-specific. The impact on the Gini coefficient of increasing tertiary attainment of men is positive and significant but the impact of increasing tertiary attainment of women is negative and significant. Third, the increasing share of tertiary educational attainment is the main factor explaining that distributive estimates shrink towards zero over time for both women and men. Only for men does larger inequality between and within educational groups significantly contribute to magnify the impact of educational expansion on earnings distributions across countries. Our analysis highlights that taking the gender dimension into account is crucial to obtain exhaustive understanding of the role of education for overall income inequality.

**Keywords:** Education, Tertiary education, Inequality, Earnings, Gender

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# 1 Introduction

Higher education<sup>1</sup> has been continuously expanding in the second half of the 20th century worldwide, and particularly in high-income countries. Thus, in 13 out of the 38 OECD member states more than half of the young population aged 25-34 attained tertiary education, and in another 13 countries the share was larger than 40% in 2021.<sup>2</sup> More than half of the population with tertiary education raises questions about what this means for inequality. The focus of this paper is which implications the expansion of higher education has for labour income inequality in high-income countries.

A noteworthy characteristic of the educational expansion that took place over the last decades is that it was more pronounced among women than among men so that to date more women complete a tertiary level than men. The concerning literature has documented and analysed the “reversed college gender gap” (Goldin, Katz, and Kuziemko, 2006) in the US (DiPrete and Buchmann, 2006) and worldwide (Sauer, 2019). However, gender segregation in higher education has been shown to persist since, among other things, men and women sort into different programs based on fields of study and prestige (Werfhorst, 2017; Weeden, Thebaud, and Gelbgiser, 2017). A multitude of studies has revealed significant gender gaps in earnings and wages among higher education graduates (Bar-Haim et al., 2018), and that these gaps tend to be larger among top income earners (Piazzalunga, 2017). But research on the implications of higher education expansion for labour income inequality has largely treated expansion as gender neutral (e.g. Jaume, 2021; Alejo, Gabrielli, and Sosa-Escudero, 2014). This is the research gap we tackle with our study. We argue that shifting the educational structure towards higher levels might entail different effects on overall labour income inequality, depending on whether the additional education accrues to women or men. Accounting for gender should thus better enable to understand the underlying mechanisms of the education-inequality relationship, and contribute to obtain more insightful implications for policy.

Against this background, we examine research questions at three levels: *(1) Distributive effects:* Does increasing tertiary educational attainment contribute to reduce or increase earnings inequality? *(2) Gender-specific effects:* Does this impact differ depending on whether the share of male or female graduates increases? *Differences across countries and over time:* (3) What is the relevance of inequality within and between educational groups, and of the proportion of tertiary educated in the population for differences between women and men as well as across countries and over time?

How more graduates alter the earnings distribution depends on how many people attain tertiary relative to lower education levels, how tertiary education is rewarded on the labour market relative to lower levels on average, and how the rewards to tertiary education are distributed among graduates. A gender-specific impact can be expected if labour incomes of highly educated men and women differ significantly, on average, and if female graduate’s returns are more or less dispersed than male’s. To gauge the combined impact of these factors we draw on LIS data for 27 countries and two time points, 1995 and 2015, which represent different stages in the process of educational expansion. Using the method of Recentered Influence Function (RIF) (Firpo, Fortin, and Lemieux, 2009), we obtain the impact of (marginally) increasing the share of tertiary educated workers, on average and separately

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<sup>1</sup>Throughout this paper we use the terms higher and tertiary education interchangeably and refer to short-cycle tertiary, Bachelor, Master and PhD degrees (see Section 3).

<sup>2</sup>OECD Education Data, 13/04/2022.

for men and women, on earnings inequality as measured by the Gini coefficient in each country, and in both points in time. By examining the mediating impact of individual labour market characteristics we provide insights into potential underlying mechanisms. We then use the country-, time- and gender-specific distributive estimates as dependent variable in a simple OLS regression to investigate the relative relevance of educational attainment, between- and within-group inequality for cross-country and temporal variation.

The paper is structured as follows. By discussing gender- and education-specific between- and within-group inequality, Section 2 provides our theoretical background. Section 3 describes our sample obtained from LIS survey data. In Section 4, we explain how RIF regression is applied in order to estimate the impact of higher education expansion on earnings inequality; thereafter we present descriptive evidence and illustrate the interpretation of RIF regression estimates in Section 5. Our basic results are presented in Section 6.1, followed by the analysis of the mediating role of labour market characteristics and cross-country and temporal variation in Sections 6.2 and 6.3 respectively. Finally, Section 7 summarises and discusses our results, and reflects on potential policy implications.

## **2 The case of within- and between-group distributions & the neglect of gender in education’s impact on income distributions**

Three interacting factors determine how individual educational achievements shape the distribution of labour income. The first factor is the level and composition of educational attainment; that is, the share of the population in each educational group. The second factor is inequality between educational groups; that is, how much more highly educated workers earn relative to lower educated workers, on average. The third factor is the distribution of earnings within educational groups. However, as the literature surveyed below suggests, being the outcome of gendered processes (Misra and Murray-Close, 2014) each factor is potentially gender-specific. First, more women attain higher education levels than men. Second, inequality among women differs from inequality among men, resulting in different education premiums. Third, the distribution of earnings among graduates is differently shaped for women and men which involves the existence of a graduate gender earnings gap.

At the start of the new millennium McCall (2000, p. 251) already noted the importance of moving “... beyond the gender wage gap as the central indicator of women’s economic status ...” and argued for the analytical importance of gender in the analysis of social inequality in the post-industrial area. Nevertheless, the two strands of the literature continued to evolve referring only parenthetically to each other (Sauer, Rehm, and Mader, 2021). In what follows we integrate theoretical considerations and empirical findings, which enables us to build expectations about the impact of gender-specific expansion on earnings distributions across countries and over time.

### **2.1 Between-group inequality & gender-specific education premiums**

With human capital theory (Becker, 1993) and the model of skill-biased technological change (Acemoglu and Autor, 2011), economists have developed a theoretical tool to explain educational expansion through rising demand for high skills, and to analyse inequality between educational groups within

the framework of market mechanisms. Based on the assumption that education contributes to higher wages through raising individual productivity it is expected that increasing the supply of graduates reduces the relative return to tertiary education in the context of high demand due to technological change. If expansion itself leads to upgraded job requirements through fostering further technological change biased towards skilled workers education premiums would be pushed upwards (Lauder, Brown, and Cheung, 2018; Acemoglu, 2002). Still, high education premia are predominantly understood as resulting from a shortfall in supply.

A bulk of empirical evidence which finds increasing education premia in times of stalling numbers of college graduates is largely based on male samples in the US and draws conclusions from the time span between the 1970s and 2000. This research built the basis for the concept of a “race between technology and education” (Tinbergen, 1975; Tinbergen, 1977; Goldin and Katz, 2010). The evidence from Autor (2014) indicates that education premiums among full-time working men and women in the US followed a similar trend, increasing between 1979 and 2000, and stable thereafter until 2012. Comparative evidence for a larger set of countries reveals large variation concerning levels as well as changes over time. Weisstanner and Armingeon (2018) find premiums to be highest in Anglo Saxon countries and lowest in Nordic countries. Trends between 1995 and 2007 are mixed, stable in the US, increasing in Continental countries, declining in Eastern and Southern countries as well as in Australia and the UK. Even if their results are based on a sample including men and women, they are restricted to full-time-full-year workers and hide a potential gender-specific evolution of education premiums. Based on country samples which include part-time workers, Strauss and Maisonneuve (2007) show that the wage premium from having attained tertiary education in 2001 tends to be larger for women in 9 out of the 21 studied high-income countries and smaller in Austria, Finland and Italy.

One of the few substantial studies on income inequality among women is McCall (2000b) who analyses gender differences in the wage premiums for college relative to high-school education across regional labour markets in the US in 1990. As opposed to other studies she finds that wage differentials among women are larger than among men; the difference between men and women is particularly sizable in a sample consisting of the full working age population instead of full-time workers only. This indicates that working time is a decisive factor contributing to low wages of low educated women. Factors related to employment insecurity (unemployment, immigration, casualisation) significantly explain women’s college premium while factors related to technology and international trade are relevant for wage differentials among men.

## 2.2 Within-group inequality & the graduate gender gap

Inequality within educational groups has been identified to account for a substantial share of earnings inequality, and to have been increasing at a similar pace (McCall, 2000a).<sup>3</sup> Importantly, within-group inequality has been shown to increase with the education level. Returns to higher education tend to be larger at the top of the wage distribution than at the bottom in the US (Lemieux, 2006) and,

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<sup>3</sup>Within-group inequality is typically captured as inequality among education, experience and gender groups (DiNardo, Fortin, and Lemieux, 1996; Katz and Murphy, 1992)

with variations, in European countries (Martins and Pereira, 2004).<sup>4</sup> Wages are also found to be more dispersed among tertiary education graduates than among workers with lower education levels, and inequality within the highest education level increased in the 90s (Budria and Telhado-Pereira, 2005). Budria and Telhado-Pereira (2005) thus conclude their study with noting that further education expansion which shifts the education structure to the tertiary level is able to contribute to rising wage inequality through increasing within-level inequality.

Their conclusion is drawn, however, from a restricted sample. Most empirical research on within-group wage inequality to date is based on samples of the male population. The few studies that are based on full population samples suggest that the spread of returns to tertiary education is more pronounced for men than for women (Buchinsky, 2001; Fersterer and Winter-Ebmer, 2003). Another strand of the literature shows that significant gender gaps in monetary labour market outcomes exist, also among graduates. Depending on sample restrictions, whether wages or earnings are considered, and the time after graduation, the unadjusted graduate gender gap ranges from 30% for German Phds (Goldan, 2021) to 20% for graduates in the UK (Chevalier, 2007) and 5.6% for recent graduates in Italy (Piazzalunga, 2017).

The human capital approach attributes within-group inequality to the dispersion of ability (Andini, 2017), which is assumed to be larger the higher the education level. Moreover, rising demand for highly specialised technical skills is thought to alter the return structure not only between but also within education groups (McCall, 2000a). Evidence that reveals particularly large gender gaps (favouring men) at the top of students' math test score distributions (Weeden, Thebaud, and Gelbgiser, 2017) would, from this perspective, contribute to explain different locations and shapes of graduate's wage distributions by gender as well.

Accounting for social and institutional processes contributes to the understanding of within-group inequality through heterogeneity among graduates which stems from education occupying a central role in shaping and maintaining the social structure (Attewell and Newman, 2010). If higher education does not solely work through increasing productivity, but also acts as positional good (Brown, 2001; Triventi et al., 2016), social classes and status groups continuously compete in order to secure their relative advantage, which has been shown to play out, among other things, through institutional and program prestige (Taylor and Cantwell, 2019; Weeden, Thebaud, and Gelbgiser, 2017). As a consequence existing social inequalities may persist or even increase (Blanden and Macmillan, 2016). Furthermore, according to Maximum (Efficiently) Maintained Inequality theory (Hout, 2006), the first who benefit from educational expansion are descendants from upper middle-class backgrounds. Only when their attainment is almost saturated do children from disadvantaged backgrounds gain access, which has often been accommodated by a mass segment of low-quality colleges or private institutions (Carnoy, 2011). Self-selection into higher education institutions according to their vertical position has a gender dimension as well. Research by Weeden, Thebaud, and Gelbgiser (2017) reveals significant prestige segregation in US doctoral education by gender: men are overrepresented in top institutions, particularly in Mathematics, while women are increasingly represented in middle and lower-tier institutions. To the extent that University status and program prestige affect graduate's

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<sup>4</sup>The gap is more pronounced in Austria, Finland, Ireland, Netherlands, Portugal, UK, US and Sweden, and less pronounced in Denmark, France, Germany, Italy, Norway and Spain

labour market prospects (Borgen, 2015; Anelli, 2016)<sup>5</sup> inequalities in access translate into (gender-specific) within-group inequality. Thus, Weeden, Thebaud, and Gelbgiser (2017, p.145) conclude that “..., the basic pattern of prestige segregation will be familiar to students of gender inequality: women are underrepresented among graduates of programs that most often lead to the higher paying, higher prestige jobs.”

Notwithstanding the importance of prestige segregation, horizontal segregation by field of study has been identified to be the most important driver of graduate gender gaps in monetary labour market outcomes. Accordingly, women and men select into different fields of study, and female-dominated fields tend to offer lower levels of remuneration. As argued by Ochsenfeld (2014, p.1), “as educational expansion continues and academic disciplines assume a licensing function for occupations, sex segregation in the labour market is becoming increasingly pre-structured by segregation into fields of study in higher education.” Some authors have attributed wage differentials by field to differences in skills and interest (Grave and Goerlitz, 2012) while others have argued for the relevance of valuative discrimination, i.e. lower pay levels being associated with women’s work (England et al., 2007; Bobbitt-Zeher, 2007; Leuze and Strauß, 2009), investment in portable human capital which can be accommodated with career breaks and flexible working hours (Estevez-Abe, 2005; Polavieja, 2008), or for the role of social norms in educational decisions leading women to self-select into fields of study which yield larger non-monetary, cultural returns as opposed to economic returns on the labour market (Ochsenfeld, 2014; Werfhorst, 2002).

In addition to their impact through field of study segregation, occupational and employment characteristics (Bar-Haim et al., 2018), working hours (Triventi, 2013) and family situation (Passaretta and Triventi, 2021) exert separate impacts on graduate gender gaps in earnings and wages. Furthermore, recent evidence on graduate mismatch (Addison, Chen, and Ozturk, 2020; Mavromaras et al., 2013) indicates that tertiary educated women are more likely than men to be overeducated and overskilled, and that particularly the combination of mismatches is associated with a significant wage penalty. At the country level, labour market and welfare state institutions such as family policies in particular determine the potential magnitude of graduate gender gaps in educational and labour market outcomes (Triventi, 2013).

The combined impact of these factors is to shift the location of women’s earnings distributions to the left. For our study it is also relevant how they affect the shape of the distribution of tertiary educated women as compared to men. On the one hand, the prevalence of part-time work, field-of-study and occupational gender segregation, and educational mismatch among highly educated women could imply a large fraction of lower earnings relative to a small share of those of full-time working women who make it to the top. This would result in larger within-group inequality among women than among men. On the other hand, Universities women graduate from and the occupations they work in after graduation might offer a more compressed range of wages as compared to male-dominated programs, fields and occupations. Moreover, glass ceilings (Piazzalunga, 2017; Ciminelli, Schwellnus, and Stadler, 2021) put an upper limit to women’s wages. This in turn would suggest lower inequality among highly educated women as compared to men. But it need not be the case that within-group inequality is also smaller than among low educated women, which is typically driven by very low earnings at the bottom.

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<sup>5</sup>Scharf, Hadjar, and Grecu (2019) find that the return to prestige is larger for women than for men.



It is beyond the scope of this paper to thoroughly discriminate between the underlying mechanisms. Still, the surveyed literature helps us to build expectations about the potential direction and magnitude of gender-specific distributive effects of educational expansion, and about how they vary across countries and over time.

*Between-group inequality* All else equal, the larger earnings differentials between groups, the larger the distributive impact. If, as suggested by the evidence in McCall (2000b), education premiums are higher among women than among men, not only in the US but also in other high-income countries, raising women’s educational attainment should exert a larger disequalising impact on earnings distributions than raising men’s educational attainment.

A second between-group element which has not been touched upon in the literature is relevant, namely the gap between low educated men and high educated women. The existence of a graduate gender gap in earnings suggests that earnings of highly educated women can be close to those of low educated men which would trigger an equalising impact.<sup>6</sup> In contrast, large education premiums for men imply that inequality between highly educated men and low educated women is even more pronounced than gender-specific between-group inequality.

*Within-group inequality* The literature suggests that, at least for men, earnings are more dispersed among graduates than among lower educated so that educational expansion would contribute to increase earnings inequality. For women, the distributive effect will depend on whether their within-group distributions are more similar to low-educated men or women, or even more unequal than those of high-educated men.

*Labour market characteristics* The surveyed literature suggests that labour market conditions are important factors which mediate the relation between educational expansion and earnings inequality. On the one hand, working time, occupation and sector of employment depend on the education level. On the other hand, the prevalence of part-time work among low educated women has been shown to be a major determinant of the premium on women’s higher education (McCall, 2000b) while gender segregation by occupation and industry - which is to some extent the result of field-of-study segregation - additionally impinges on inequality among tertiary educated women.

### 3 Data: The Luxembourg Income Study

We make use of the comparative features of harmonised survey data from LIS<sup>7</sup>. The LIS database is an extensive source of micro-data collected from 52 countries in Europe, North America, Latin America, Africa, Asia, and Australasia, in total spanning over five decades. LIS datasets contain harmonised household- and individual-level data on labour and capital income, pensions, public social benefits and private transfers, taxes and social security contributions, expenditures, as well as on employment characteristics and socio-demographics.

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<sup>6</sup>This is potentially the most important mechanism through which higher educational attainment contributes to reduce the overall gender earnings gap.

<sup>7</sup>Luxembourg Income Study (LIS) Database, <http://www.lisdatacenter.org> (multiple countries; 11/2019-04/2022). Luxembourg: LIS.

Our sample is composed of 23 European countries, Canada, the United States, Australia and Japan. For each country we pool surveys over a five-year window around 1995 and 2015 respectively.<sup>8</sup> However, we do not observe all countries over both time periods, either because no survey is available for the concerning time window or because no data on educational attainment or earnings is reported.<sup>9</sup>

Our country-period samples consist of people aged between 31 and 65 who pursued any employment activity in the current period.<sup>10</sup> Due to our interest in gender-specific effects, we chose not to restrict our sample to full-time-full-year workers<sup>11</sup> as this would exclude women who have been shown to be overrepresented on the margins of the labour market regarding working hours and type of employment (Bar-Haim et al., 2018). We capture earnings inequality based on personal level data on incomes that accrue from dependent employment or self-employed work, including cash payments and the value of goods and services received. We exclude zero incomes and top-code labour income at the 99th percentile.

The main explanatory variable of our analysis is a dummy variable indicating whether a person has attained tertiary education. We obtain this information from a nine-category variable which measures the highest education level attained and is based on ISCED 2011 mappings.<sup>12</sup> Tertiary education is thus comparable across countries and over time. It includes short-cycle tertiary degrees, Bachelor, Master and PhD degrees. In separate specifications we add controls for age, dependent employment, industry and occupation (both based on 3 categories) and employment in the public sector. This information is, however, not equally available for all countries.

## 4 Method: Recentered Influence Function Regression (RIF)

An immediate way to think about how educational expansion can affect the overall distribution of labour income is by considering a shift of density mass from the lower to the higher education distribution. The impact of varying the relative shares of the two groups depends on the locations and size of the underlying densities relative to each other (Jenkins and Van Kerm 2005).

The effect of density shifts on various inequality measures is what a technique known as Recentered Influence Function (RIF) regression captures. This method has been firstly proposed by Firpo, Fortin, and Lemieux (2009) to gauge the impact of changes in some explanatory variable on quantiles of the unconditional distribution of an outcome variable. Since then, the method has been extended to various distributional statistics (Essama-Nssah and Lambert, 2011) and is increasingly applied to infer about the extent to which differences in individual and job characteristics account for differences

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<sup>8</sup>For each country we merge surveys from 1993, 1994, 1995, 1996, 1997 and 2013, 2014, 2015, 2016, 2017, if available. The number of surveys thus varies across countries.

<sup>9</sup>Switzerland, France and Sweden are only observed around 1995; Estonia, Japan, Lithuania, Slovakia and the UK are only observed around 2015.

<sup>10</sup>This follows the ILO definition of employment. Accordingly, employed persons should have worked for at least one hour for pay or profit in the reference period or had a job but did not work due to temporary absence from the job because of sickness, maternity leave, holidays, etc. or due the nature of their working time arrangement, such as shift work, etc.

<sup>11</sup>Our results are robust against introducing upper and lower limits on working hours (see Appendix C).

<sup>12</sup><http://uis.unesco.org/en/isced-mappings>

in (labour) income inequality.(e.g. Chi and Li, 2008; Choe and Van Kerm, 2018)

RIF regression is based on transforming the outcome variable of interest using the Recentered Influence Function, which is defined as follows,

$$RIF(y_i, v(F_Y)) = v(F_Y) + IF(y_i; v(F_Y)) \quad (1)$$

$$IF(y_i; v(F_Y)) = \lim_{\epsilon \rightarrow 0} \frac{v((1 - \epsilon)F_Y + \epsilon\Delta_{y_c}) - v(F_Y)}{\epsilon} \quad (2)$$

where  $y_i$  is the outcome variable,  $F_Y$  is the CDF of  $y$  and  $v(F_Y)$  is a functional used to estimate a distributional statistic, e.g. quantiles, quantile ratios, Gini, Theil, ect.. The IF compares two distributions: the original distribution  $F_Y$  and the distribution of  $y$  that results from an infinitesimal contamination at  $y_c$ . It thus captures the change in a distributional statistic that is due to a small change in the distribution of  $y$  which gives more weight to observations with values  $y_c$ . “Recentering” the IF by adding the level of the inequality measure allows for an interpretation as the relative contribution of observation  $y_c$  to the distributional statistic (Rios-Avila, 2020).<sup>13</sup>

Firpo, Fortin, and Lemieux (2009) have shown that regressing the RIF onto the explanatory variables of interest enables to estimate the effect of a change in the distribution of covariates on the unconditional distribution of  $y$ , as measured by the distributional statistic, holding conditional distributions constant. In a multivariate setting the obtained impact is thus labelled as unconditional partial effect (UPE), which one can estimate using Ordinary Least Squares (OLS) assuming a linear relation between the outcome variable, the main explanatory variable and further covariates. For a continuous explanatory variable, the UPE is interpreted as the impact of a change in its distribution such that the unconditional average increases by one unit (Rios-Avila, 2020).

Our outcome variable is labour income, which we transform using the RIF for the Gini index. We are interested in the distributive effect of changes in the distribution of educational attainment. Our main explanatory variable is a dummy variable indicating whether a person has attained tertiary education ( $e$ ). Our baseline specification which controls for age, age squared and survey fixed effects ( $Z$ ) to account for age-specific earnings profiles and discrepancies across surveys within the five-year windows around 1995 and 2015 respectively is thus given as,

$$RIF(y_i, v(F_Y)) = \alpha + \mathbf{e}\beta_e + \mathbf{Z}\delta + \epsilon; \quad E(\epsilon_i) = 0 \quad (3)$$

Following Choe and Van Kerm (2018), the discrete UPE of increasing tertiary attainment ( $\beta_e$ ) is derived from substituting tertiary education graduates for workers without tertiary education, holding the income distribution conditional on being tertiary educated and conditional on survey years constant. Appendix A summarizes their derivation of the UPE formally. The sign and magnitude of the discrete UPE depends, on the one hand, on the relative population shares of tertiary vs. non-tertiary educated, and on differences in the shapes of the conditional distributions of different education types, on the other hand. It has to be noted, however, that holding the conditional distribution constant implies to assume that rates of returns remain constant, i.e. are not affected by changes in the

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<sup>13</sup>Moreover, the RIF provides an approximation of  $v(F_Y)$  given the influence of  $y_c$ . Thus, integrating the RIF over all possible values of  $y$  one obtains the overall level of the distributional statistic

composition.

To test for gender-specific distributive effects, we add gender as covariate to Equation 3 and include an interaction term with tertiary education. In Equation 4, the reference group against which the other conditional densities are evaluated with are males who did not attain tertiary education. We thus obtain discrete UPEs of swapping men without tertiary education with tertiary educated men ( $\beta_m$ ) and women ( $\beta_f$ ), respectively.

$$RIF(y_i, v(F_Y)) = \alpha + \mathbf{e}\beta_e + \mathbf{e} * \mathbf{g}\beta_{e,f/m} + \mathbf{g}\gamma + \mathbf{Z}\delta + \epsilon; \quad E(\epsilon_i) = 0 \quad (4)$$

We also provide results based on accounting for dependent employment, part-time work, occupation, industry and public sector employment sequentially (see Section 6.2).

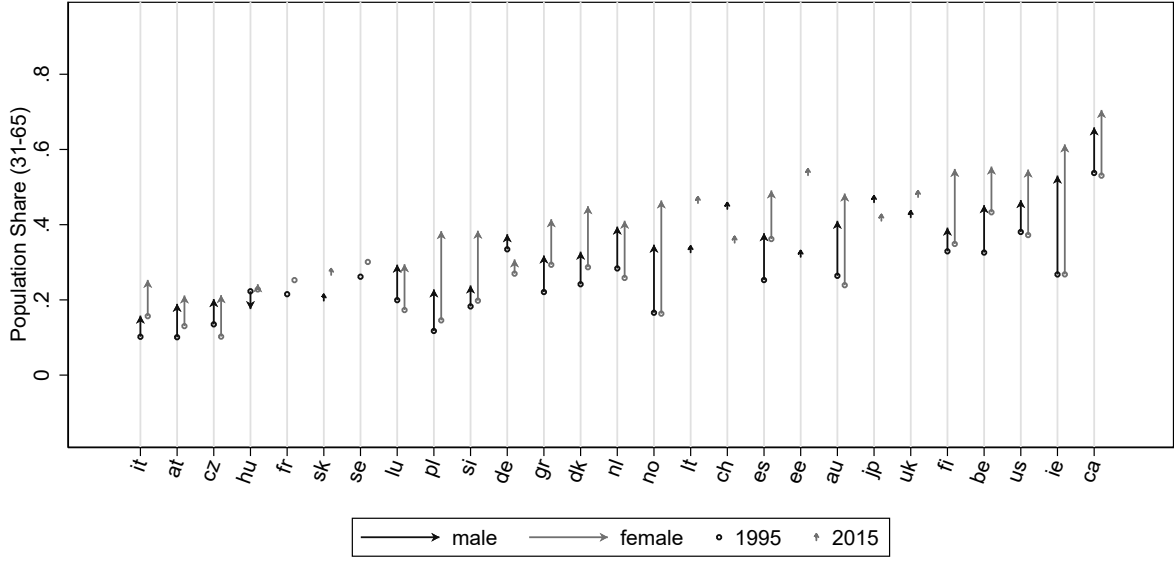
Estimation of Equation 3 is conducted in a two-step procedure. First, the  $RIF(y_i, v(F_Y))$  for the distributional statistic of interest is estimated for each sample observation. This involves obtaining  $F_Y$  from the sample, as it is unknown itself. Second, the  $RIF(y_i, v(F_Y))$  is used as dependent variable in the regression specified in 3, which is estimated using OLS. To deal with the resulting complex dependence between sample observations we use standard errors computed based on bootstrap resampling for inference. (Firpo, Fortin, and Lemieux, 2009) We conducted RIF regression calculations using the statistical software Stata (version 16.1). The user-written package `rifhdreg` (Rios-Avila, 2020) facilitates RIF estimation for a large set of distributional statistics, consolidates the two estimation steps and allows to select different types of standard errors. To obtain bootstrapped standard errors, we use the `bootstrap` prefix before the `rifhdreg` command.

## 5 Descriptive Evidence & Interpreting RIF Estimates

Figure 1 shows estimates around 1995 and 2015 of the share of men and women aged between 31 and 65 with tertiary education in 27 high-income countries for which we have data in LIS. This unveils that tertiary education expanded in all countries. However, there is substantial variation in both the level and the growth of tertiary education attainment. In 1995, just 7% of individuals reported tertiary education in Italy against 47% in Canada. The range further widened over time and extends from 8% in Italy to 63% in Canada in 2015. While Canada has the largest share of tertiary educated in our series, Ireland experienced the most substantial expansion with increases in the proportion of graduates by 28 and 35 percentage points for men and women respectively. By contrast, Italy not only has the smallest proportion of tertiary educated people in both time periods, but is also among the countries – with Austria, Germany, Hungary and the Czech Republic – which recorded relatively little change over time.

Figure 1 also makes it clear that women have outpaced men with regard to their educational attainment. In 1995 it was only in Northern European countries (Denmark, Finland and Sweden) that women had higher shares of tertiary education graduates. By 2015, women have higher rates of tertiary education than men in all countries, except Germany, Greece, Japan, Luxembourg and the Netherlands.

Figure 1: Tertiary Attainment by Gender and Age

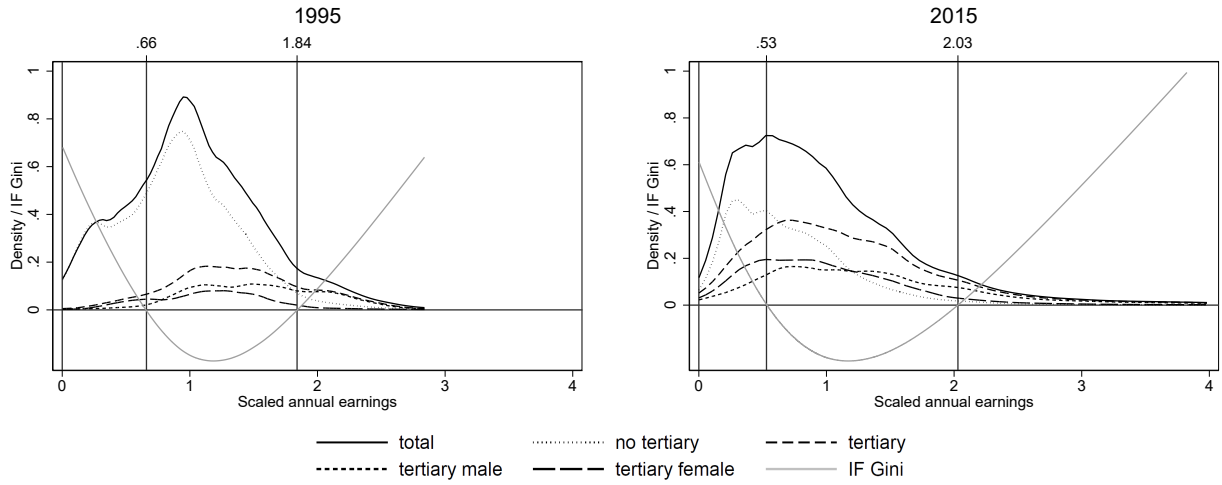


Notes: Switzerland, France and Sweden are only observed around 1995; Estonia, Japan, Lithuania, Slovakia and the UK are only observed around 2015.

Population shares are indicative of the relative weight of education types in the unconditional income distribution and determine the magnitude of the distributive effect. The larger the population share, the more does the education type determine the shape of the unconditional income distribution, thus, the smaller the effect of further (marginal) permutations. Conversely, the smaller the population share of an education type, the larger the marginal effect of increasing its relative weight in the unconditional income distribution. The sign of the distributive effect is determined by the relative location of the distribution conditional on being tertiary educated as well as on how dispersed incomes are within education types. A hypothetical scenario of perfectly equal distributions for each educational group and a high tertiary education premium implies that increasing the relative weight of tertiary education puts more mass into the upper tail, thus altering the shape of the unconditional distribution in a way so as to increase overall income inequality. If the incomes of the tertiary educated are more dispersed than those of the lower educated population the positive distributive effect would be aggravated. Conversely, a relatively more equal distribution among tertiary graduates would mitigate the impact. Differences in educational attainment and gender-specific distributions conditional on being tertiary educated then imply gender-specific magnitudes and signs of the distributive impact of educational expansion.

Figure 2 illustrates how these three factors interact to mechanically shape the relationship between educational attainment and the unconditional earnings distribution. For Ireland in 1995 and 2015, we show the unconditional density function of labour income together with the densities conditional on not being tertiary educated and on being tertiary educated by gender. Each conditional density has been multiplied by the share of the group in the population so the three lines for the conditional densities add up to the unconditional density. Figure 2 also depicts the IF for the Gini index, from which

Figure 2: Densities: Ireland 1990s - 2010s



one can infer the income ranges associated with positive and negative inequality effects respectively. Annual labour income is scaled by its country- and period-specific mean, amounting to 22,550 and 40,180 USD (in 2017 values) in 1995 and 2015 respectively. In the case of Ireland, putting more mass on incomes between 66% and 185% of mean income contributed to reduce the income Gini in 1995; this range expanded to cover 53% and 203% of mean income in the 2015.

In 1995, the share of graduates was relatively low so that the shape of the unconditional distribution was determined by the conditional distribution of the low educated. Yet, incomes of the tertiary educated were more dispersed than those of individuals with lower education levels (Standard deviation: 11,776 vs. 10,357). They thus not only spanned over the inequality-reducing range but also shaped the upper tail of the unconditional distribution, contributing to the area where income inequality increases. The same is true for 2015. However, the share of the population with tertiary education had reached 50% by then so that the unconditional distribution is simultaneously shaped by the two education types. Moreover, the mass of tertiary educated incomes has expanded at levels which fall into the inequality reducing segment as indicated by the IF.

In Ireland the distributions conditional on being tertiary educated are differently shaped for women and men. Labour incomes of women were lower on average, and less dispersed, in both time periods. Notably, it was the conditional distribution of tertiary educated men that largely determined the segment of the unconditional density above the upper threshold where earnings inequality increases. Conversely, the conditional distribution of tertiary educated women was more relevant to form the inequality-reducing segment. Until 2015, mass had also increased at income levels below the lower threshold for tertiary educated women.

By plotting different parameters of women's and men's earnings distributions, Figures 3 to 4 summarise this information for the whole sample of countries over both time periods. Notwithstanding notable variations across countries and over time, this descriptive evidence suggests some empirical regularities which determine the distributive impact we obtain from RIF estimation and build the

basis for the cross-country-temporal regressions we conduct in Section 6.3. First, in accordance with Mc Call’s (2000) evidence for the US, we find that inequality between educational groups as measured by the premium for tertiary education based on median earnings<sup>14</sup> tends to be larger among women than among men in a broader set of high-income countries (Figure 3). In some countries such as Ireland and Australia women’s premiums are lower in 2015 than in 1995 while men’s premiums are larger. Premiums increased for both genders in most countries; in some countries such as the US and Luxembourg this tendency is larger for men than for women, in others such as Austria, Germany and Belgium the reverse is true.

Second, earnings of women with a tertiary degree are lower than men’s, on average (Figure 4). A significant gender gap in earnings of higher education graduates exists in all countries ranging from 117% in Japan over 65% in Germany to 12% in Slovenia (see Table 3 in Appendix B ). Third, the dispersion of earnings within the tertiary education group tends to be larger than within the lower education group (upper panel of Figure 5). This is true for both genders but slightly more pronounced for men. In fact, men’s earnings are more dispersed than women’s independent of their education level. The picture looks different when using the Gini index which measures relative inequality. For men, inequality within the high-education group does not differ substantially from inequality within the low-education group. For women, in some countries such as Italy, Australia and Ireland where inequality within the lower-education group was relatively large in 1995, inequality among the tertiary educated had increased until 2015 so that the Ginis of both education levels match each other in most countries in 2015 (lower panel of Figure 5). Taken together our descriptive findings indicate that the earnings distributions of tertiary educated women and men have different locations and shapes. Notably, earnings distributions conditional on being a tertiary educated women tend to be more similar to those conditional on being a lower than on being a tertiary educated man (see Figures 9 and 10 in Appendix B).

## 6 Results

### 6.1 Main Results

Figure 6 presents our baseline results for the 27 countries of our sample, and for each time period. Countries are sorted based on their level of educational attainment in 2015. Average distributive estimates not accounting for gender are derived from estimating equation 3. Gender-specific estimates are obtained from adding a gender dummy as well as an interaction term between tertiary education and gender (see Equation 4). The RIF estimates depicted on the y-axis indicate how many points the Gini in a particular country and time period changes if the proportion of graduates increases by ten percentage points, and, correspondingly, the proportion of non-tertiary educated workers decreases by ten percentage points. This is expressed relative to the Gini level in the concerning period.<sup>15</sup> Again taking Ireland in 2015 as example, given the locations and shapes of the conditional densities relative

<sup>14</sup>Using the median instead of means takes account of the skewness of the distribution. This is particularly relevant when comparing earnings of women and men. Due to part-time work, women’s earnings tend to be more right-skewed than men’s.

<sup>15</sup>We use the average Gini value across gender here.

Figure 3: Between-group inequality

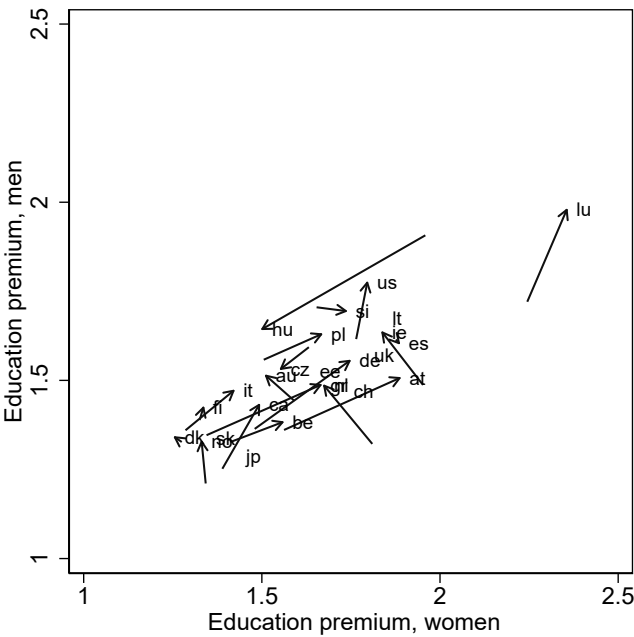


Figure 4: Graduate gender earnings gap

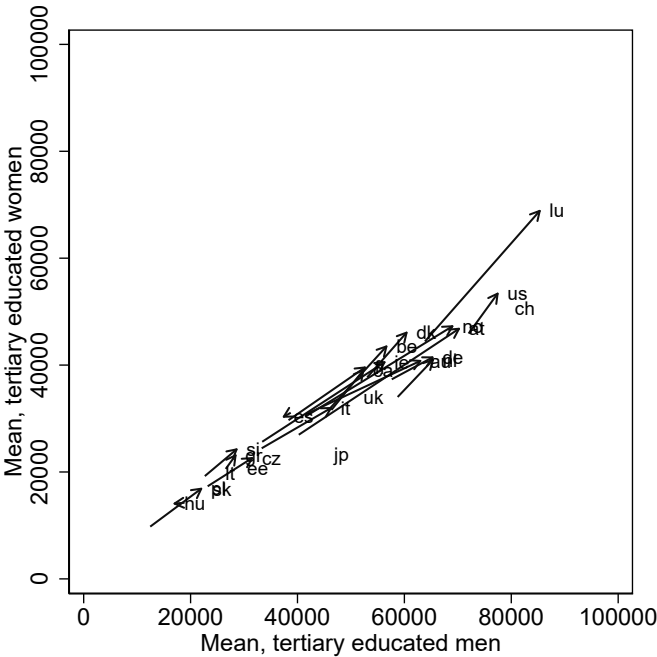
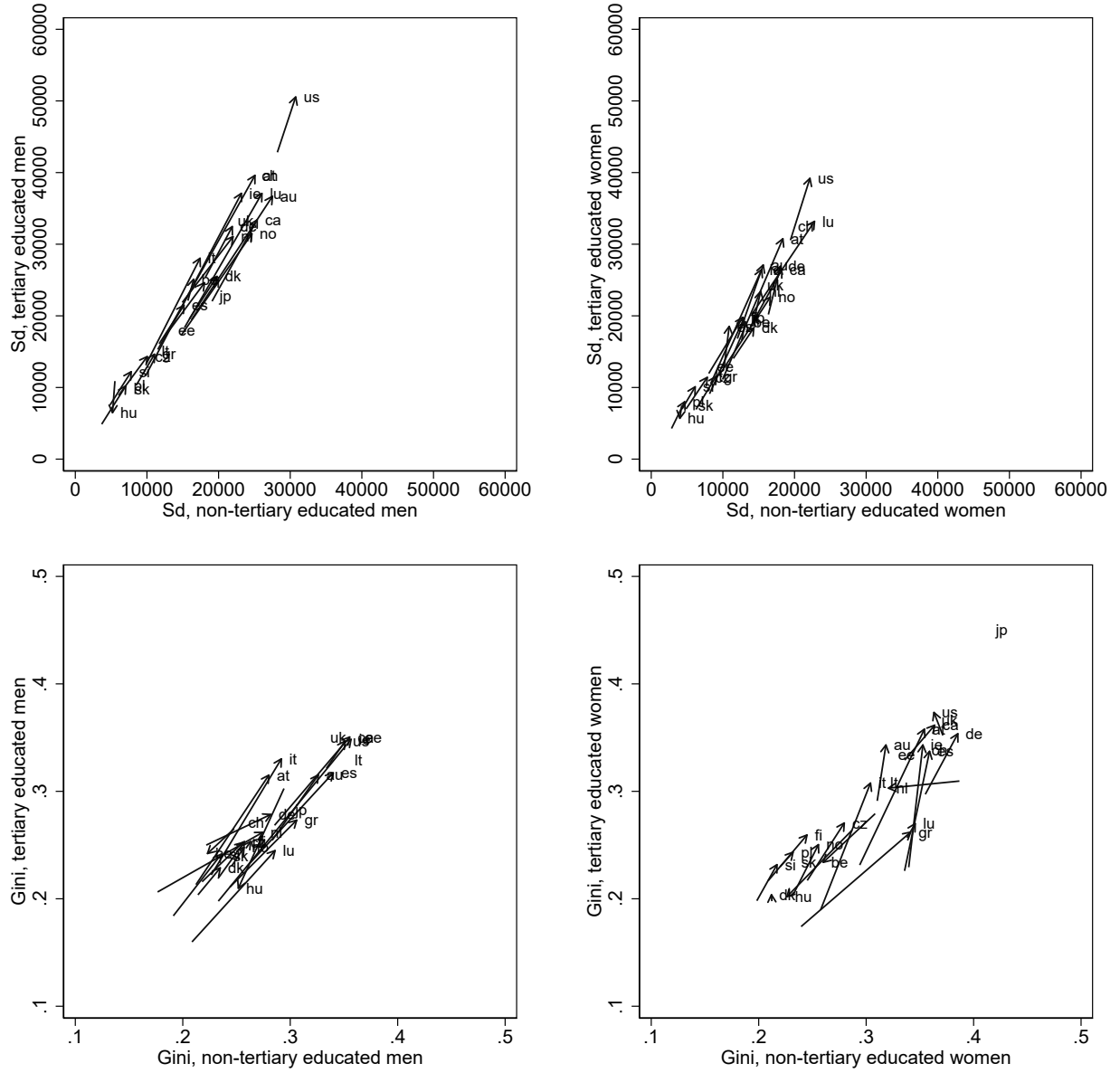


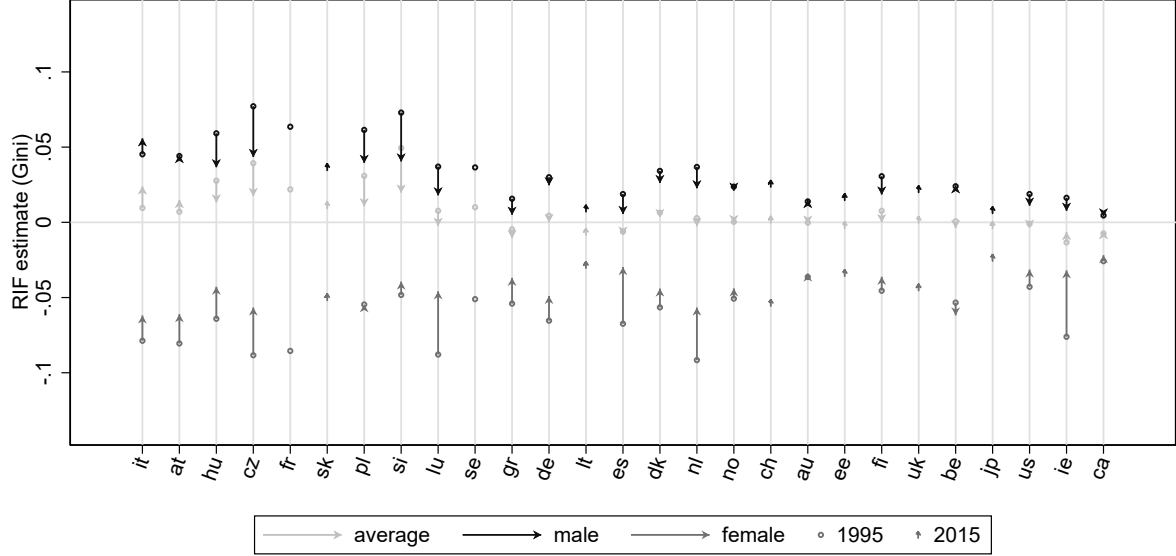


Figure 5: Within-group inequality



to each other, increasing the share of graduates by ten percentage points would mechanically reduce the Gini by 0.9%. However, this aggregate impact hides important differences by gender. Increasing female attainment would reduce the Gini by 3%, while increasing male attainment would increase the Gini by 0.5%. With -7% and +1.4%, respectively, the opposed impact of men and women were larger in 1995.

Figure 6: RIF Estimate by Gender and Time



Notes: Countries are sorted by level of tertiary attainment in 2015. For Switzerland, France and Sweden we use 1995 values; Estonia, Japan, Lithuania, Slovakia and the UK are only observed around 2015.

The findings for Ireland hint at three aspects of a more general pattern which emerges for the majority of countries in our sample. First, the average distributive effect tends to be small and not significantly different from zero in 11 countries. Exemptions are either found in the South (Italy), in Continental Europe (Austria, France) or in Eastern Europe (Hungary, Czech Republic, Slovakia, Poland, Slovenia) where tertiary attainment is relatively low, or in countries where attainment is relatively high (Ireland, Canada). Second, the distributive effect is gender-specific. The impact of increasing tertiary attainment on the earnings Gini is positive for men and negative for women. Even if the extent to which this is the case differs, it holds for all countries and the two time periods. Third, the distributive impact decreased over time so that the impact moved towards zero for both women and men.

## 6.2 Accounting for Labour Market Characteristics

The relative position of workers in the earnings distribution depends not only on their educational attainment but also, among other things, on their labour market conditions. Incomes tend to be higher, but also more polarised among the self-employed than among dependent employees; part-time employment reduces earnings potential, and earnings distributions are more compressed in some

industries and occupations than in others (e.g. Weeden, 2004; Weeden and Jesper, 2004). Working conditions are, to some extent, related to the level of education, and differ between women and men. Importantly, the literature surveyed in Section 2 suggests that part-time work and gender segregation by occupation and sector of employment are relevant factors determining between- and within-group inequality among women as well as the graduate gender gap in earnings.

To provide insights into potential mechanisms that underlie the education inequality relation and the diverging gender-specific effects, we examine the impact of labour market characteristics on earnings inequality by adding a set of further covariates to Equation (4):<sup>16</sup> dummy variables indicating dependent employment, part-time work and public sector employment; dummy variables for three aggregate occupations<sup>17</sup> and sectors of employment.<sup>18</sup> Table 1 shows how populations in our sample of countries are distributed, on average, across labour market characteristics by time, educational attainment and gender. Panel (a) of Figure 7 depicts the impact of each covariate on the Gini coefficient for 2015 (light grey colors indicate insignificance);<sup>19</sup> since all labour market characteristics are dummy variables the RIF estimates are interpreted as in Section 6.1. For 2015,<sup>20</sup> panel (b) of Figure 7 compares the baseline effect obtained from estimating Equation 3 to different specifications, adding labour market characteristics sequentially. Doing so reveals their relative importance in mediating the education inequality relationship. Model 1 accounts for dependent employment, model 2 for part-time work, and models 3,4,5 for occupation, sector and public employment respectively. The order of variables is, on the one hand, based on the importance the literature has attributed to them for explaining gender-specific labour market outcomes. On the other hand, it accommodates data restrictions as not all characteristics are available for all countries. We also estimated specifications with interaction terms between labour market characteristics, tertiary education and gender respectively. For the sake of space we do not report these results here, but they are available from the authors upon request.

#### *Part-time work*

Among the labour market conditions we capture, working time has the most substantial implications for earnings inequality. Notwithstanding variation across countries, increasing the proportion of part-time workers by ten percentage points accounts for 5% of the income Gini in 2015, on average. Women with tertiary education are more likely than men to work part time; in 2015, the share of tertiary educated women working part time was more than three times larger than the proportion among tertiary men. Still, part-time work is less prevalent among graduates than among lower educated, and has a significantly lower positive impact on earnings inequality (revealed by interacting part-time work and tertiary education) so that larger proportions of female graduates contribute to increase inequality among women. Thus, accounting for part-time work moves the negative distributive effect associated with women slightly more towards zero in a group of largely Continental European countries with

<sup>16</sup>For each country we add the largest possible set of covariates.

<sup>17</sup>Labourers/elementary (ISCO 9), other skilled workers (ISCO 3-8, 10), managers and professionals (ISCO 1&2). Harmonised and aggregated in LIS data based on country-specific information on the 10 major groups of ISCO classification.

<sup>18</sup>Agriculture, industry, services. Harmonised and aggregated in LIS data based on country-specific 4-digit ISIC Rev.4 industry classification of first job.

<sup>19</sup>Results for 1995 are reported in Appendix D. They are qualitatively similar but generally larger, particularly for part-time work and dependent employment. The impact of occupation is smaller or insignificant (ES, GR, IT) while the sector of employment is more relevant than in 2015, particularly in the South where the agricultural sector was still relatively large.

<sup>20</sup>Results for 1995 are reported in Appendix D.

Table 1: Individual labour market characteristics - sample averages

LM characteristics	1995				2015			
	no tertiary		tertiary		no tertiary		tertiary	
	m	f	m	f	m	f	m	f
Earnings	28111	18387	40308	28378	32586	21651	49403	35061
Dependent	77	82	82	89	80	87	83	88
Part time	5	33	9	33	8	32	6	23
<i>Occupation</i>								
Elementary	17	22	7	8	10	17	1	2
Skilled	70	67	34	39	79	74	36	38
Managerial/Professional	13	12	62	56	11	9	63	60
<i>Industry</i>								
Agriculture	10	7	3	1	7	5	3	1
Manufacturing	43	21	24	8	41	17	24	11
Services	47	72	73	91	52	78	73	88
Public Sector	25	31	41	61	12	20	26	40

relatively high shares of female part-time work (Austria, Poland, Luxembourg, Germany, Netherlands, Switzerland and Belgium).<sup>21</sup>

### *Sector of employment*

Other labour market characteristics tend to exert a negative or insignificant impact on the Gini. This is particularly true for dependent employment, which is most prevalent among tertiary educated women in both time periods. Conversely, the higher incidence of self-employment among tertiary educated men adds to the estimated positive effect on the Gini. Sector of employment does not exert a significant effect on the earnings distribution in most countries. What is relevant is employment in the public sector which significantly reduces the Gini in the majority of countries where this information is available.<sup>22</sup> In both time periods, public employment is higher among the tertiary educated, and within this group particularly among women. It hence contributes to explain the different signs of male and female distributive effects.

### *Occupation*

In comparison to labourers and elementary workers, larger proportions of skilled workers, managers and professionals significantly contribute to reduce the Gini. In most countries the equalising effect is larger for skilled workers than for managers and professionals, which are, however, predominantly filled by graduates. Interacting occupation and gender reveals similar gender-specific effects to those we obtain for tertiary education: in all countries except the US, Switzerland and Hungary more women in managerial and professional occupations reduce earnings inequality while the effect of increasing the share of men is either insignificant or positive. This implies that labour incomes of tertiary educated managers and professionals differ between women and men, putting them into different parts of the earnings distribution so that they have different implications for earnings inequality. Accounting for occupation hence slightly reduces the equalising impact in Belgium, Luxembourg, Finland, Spain while, concerning males, we find a small tendency of controlling for higher earnings levels and larger dispersions of tertiary educated professionals and managers to reduce the positive impact on the Gini.<sup>23</sup>

The results we obtain from sequentially adding labour market characteristics to our baseline specification show that the impact is relatively small. We also performed Wald tests to test whether the distributive effect obtained from the base line model differs significantly from models 1-5. For neither model comparison this turns out to be the case. The main result concerning the magnitude and direction of gender-specific distributive effects thus remains. This is surprising considering the separate impact some labour market characteristics have on earnings inequality, and with regards to the variation across countries and by gender revealed in Table 1. Nevertheless, the distributive effects we obtain after accounting for the full set of covariates can be understood as being “net of” variation in individual labour market characteristics, and can thus be used to further assess which factors explain differences across countries and over time.

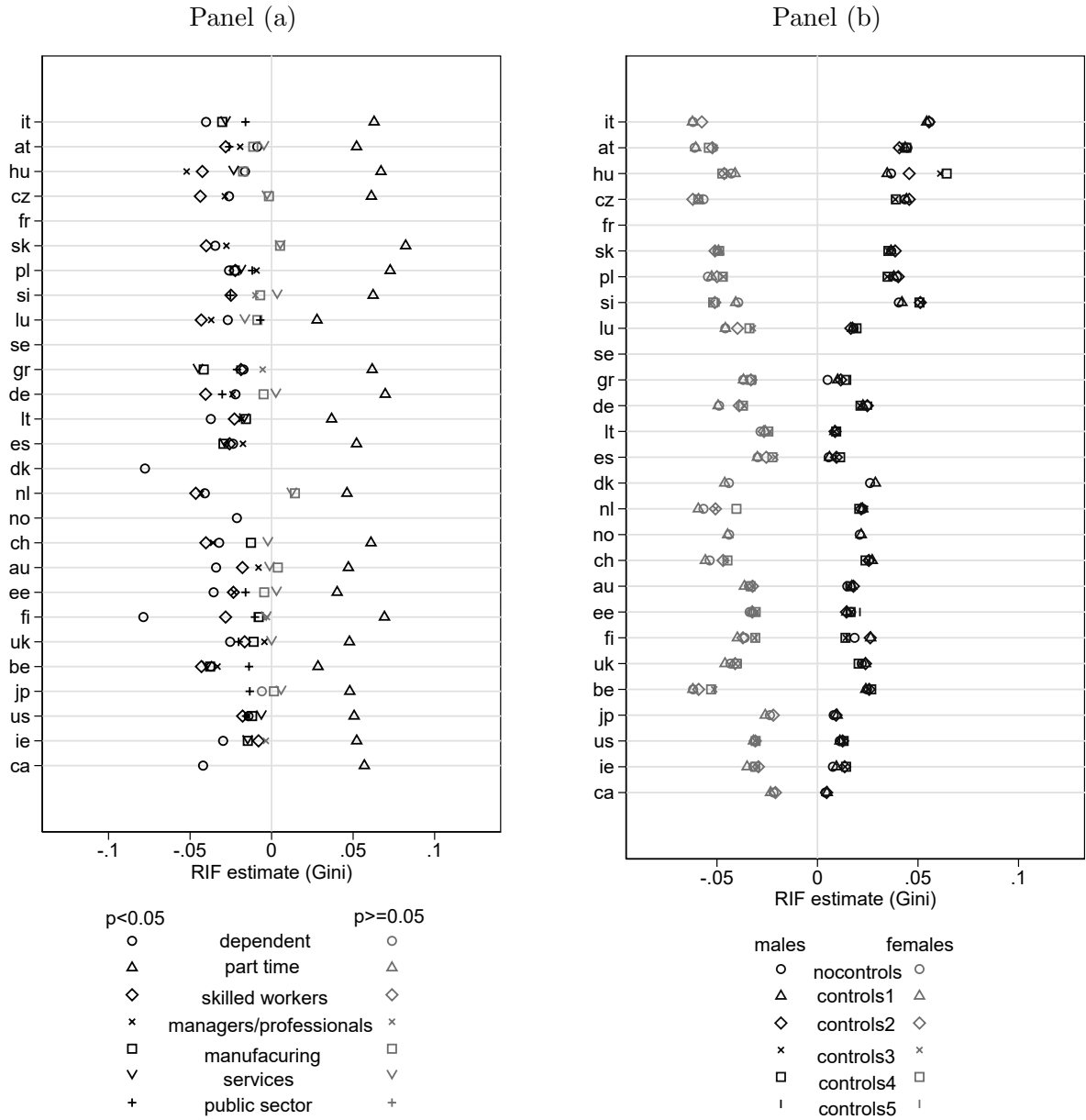
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<sup>21</sup>In addition, part time work is also highly prevalent among females in Spain and Greece; country-specific summary statistics can be obtained from the authors upon request.

<sup>22</sup>The effect is insignificant in Finland and Ireland.

<sup>23</sup>In 2015 this is true for Czech, Poland and Finland; in 1995 it is true for a larger group of countries: Austria, Australia, Hungary, Czech, Luxembourg, Greece, Germany.

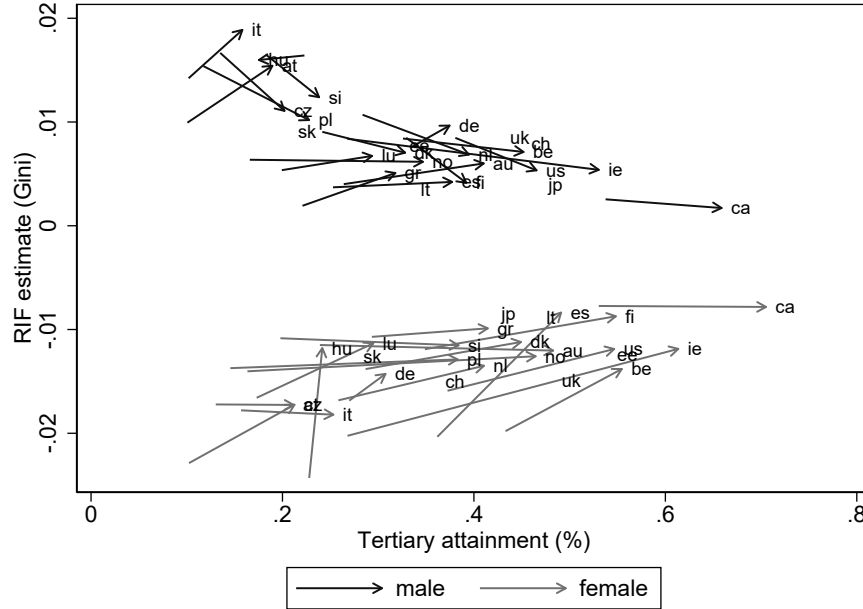
Figure 7: Labour market characteristics 2015



### 6.3 Differences Across Countries & Over Time

Our results presented so far reveal that the distributive impact of higher education expansion differs across countries and has changed over time. Figure 6 hints at the relevance of the attainment level. The estimate tends to be largest in countries with low tertiary attainment, and smallest in high-attainment countries. Moreover, the estimated distributive effect decreased in magnitude while tertiary educational attainment increased between 1995 and 2015 (see Figure 1). Figure 8 shows the RIF regression estimates obtained from the most extensive model (see Section 6.2) and tertiary education attainment by country, time period and gender. With some exemptions, it suggests a tendency of the distributive effect to move towards zero with educational expansion.<sup>24</sup>

Figure 8: RIF Estimate vs. Tertiary Attainment 1995 – 2015



The share of the population in each educational group is only one of three factors which mechanically shape the sign and magnitude of the distributive impact; the other two concern how earnings are distributed between and within educational groups (see Section 5). To gauge the relative relevance of these factors for variation across countries and over time we conduct a simple regression analysis based on a pooled sample by country, time and gender. The dependent variable is the RIF regression estimate obtained after controlling for labour market characteristics. Results are presented in Table 2. Accounting for gender supports the reversed sign of the distributive effect when the additional education accrues to women. Columns (1) and (2) add tertiary attainment and the premium for tertiary education respectively, which are both not statistically significant. Column (3) further adds standard deviations for the non-tertiary and tertiary education groups to capture within-group inequality, and column (4) exchanges absolute dispersion measures with the Gini index. For both measures we find

<sup>24</sup>For males (females) the correlation coefficient is -0,66 (0.57).

that increasing inequality among graduates significantly contributes to increase the distributive impact. Accounting for within-group inequality also affects the relevance of the premium, which turns to be significant at the 10% level in the specification with the Gini index.

Column (5) shows a fully interacted model with gender. This reveals that not only are tertiary attainment, between- and within group inequality gender-specific, but also is the impact of each variable on the distributive effect. Tertiary attainment turns out to be the only relevant factor for women. The increasing share of female graduates significantly contributed to reduce their impact on earnings distributions. The reversed sign indicates that this is also true for men. An increase in tertiary attainment equal to the sample average between 1995 and 2015 for women (0.158) and men (0.098) accounts for 17% and 24% of gender-specific RIF estimates respectively. For men between- and within-group inequality are relevant as well. Larger premiums on and Gini coefficients for tertiary education significantly contribute to magnify the distributive effect of men. The impact is larger for within-group (54.5%) than for between-group inequality (7.7%).<sup>25</sup>

## 7 Discussion & Conclusions

In responding to our research questions we obtain three main insights from our study. First, no average distributive effect of higher education expansion exists. Average distributive estimates tend to be insignificant as they conceal differences between women and men. Thus, second, the distributive effect is gender-specific. It makes a difference whether expansion mostly comes from men or women: the impact on the Gini coefficient of increasing tertiary attainment of men is positive and significant but the impact of increasing tertiary attainment of women is negative and significant. Third, the increasing share of tertiary educational attainment among both women and men aged 31 to 65 is the main factor explaining that distributive estimates shrink towards zero over time. Only for men does larger between- and within-group inequality significantly contribute to magnify the impact of educational expansion on earnings distributions across countries.

The opposite signs of the distributive effect for women and men are explained by different locations and shapes of education- and gender-specific earnings distributions in high-income countries. Tertiary educated women largely contribute to the middle and the bottom while tertiary educated men tend to occupy the upper tail. One can read this result as yet another piece of evidence of the earnings disadvantage of women, which can be reconciled with factors that have been discussed in the literature on graduate gender gaps in earnings and wages. Besides the prevalence of part-time work, also among tertiary educated women, these include gender segregation by field of study and, relatedly, occupation as well segregation by program prestige and educational mismatch. Looking at the top, our evidence which reveals gender-specific earnings distributions of managerial and professional occupations conforms with research pointing to the existence of “glass ceilings”. Accordingly, wage gaps are most pronounced in the upper tail and women’s labour income is compressed from the top.

Less attention has been paid in the literature to factors which explain inequality among women. This concerns inequality within the group of graduates as well as inequality between high and low educated women. In accordance with previous findings for the US, our descriptive evidence reveals that

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<sup>25</sup>Magnitudes are computed as  $(\hat{\beta}(var) * \Delta(var)) / \hat{\beta}(RIF)$ .



Table 2: Explaining cross-country and temporal variation

	(1)	(2)	(3)	(4)	(5)
Tertiary	-0.00088 (0.00336)	-0.00093 (0.00338)	0.00151 (0.00373)	-0.00163 (0.00365)	-0.02130*** (0.00456)
Tertiary (f)					0.01516*** (0.00360)
Premium		-0.00047 (0.00210)	-0.00349 (0.00215)	0.00415* (0.00223)	0.00837*** (0.00281)
Premium (f)					-0.00102 (0.00214)
Dispersion <sub>Ter</sub>			0.00000*** (0.00000)	0.06980*** (0.01563)	0.11214*** (0.02162)
Dispersion <sub>Ter</sub> (f)					0.02206 (0.01464)
Dispersion <sub>No-ter</sub>			-0.00000*** (0.00000)	-0.08390*** (0.01681)	-0.11728*** (0.02387)
Dispersion <sub>No-ter</sub> (f)					-0.03029* (0.01591)
Female	-0.02267*** (0.00090)	-0.02261*** (0.00094)	-0.02390*** (0.00096)	-0.02157*** (0.00086)	-0.01933*** (0.00520)
Constant	0.00892*** (0.00119)	0.00964*** (0.00344)	0.01710*** (0.00359)	0.00713** (0.00318)	0.00459 (0.00416)
Obs	92	92	92	92	92
$R^2(adj)$	0.877	0.876	0.899	0.902	0.944

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

education premiums are larger for women than for men, and have been increasing in most high-income countries between 1995 and 2015. This would have suggested to find a significant contribution of between-group inequality to the shrinking magnitude of tertiary educated women's distributive impact. However, neither between- nor within-group inequality among women are significant factors to explain cross-country and temporal variation. Two forces working in opposite directions might be relevant here. On the one hand, increasing higher educational attainment among women magnifies differences between women with different (and potentially with similar) education levels, thereby contributing to increase earnings inequality. On the other hand, earnings of tertiary educated women tend to be similar in levels and dispersion to those of non-tertiary educated men, with whom they constitute the inequality-reducing segment. Hence, the net effect of within- and between group inequality turns out to be zero. Conversely, for men larger between-group inequality implies that their earnings are distant from both low educated men and women, on average, and larger within-group inequality implies that relatively few make substantial earnings at the top. Taken together this makes men more likely than women to contribute to the upper tail which constitutes the inequality-increasing segment of earnings

distributions.

In concluding some caveats and limits of our analysis have to be noted. Our results do not provide insights into how *changes* in educational attainment have impacted on *changes* in income inequality. Instead, we provide a snapshot of the effect of altering the educational composition in the population on earnings inequality in two points in time. Our results are descriptive in nature; they are based on a hypothetical exercise of swapping graduates for non-tertiary educated, holding the income distribution conditional on being tertiary educated constant. This implies to assume that rates of returns are not affected by changes in the composition. Such a static perspective takes the extent of between- and within-group inequality as given and then consider the impact of increasing the share of tertiary education graduates. Our methodology does not allow us to capture dynamic effects. However, adaptation processes triggered by educational expansion are potentially relevant to explain changes over time and variation across countries. If returns to education decline as the supply of graduates grows, the education premium should decline. Yet, while we observe that education expanded in all countries, we find substantial variation in education premiums. Moreover, expansion having been more pronounced among women suggests to find even more negative distributive effects; instead, they moved towards zero. If, on the other hand, graduates enter non-graduate labour markets and crowd out low-skilled workers of their jobs, the relative return to low education declines (Bar-Haim, Chauvel, and Hartung, 2019; Ballarino, Bernardi, and Panichella, 2016). At the same time inequality among the highly educated likely increases. To the extent that it became more prevalent for women than for men between 1995 and 2015 and is superseded by other factors in our between- and within-group estimates, overeducation is a potential explanatory factor for the smaller equalising effect of rising women’s education levels in 2015 as compared to 1995.

External contextual factors we do not account for in our panel estimation can affect education premiums and within-group inequality but might also bias the estimate we obtain for tertiary attainment levels since they affect the (gender-specific) extent of expansion as well. Higher labour force participation might have motivated women to pursue further education but has also been shown to entail that more women are present at the bottom of the earnings distribution (Misra and Murray-Close, 2014). Cross-country differences and changes in gender norms can, as well, impinge on how attractive it is for women to pursue tertiary education. More generous welfare state policies with regards to leaves, childcare and public sector employment have been found to increase the gender gap among advantaged workers, but to reduce the gender gap at the bottom by improving the relative position of dis-advantaged women (Mandel, 2012). Thus, more welfare state generosity would contribute to lower inequality among women, but potentially to larger inequality between men and women, particularly among the highly educated, thereby impeding women’s educational expansion. Beyond this, a precondition for a relation between educational achievements and income inequality is the existence of a relation between education and labour income at the individual level. However, empirical evidence surveyed in Goldthorpe (2014) reveals that this association has weakened in European countries since the late 20th century, implying that education also becomes less relevant for explaining inequality outcomes. The extent of differences between women and men in this regard remain an open question. Further research along the lines of McCall (2000b) from a broader comparative angle is needed for a better understanding of the relative importance such macro-level factors. Importantly, within- and between-group inequality among women are important dimensions of inequality in their own right, and are under-researched so far.

Bearing the limits of our analysis in mind, our results can provide valuable insights for policy. Taking the gender-specific nature of the effects of educational expansion into account highlights potential trade-offs. Taken at face value, our results suggest that policies aimed at reducing overall (vertical) income inequality might entail expanding female higher education, but only as long as it leaves the location and dispersion of their earnings constant. This conflicts with policy goals aiming to improve the labour market prospects of tertiary educated women. Conversely, a focus on (horizontal) gender equality would entail trying to close the graduate earnings gap but this may be at the cost of increasing labour income inequality among women and thus generally. This is a reminder that taking account of potential conflicting policy goals between different dimensions of inequality is important in pursuing wider social equity aims.

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## A Discrete Unconditional Partial Effects (UPE)

The distribution of earnings ( $y$ ) conditional on covariates  $\mathbf{z}$  is given as

$$F_{\mathbf{z}}(y) = \sum_{e \in \{0,1\}} s_{e|\mathbf{z}} F_{e|\mathbf{z}}(y) \quad (5)$$

where  $s_{e|\mathbf{z}}$  is the share of workers with - 1 - (without - 0) tertiary education among dependent employees aged 31-65, and  $F_{e|\mathbf{z}}(y)$  is earnings distribution conditional on (not) being tertiary educated, both conditional on other covariates.

Substituting tertiary education graduates for workers without tertiary education by a factor  $t$  without changing conditional distributions and the distribution of covariates results in a permuted distribution,

$$G_{\mathbf{z}}(y) = \int_{\Omega_Z} (s_{1|\mathbf{z}} + t) F_{1|\mathbf{z}}(y) + (s_{0|\mathbf{z}} - t) F_{0|\mathbf{z}}(y) f_Z(\mathbf{z}) d\mathbf{z} \quad (6)$$

The UPE is defined based on the difference between the distributional statistics  $v(\cdot)$  obtained from the original as opposed to the permuted distribution,

$$UPE(v(F), 1) = \lim_{t \rightarrow 0} \frac{v(G_{\mathbf{z}}(y)) - v(F_{\mathbf{z}}(y))}{t} \quad (7)$$

Firpo, Fortin, and Lemieux (2009) and Choe and Van Kerm (2018) have demonstrated that the UPE can be expressed as a function of expected RIFs,

$$UPE(v(F), 1) = \left( \int_{\Omega_Z} E[RIF(y_i, v(F_Y)) | e = 1, Z = \mathbf{z}] - E[RIF(y_i, v(F_Y)) | e = 0, Z = \mathbf{z}] f_Z(\mathbf{z}) d\mathbf{z} \right) t \quad (8)$$

and estimated by applying OLS to (3).

As it is visible from (6), in order to obtain a meaningful interpretation of the UPE in terms of population share changes,  $t$  can take values between 0 and 1. Yet, in estimating (3) one uses  $t = 1$ . We thus divide the obtained estimates ( $\beta_e, \beta_f, \beta_m$ ) by 10 so that they can be interpreted as the effect on the distributional statistic of increasing tertiary attainment by 10 percentage points. This also applies to other discrete covariates such as the dummy variables that indicate part-time work, industry and temporary employment.

## B Further descriptives

Figure 9: Mean: tertiary educated women vs. lower educated men

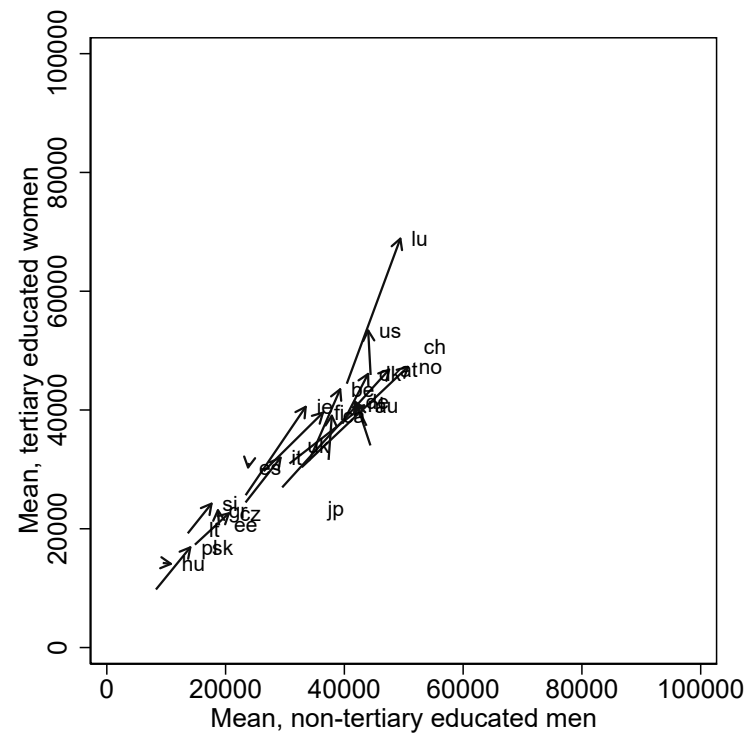




Figure 10: Within-group inequality: tertiary educated women vs. lower educated men

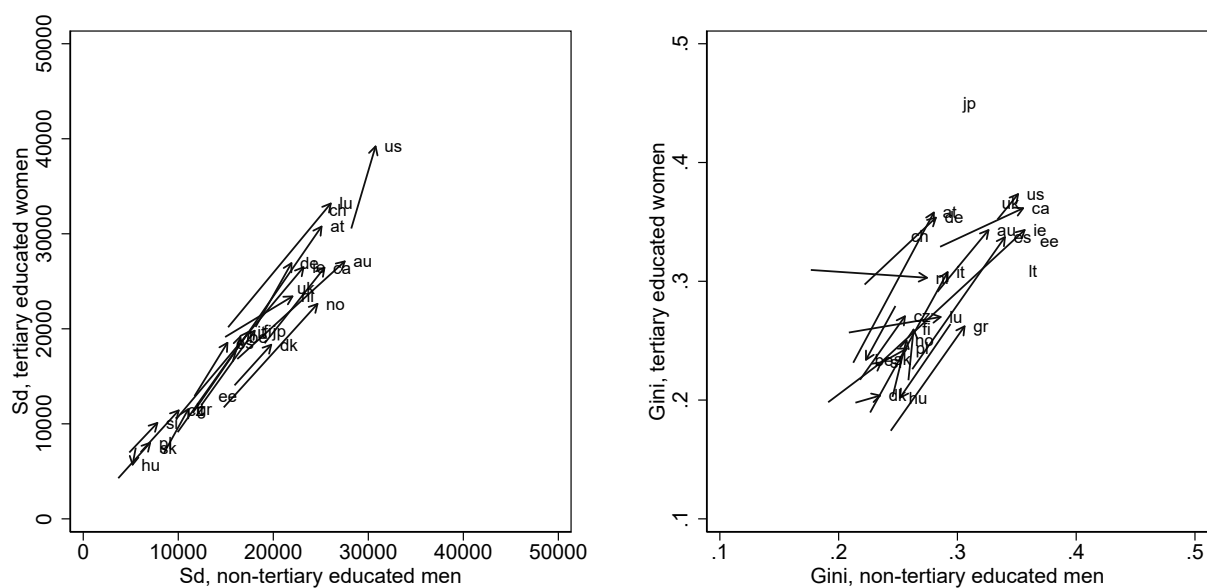


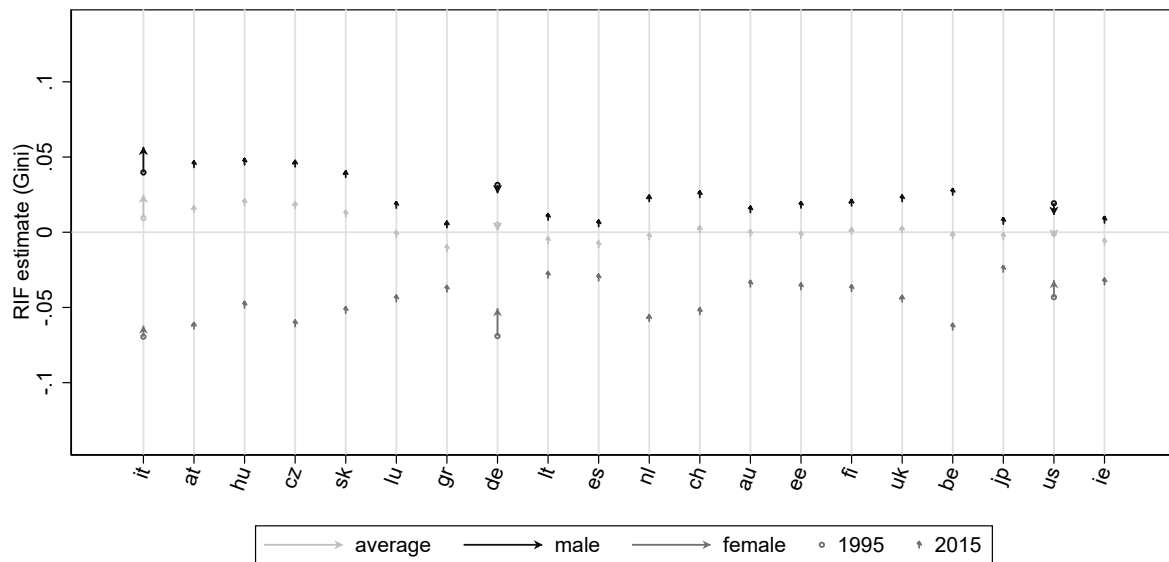
Table 3: Graduate gender earnings gaps

Country	2015	1995
AT	54.12	48
AU	45.91	37.46
BE	23.96	39.1
CA	31.95	52.98
CH	61.48	
CZ	35.76	29.42
DE	64.93	46.45
DK	24.8	34.08
EE	31.6	
ES	24.42	23.23
FI	30.57	20.72
FR		36.27
GR	20.35	22.15
HU	17.3	28.44
IE	32.08	34.83
IT	30.64	32.36
LT	19.21	
JP	117.43	
LU	28.14	47.82
NL	55.06	69.45
NO	40.32	12.52
PL	25.19	25.35
SE		48.59
SI	12.03	19.15
SK	28.9	
UK	43.33	
US	45.3	54.16

## C Robustness: Working time

We chose not to restrict our sample to dependent employees or full-time-full-year workers but to control for part-time work in our full model (see Section 6.2). However, part-time work can imply any number of hours between one and 30. Particularly very low but also very high working hours might bias our results. We thus conduct a robustness test introducing lower and upper limits of working hours which depend on country- and time-specific levels of the first and 99th percentile respectively. Results are provided in Figure 11. Unfortunately, information on working time is only available for a restricted number of countries, and mostly only for 2015. Nevertheless, our main results turn out to be not affected by outliers with regards to hours of work.

Figure 11: RIF Estimate by Gender and Time



Notes: Countries are sorted by level of tertiary attainment in 2015.

## D Labour market characteristics 1995

Figure 12: Labour market characteristics 1995

