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Abstract
While there has been intense debate in the empirical literature over the evolution of the college wage premium in the United States, its evolution in Europe has received little attention. This paper investigates the causes of the evolution of the college wage premium in 12 european countries from 1994 to 2009. I use cross country variation in relative supply, demand, and labour market institutions to examine their effects on the trend in wage inequality.
I address possible concerns of endogeneity of the relative supply using an IV strategy exploiting the diffential legislations of university autonomy and their variations over time. In explaining the evolution of wage inequality, both market and non-market factors matter: an increase in relative supply decreases the college wage premium; the minimum wage also has a significant and negative effect.

Keywords
College wage premium, Inequality, Relative supply.

JEL Codes
J24, J31, I24.

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1 Introduction

In the last two decades there has been a huge increase in the average years of attained education and the proportion of young people enrolled into higher education has risen significantly in all developed countries. Over the 1990-2005 period, undergraduate enrolment increased by almost 50 percent in Sweden, Finland and Denmark, and by over 30 percent in the UK, Ireland, Italy, Spain and Portugal thanks also to european policies (i.e. Lisbon 2000). This "boom" in education can be interpreted as a supply shock to european labour market and is likely to have substantially affected the structure of wage differentials.

Many contributions in the literature dealing with the US have noticed a growing college wage premium over time and a greater college premium implies greater inequality. The underlying causes of increasing inequality are highly debated among labour economists. While there are two leading explanations - skill biased technical change (SBTC) and labour market institutions[1]- the role of the supply of college graduates in determining changes in the returns to a college education has yet to be explored in depth. Many empirical studies such as Katz and Murphy (1992), Taber (2001) found SBTC to be the driving force behind rising wage inequality: this conclusion stems from the observation that the relative supply of high skilled workers and the skill premium can only increase together if the relative demand for high skilled also workers increases at the same time. There is substantial evidence in support to the fact that skill differentials in the US have increased considerably in the last two decades. Between 1961 and 1979, returns to a college education (compared to a high-school degree) rose from 61% to 82% despite the huge increase in the number of college graduates. The trend in Europe is less clear.[2] Rising returns have been observed for Portugal, Denmark and Italy, constant returns have been found in the UK and Germany, and falling returns for Sweden and Austria (at the beginning of 2000). However, most of this evidence refers to the period until the end of the 1990s with little attention being dedicated to the development of this phenomenon successively. Evidence on the evolution of the college wage premium and skill differentials in Europe is more scarce. Recent evidence of the impact of the increasing supply of graduates on their wage is available for the UK: Walker and Zhu (2008) are interested in how the college premium has varied over time, across subjects of study, wage distribution and two different cohorts. They show that up to 2000 there is almost no evidence of declining returns to college following the surge

[1]'Institutions' are non competitive forces acting on the labour market, such as labor unions, minimum wage, product and labour market regulations, taxes and subsidies and social norms. All these factors can affect the shape of wage distribution, including earnings inequality.

[2]Katz and Murphy (1992). They analyse changes in wage inequality over 25 years, from 1963 to 1987, in the US, concluding that the rising in the relative demand for more skilled workers is "a key component of any consistent explanation for rising inequality and changes in the wage structure over the last 25 years".

in participation in higher education. However, beyond 2002 they find suggestive evidence of modestly declining wage premia for graduates. Furthermore, only very few studies deal with the relation between wage inequality and education. Using UK data, Harmon, Oosterbeek, and Walker (2003) find that returns to schooling are higher for those at the very top of the wage distribution compared to those at the very bottom. Martins and Pereira (2004) have provided descriptive evidence showing that in the mid-1990s, in fifteen european countries, returns to education at the upper quantiles significantly exceeded those at lower quantiles, that is, increasing education increases within wage inequality.

Given that in the last two decades the demand for higher education has seen sheer expansion, it is interesting to investigate whether or not the returns are changing. It is reasonable to assume that changes in educational participation rates across cohorts will also imply changes in the ability-education relationship. If the ability composition changes, this can have an impact on estimated returns to education and to degrees. Reasoning with a simple supply and demand framework, an increase in the supply of highly educated workers would cause a decline in their wages. The demand for college graduates may be rising dramatically but if the supply keeps up with the demand, college wages will not increase.

Nevertheless, the supply and demand framework alone cannot account for empirical puzzles such as the one in the US. Thus, if these inequality trends are not primarily explained by market-driven changes in the supply and demand for skills, it is possible that episodic institutional shocks are also a relevant factor. Changes in institutional factors such as the minimum wage have contributed to the evolution in the wage differential between college and non-college educated workers.[3] Goldin and Katz (2007) combine the usual supply-demand framework with institutional rigidities and alterations in order to understand returns to education in the US in the past century. DiNardo, Fortin, and Lemieux (1996) find that, in addition to supply and demand factors, de-unionization and declining minimum wages, are important in explaining wage inequality. Using variation in the minimum wage across regions, Lee (1999) shows that not only is minimum wage negatively correlated with rising inequality at the top end of wage distribution but it can also explain much of the increase in the dispersion at the lower end of the wage distribution.

Europe may differ from the US in this case: in fact, the presence of stronger institutions has helped and continues to help moderate the changes to the college wage premium in european countries. Machin (1997) and Dickens, Machin, and Manning (1999) find that in the UK, higher union density and higher minimum wages, respectively, reduce wage inequality. Manacorda (2004) and Edin and Holmlund (1995), studying Italy and Sweden, respectively, find that wage setting institutions are important for wage inequality. Koeniger, Leonardi, and Nunziata (2007) use

[3]See Fortin and Lemieux (1997) for a review of the effect of labor market institutions on the wage structure.

panel data on institutions in OECD countries to assess the quantitative relationship between institutions and male wage inequality. Their findings show that labour market institutions do matter: the employment protection index, unemployment benefit, union density and minimum wage have a significant negative association with wage inequality within countries.

While (increasing) US wage inequality is extensively documented in the literature, there is less evidence on the (non-increasing) european wage dispersions. The difference in the pattern of college wage premium between the United States and Europe may be due to their different markets and institutions. When technological progress generates a higher relative demand for skilled labour, competitive markets increase wage differentials across skill groups in the United States, while in Europe compressed and rigid wage differentials have reduced inequality.[4] This paper fills this gap in the literature, investigating the evolution of the college wage premium in Europe over the last 15 years. It explores which dimensions of inequality are changing and which shifts in demand and supply and/or changes in wage setting institutions are responsible for this trend. Hence, I assess the pattern of the college wage premium as a result of the recent expansion in graduation rates. I aggregate individual data in cells identified by country, time, age cohort and gender to obtain information on college wage premium. The main novelty of this paper is that I address possible concerns of endogeneity of relative supply, in the college wage premium equation by using an instrumental variable strategy, which is something that has never been done before in the literature dealing with college wage premium. By exploiting the differential legislations of tertiary education institutions, namely the degree of university autonomy in different countries, and their variation over time, I am able to estimate the causal effect of relative supply on the wage premium. There is evidence that both market and non market factors play a role in explaining inequality. More specifically, college wage premium appears to be negatively correlated to changes in relative supply and positively correlated with the relative demand index. Institutional constraints, such as minimum wage and unions have a minor role. Additionally, the effect of relative supply is more important for males and for countries which have faced a stronger and faster increase in higher education graduation rates.

The paper is organized as follows: Section 2 presents the data used and describes the raw trends in wage changes, education differentials and wage inequalities. Section 3 is dedicated to the empirical framework. Section 4 and 5 show the results of the trends in between-education-group wage inequality and the potential explanations for these evolutions in addition to some robustness checks. Section 6 concludes.

[4]See Levy and Murnane (1992) and Bertola and Ichino (1995).

2 Data and aggregate trends

I use a unique dataset, merging the European Survey of Income and Living Condition (EU-SILC) and European Community Household Panel (ECHP) to assess returns to college and wage inequality in Europe from 1994 to 2009.[5] The ECHP is a survey of 15 countries in the European Union from 1994 up to 2001.[6] The EU-SILC is a collection of timely and comparable multidimensional micro data covering EU countries, starting in 2004 and ending in 2009, for a total of six waves. These surveys share many features, which makes it possible to harmonize the variables of interest.[7]

One advantage of these data is that they provide information for an overall period of 15 years within which I can observe a total of 12 european countries: Austria, Belgium, Germany, Denmark, Spain, Finland, France, Greece, Ireland, Italy, Portugal and the United Kingdom. For each country in the sample, I only consider the sub-sample of individuals who reside in the country of birth (more than 94 percent of the total in 2009) because EU-SILC data do not report the country of origin.[8]

The reference sub-sample focuses on native male and female working employees (self-employed are excluded) between 25 and 50 years old. This age framework allows me to compare the youngest college graduates with their non-graduate counterparts and to avoid selection bias due to retirement and pensions.

I use net annual earnings in the reference sub-sample of all wage and salary workers in the public and private sector. All measures of wages in the paper are adjusted and deflated using the Purchasing Power Parity PPP (base Euro 15=1) to take into account different costs of living and to allow for comparison among years.

Educational attainments are measured by the highest level of education completed, based on ISCED levels, common to all countries and whose information is available in all data-sets.[9]

[5]This paper is not the first one using ECHP and EU-SILC as a single data source. See for example Massari et al. (2012) and Goos et al.(2009).

[6]The advantage of the ECHP over country-specific panel datasets consists in the homogeneity of the sampling procedures and of the questionnaires across countries which allow a high level of cross-country comparability.

[7]See "Comparative EU statistics on Income and Living Conditions: Issues and Challenges" available at $www.ceps.lu/publihc_viewer.cfm?tmp = 122$. When aggregating sample weights are used.

[8]In principle selecting only native workers may may lead to issues bias estimates, thus these estimates should be interpreted as a lower bound of the real effect.

[9]The two surveys record differently information about schooling and sometimes not even consistently through time. ECHP only displays information about the highest earned qualification, and provides an education variable in three levels: low -middle-high skills (i.e. low, secondary, post secondary-tertiary). They correspond to 0-2, 3 and 4-6 ISCED levels respectively. EU-SILC contains information on both earned qualifications (highest ISCED level achieved) and on ages at which individuals left school. ISCED states for international standard classification of education,

Therefore, I define high skilled workers as workers with at least some higher education (i.e. tertiary or post-secondary non-tertiary education) and low skilled people as those with high school diplomas. As standard in the literature, college wage premium is defined as the ratio of wage rates between college and high school graduates. For the sake of this analysis, I take the microdata and I group them into cells defined by time, country, age cohort and gender. To control for aggregate labour supply and demand conditions, I use data from the OECD, EUKLEMS and ILO.[10] In particular, for the supply index, an indicator of gender specific relative supply of college graduates with respect to high school diplomates, I use OECD data on the relative skill endowment, measured in terms of educational attainment.[11] For the construction of the demand index (à la Katz and Murphy), an indicator of the relative demand for high skilled workers, I use data from EUKLEMS on the share of hours worked by high skill workers relative to low skill workers. In investigating the evolution of wage inequality, institutions are another potential explanation of the trend in the college wage gap.[12] Institutional data are provided by OECD and ILO.[13] These are yearly data, measuring wage bargaining institutions, strictness of employment protection legislation, minimum wage, union density and public sector employment.

2.1 Relative wage changes, education differentials and wage inequality.

Over recent decades, tertiary education attainment has more than doubled in most european countries. The strong increase in participation rates in Europe is evident from Figure 1, which shows the recent history of the percentage of each cohort currently undertaking higher education and the average amount of years of education achieved by each cohort. The figure confirms the increasing trend in education attainment in Europe over time, showing that the average years of

it is an instrument implemented by the European Union for compiling internationally comparable educational statistics. It was designed by the UNESCO in the early 1970's to serve "as an instrument suitable for assembling, compiling and presenting statistics of education both within individual countries and internationally"(UNESCO 1997). See *http* : *//epp.eurostat.ec.europa.eu* for further details.

[10]Detailed information can be found in the data appendix A1.

[11]The ratio of college graduates over high school graduates is a standard measure of the relative supply of graduates in each country.

[12]Traditionally in the literature, the institutional features that are considered to be important for wage formation are: unions and bargaining institutions, wage regulation and welfare benefits, and labour market policies. A common finding of the studies that have investigated the effects of institutions on wage dispersion is that the interactions between supply, demand and institutions can take several routes altering both the between and the within structure of wages. See for example Brunello, Comi, and Lucifora (2000) and Barth and Lucifora (2006).

[13]Detailed information on institutional data used in the empirical analysis can be found in appendix AII. Table A2 contains summary statistics of the institutional variables.

education achieved and the fraction of college graduates have increased by year of birth. For people born in 1955 the average number of years of education completed was almost 13.5 years, and the percentage of higher educated (i.e. high skilled people) of that cohort was 30%; these numbers are almost 15 and 45% for the 1975 cohort.

Over the period, mean real income by educational group changed differently across countries and educational groups. However, the generally increasing trends in education patterns are fairly similar across many european countries. Figure 2 shows the trend of relative supply of college graduates to high school graduates separately by gender; the trend is constantly increasing over time for both men and women in european countries.

Panel A of Table 1 reports individual level descriptive statistics of education and income for the two dataset used. The percentage of people achieving different degrees, together with the average years of education achieved and the log of wages are shown for both men and women. Educational achievement is increasing over time in Europe, for both men and women. The other stylized fact that emerges is that women are overtaking men in college attainment.

Looking at the trend in college wage premium in Europe, figure 3 shows that its evolution has been very similar among european countries, with the exception of the UK. It is possible to observe a stable and slightly decreasing trend for the college wage premium for both men and women, with women receiving, on average, a slightly higher premium. The pattern observed would suggest that the huge influx of college graduates has saturated the demand for this type of worker, continuously reducing their potential comparative advantage and eroding the differences between peers with degrees and high school diplomas. This trend in the evolution of college wage premium is remarkably different from what is observed in the US where wage dispersion has increased sharply over time. European institutional rigidities have always been seen as the principal explanation for the differences in wage inequality between Europe and United States.[14] A possible explanation of the non-increasing trend in Europe compared to the increasing trend in the US may lie in the different production structures characterizing the two continents: the strong leading effect of SBTC in the US could be much lower in Europe because of the lack of high-skill intense sectors.[15]

Moreover, the evolution over time of the college wage premium could be due to both different dynamics of cohort-specific relative wages as well as changes in the composition of employment by cohort. This means that the relative wage may vary across cohorts and, more specifically, that younger cohorts can experience higher wage gaps. Panel B of Table 1 shows the evolution of the education premium, a measure of between-groups-wage inequality. It measures the college wage premium,

[14]See Bertola and Ichino (1995).
[15]See Bertola and Ichino (1995).

that is, the ratio of the earnings of college graduates to the earnings of high school graduates. The trend in the education premium seems to be decreasing slightly for both men and women from different age groups although these differences are not significant. Thus, since different age cohorts workers are imperfect substitutes in production, I also aggregate data controlling for age cohorts.

3 Empirical framework

I draw on the standard model in the literature, which is presented in appendix A1, to analyse the leading proximate causes of overall and between-group wage inequality.[16]

Understanding the sources of the variation in college wage premium means using a model where wage premia are determined by the interaction of market forces, namely, supply and demand of various kind of labour and labour market institutions (wage setting norms, unionization, minimum wages).

Taking the standard supply and demand framework to the data, the equation of interest is the following:

$$lnw = \rho \left(\frac{\alpha_{hct}}{\alpha_{lct}} \right) - \frac{1}{\sigma} ln \left(\frac{H_{ct}}{L_{ct}} \right) \tag{1}$$

where the variable of interest, w, represents the relative wage of skilled to unskilled workers. The relative wage of different educational groups is generally used as a measure of between-group inequality. $\left(\frac{H_{ct}}{L_{ct}} \right)$ represents the relative supply of skilled versus unskilled labour, and $\left(\frac{\alpha_{hct}}{\alpha_{lct}} \right)$ the SBTC.

As is frequently done in the literature, to control for changes in demand conditions, I proxy the relative demand shift, with a demand index, time trends and a measure of technology -R&D intensity.[17] [18] The idea is that all these measures increase relative productivity in the skill intensive sectors; I thus expect a positive coefficient in my estimations. The standard model allows both supply and demand for skills to grow exogeneously. With exogenous variation in the demand of skills, the theory predicts that the wage premium should vary inversely with the relative supply of skills. In the absence of institutional constraints, the wage premium goes up or down depending on whether demand grows faster than supply, or viceversa. Since demand and supply alone can not explain the complete trend of college wage premium, institutions are added to the model as additional proximate causes of wage

[16] Katz and Murphy (1992)

[17] This demand index is similar to the demand index used by Katz and Murphy (1992) which is based on the changes in the relative employment.

[18] Ratio of R&D expenditure over value added in the manufacturing sector measured every year in each country.

inequality (see Goldin and Katz,2007). Institutions may ease or limit the operation of market forces.

Taking the theoretical framework to the data, I estimate the following:

$$ln\left(\frac{w_{cta}^{H}}{w_{cta}^{L}}\right) = \gamma_0 + \gamma_1 D_{ct} + \gamma_2 ln\left(\frac{H_{ct}}{L_{ct}}\right) + \gamma_3 X_{ct} + \gamma_4 G + \tau_t + \mu_c + \eta_a + \varepsilon_{ct} \quad (2)$$

where D_{ct} is the relative demand indicator, $\left(\frac{H_{ct}}{L_{ct}}\right)$ is the relative supply indicator, X_{ct} is a vector of labour market institutions, namely, union density, minimum wage, employment protection and a measure of public sector employment, G is a gender dummy equal to 1 for males and to 0 for females and τ_t, μ_c and η_a are time country and age cohort fixed effects, respectively.[19] The coefficient γ_2 provides an estimate for $1/\sigma$, that is the inverse of the elasticity of substitution between skilled groups. This equation suggests an explanation of relative wage movements comprising both market factors and institutional factors.

To get efficient estimates and to avoid underestimation of standard errors that can emerge in case of wage premium persistence, standard errors are bootstrapped using clustering at country level. Using the US as reference, the model above suggests that the competitive wage of a particular type of worker depends positively on the average rate of technical change - meaning a positive effect on the wage ratio of SBTC, negatively on their relative supply change and positively on their relative product -demand shift (that is associated to the technical change).

Concerning institutional factors, the effect is less straightforward. The impact of institutions is generally concentrated in specific parts of the wage distribution. Institutions may affect wage differentials in various ways, also depending on the elasticity of labour supply and across demographic groups. Moreover, institutions have different effects across industries by changing the incentives for capital investment and thus indirectly affecting wage inequality. Unions increase the wage rates of their members above the level they would achieve in the absence of representation, thus favouring low skilled workers and inducing inequality to decline. The problem with this argument is that it ignores the effects of union wage policy on non-union wages. If a set of jobs usually performed by a particular type of worker is unionized and the employer forced to pay higher wages, the supply of labour to all other jobs done by that type of worker will increase together with a reduction in wages. Therefore, it is not clear if the average wage for the group rises or falls with the increase in union representation. Additionally, white-collar workers at the higher end of the wage distribution may be very unionized - for example, this is the case of some professional orders in Italy - making it hard to establish the effect of unions on the wage premium. By setting an explicit threshold for the lowest wage rate paid, the presence of a statutory minimum wage tends to reduce wage dispersion. Minimum

[19]Detailed information on the variables and the sources of the institutional data is contained in the Appendix A2.

wage can impact the wage distribution in several ways: firstly, by preventing employers from hiring workers with productivity below the minimum wage. Secondly, by preventing firms from pushing down wages for workers with low bargaining power and reducing heterogeneity at the bottom. Additionally, a minimum wage increase leads to an increase in wages for workers paid at the minimum wage level, a weaker increase for workers with wages slightly above the minimum wage (spill-over effects) and has little or no effect on high-paid workers.[20] Thanks to its regressive nature, this measure is likely to have a stronger effect at the bottom rather than at the top of the wage distribution.

Employment protection policies are often associated with a more compressed wage structure. They protect unskilled more than skilled workers and thus have a negative effect on the wage ratio.[21]

In turn, if we accept the hypothesis that the effects of institutions on the outside option of workers are mostly in favour of the unskilled, I would expect aggregate institutional measures to have a negative impact on the relative wage. They improve the outside option of employers for low skilled groups, strengthening their bargaining position and compressing the skill wage differentials.

In addition to this standard set of labour market institutions, I add a measure of public sector pervasiveness -relative percentage of the population working on the public sector. Because public sector employment is perceived as safer and offering more benefits, the more risk averse individuals sort into public sector employment.[22] The idea is that public sector employment may have acted to offset the widening wage inequality seen in recent years and to narrow the college wage premium.[23]

Since it is plausible that market and institutional factors alter the wage distribution both across skill groups and across age groups, data are aggregated by country, year of the survey and age group.

While this model, including cross-country differences in the role of labour institutions, does a reasonable job in accounting for trends in skill premium, some questions are left unsolved.

The standard assumption in the literature is that the relative skill supply is pre-determined. While the assumption appears to be reasonable if one has a short-run perspective, the long run dynamics of college enrollment makes the assumption questionable, and raises the issue of the likely endogeneity of relative skill supply. Indeed, it is reasonable to suppose that, in the long run, the fraction of workers that chooses to become more educated responds both to innovations increasing the

[20] Charnoz, Coudin, and Gaini (2011).

[21] See Boeri and Jimeno (2005).

[22] This is shown to be the case in Germany by Pfeifer (2011)

[23] However, it seems to be the case that workers at the lower tail of the wage distribution benefit more from public sector employment than workers at the upper tail of the wage distribution. Actually, there is evidence that there can be a wage penalty for highly qualified employees - see for example Melly (2005).

relative demand for more educated labour and ability premia.

Previous literature focuses on the relationship between relative supply and college wage premium without considering the potential endogeneity of the relative supply. Failure to take this issue into consideration could result in OLS estimation of the effect of relative supply on college wage premium being inadequate ($\hat{\gamma}_2$ is biased). Theoretically, the bias is negative ($\operatorname{plim}_{n\to\infty} \hat{\gamma}_2 < \gamma_2$) if the errors are negatively correlated or if relative supply is measured with error, and positive otherwise.

From the individual point of view, given the existing set of possibilities for accessing education, a worker can choose whether to undertake education and to what extent, in order to maximize his/her lifetime earnings (i.e. as well as in relation to the relative wages expected). Therefore, a significant relationship between education attainment - relative supply - and some individual outcomes may simply result from some unobserved heterogeneity determining both variables. Similarly, there may be concerns with regard to some unobserved country-specific factor that shifts the relative demand for skilled workers, leading to higher relative wages and higher relative employment, and confounding the estimation of the inverse substitution elasticity. To overcome these concerns, I use an instrumental variable strategy. I exploit data on the reforms affecting the university system, as an instrumental variable for the aggregate relative supply ratio. In particular, I use an index measuring university autonomy in several domains.[24] This empirical strategy exploits the differences across countries in accessibility to tertiary education due to changes in institutions and legislations.

Another possible issue is the potential endogeneity of the relative demand index: hours worked can be jointly determined with wages, thus determining supply-induced demand. To overcome this potential pitfall I use a proxy measure for relative demand: time trends and a measure of technology -R&D intensity. Results are proven to be robust also using only R&D intensity and time trends as proxy for relevant demand.[25]

4 Estimation results

Cross countries differences in the evolutions of wage distributions are driven by labour market forces and by the market specific labour market insitutions. To investigate the proximate causes of the inequality, I regress the college wage premium on a set of variables including proxy for relative demand and supply and some insti-

[24]The domains of university autonomy are: budget, recruitment, organization, logistic, courses organization, self-evaluation and development plans. The data used here have been kindly provided by Daniele Checchi, Elena Meschi and Michela Braga, who in Braga, Checchi, and Meschi (2013) have constructed a dataset on school reforms occurred in the last century in 18 countries in Europe. See appendix A2 for details about the data and the reforms.

[25]Results are omitted but available upon request.

tutional indicators. The idea is to identify which are the main drivers and whether they act differently from the ones involved in the american scenario. The standard OLS estimation results are presented in Table 2. Results show that institutions matter together with demand and supply factors. The first column of Table 2 uses the original specification of Katz and Murphy (1992) - baseline specification in the tables - with only relative demand and supply measures included as explanatory variables, in addition to country fixed effects, cohort fixed effects and time fixed effects, gender and survey dummies. I then add some measure of institutional constraints in each column to estimate the "full" model. In column 2, I add controls for minimum wage, employment protection legislation and union density, these controls accounts for country specific labour market insitutions. Column 3 incorporates an alternative measure of the relative demand-R&D intensity. Finally, in the last column, I add the percentage of people working in the public sector. The coefficients for the relative supply and relative demand variables are negative and for relative supply index, positive for the relative demand index. The coefficient of the relative supply index is slightly higher, in absolute value, than the relative demand indicator in the baseline and in the richer specifications (-0.0127 vs. 0.0083). The alternative measure of demand, R&D intensity, has a positive and significant effect although it is very low.[26] The negative and significant coefficient of the dummy for male is not surprising. It is well known that, on average, there is much more selection into education for women rather than for men. A higher college wage premium for women is a common finding in the literature.[27] Institution constraint' coefficients are expected to have mainly a negative sign, since these policies should affect unskilled more than skilled workers. A one percent increase in the minimum wage lowers the college wage premium by around 2.3%: thus revealing that increases in the minimum wage provide a valid explanation for the slowdown in the positive trend in wage premia in Europe over the period. Although negatively correlated with wage inequality, the effect of union density is almost zero. Employment protection legislation does not seem to matter. Public sector employment is negatively but not significantly correlated with wage inequality.[28] Consequently, it seems that in european countries an important determinant of the non-increasing trend in college wage premium is the strong increase in the relative supply. Comparing these estimates to the US,

[26]In order to make these results comparable with others in the literature, referring to Autor, Katz, and Kearney (2008), I also included a time trend as a proxy for the demand for high skilled workers: a positive coefficient would be interpreted as a sign of SBTC. What I find is that the sign is not always positive neither significant, confirming the lower effect of the demand in contrast to the relative supply.

[27]See Goldin, Katz, and Kuziemko (2006).

[28]Unemployment could also be a part of the story, as argued in Autor, Katz, and Kearney (2008): selection into unemployment could shift to the right the distribution of unobserved skills and of wages. However, adding unemployment rate and relative unemployment of skilled to unskilled people to the wage inequality regression does not change remarkably the results. Results are omitted but are available upon request.

it is evident that in Europe demand plays a much smaller role in boosting wage inequality. This may be due to the different sectorial composition of the european production sector, which is generally characterized, by a lower technology intensity with respect to the american production sector.

4.1 Assessing the endogeneity bias

As mentioned in the previous section, although this model does a good job in capturing the general trend of the college wage premium, it suffers from a potential endogeneity problem. In the very short-run, the supply of skills and labour market institutions may be treated as given. However, in the long run, the growth of supply and the changes in the skill premium can be jointly determined.

To assess the potential endogeneity of the relative supply, that is the relative share of the labour force with tertiary education relative to the share of the labour force with a high school diploma, I use an instrumental variable strategy.[29]

In particular, I use an index measuring the expansion of university autonomy as instrument.[30] University autonomy is shown to be positively associated with student achievement. Figure 4 shows the existence of a positive relation between increasing university autonomy and the relative supply.[31] The graph depicts the association between the level of university autonomy and the relative supply measured after 5 years, in 1994 and 2005. It is easy to notice the presence of a positive gradient between the two variables. Moreover, it is evident that in time countries have experienced an increase in university autonomy, followed by an increase in the relative supply.

Reforms increasing university autonomy are generally viewed positively. It is thought that by involving more competition, they somehow increase college participation, thus improving quality, however, the drawback is that this could increase social stratification.[32] All the different aspects of university autonomy considered in the index are features that increase the efficiency of the institutions, thus lowering costs, and, in a general equilibrium framework, a reduction of the universities' cost curve is the flip-side of an increase in the supply curve of graduates. While other

[29] A common way of addressing this issue is to use different characteristics of the institutional structure of the education system as instruments for the educational attainment. See also Hanushek and Woessmann (2012).

[30] The expansion in university index measures autonomy at tertiary level in the following dimensions: budget, recruitment, organisation, logistic, courses organisation, self-evaluation and development plans. Allowing greater autonomy to university implies greater differentiation in admission curricula, resource availability, and attractiveness for best researchers. See Braga, Checchi, and Meschi (2013) for further details.

[31] Since 1980 European countries implemented reforms generally aimed at increasing the degree of autonomy given to higher education institutions. This degree of autonomy varied enormously between countries and between the university and non-university sectors.

[32] Braga, Checchi, and Meschi (2013).

policies such as the ones inducing selectivity or those enclosing student financing or educational expenditures may be endogenous - potentially driven by the demand or by the wealth of the country- university autonomy can reasonably be assumed to be uncorrelated with the disturbances of the "inequality equation". Since there have been some trends in these reforms increasing decentralization and autonomy of decision-making in schools and university, there is no implication that this is driven by demand for a particular type of skilled/unskilled individuals or by systematic differences in economic and cultural systems.[33] Overall, these results suggest that these reforms on different aspect of university autonomy identify an authentic source of exogenous variation across years and countries: they have an exogenous impact on college enrolment/relative supply, are expected to impact the relative wage only through college enrolment, and do not suffer from reverse causality.

By pooling countries, I exploit the fact that the timing of reforms concerning university autonomy varies across countries. By doing so it is possible to disentangle tertiary education reform from cohort fixed effects. A key assumption here is that we can treat the pooled data from multiple countries as one population and therefore treat the timing of the natural experiment in different countries as regional variation in the timing in the same way as one would use between US states variation.[34] Table 3 shows first stage estimates of the IV strategy for the relative supply: relative supply is regressed on all the exogenous controls plus the indicator measuring the variation in university autonomy reforms, measured five years before. The underlying assumption is that it takes an average of five years in order for these reforms to take action, be implemented and affect the relative supply.[35] In all the specifications, the instrument measuring the expansion in university autonomy is shown to be a good explanatory variable for aggregate relative supply: the coefficient is always positive and significant confirming the evidence depicted in Figure 4, suggesting that exposure to reforms improving university autonomy tends to lead to a higher relative supply of graduates. Therefore, the level of tertiary education in a particular year and in a specific country is reasonably deemed to be affected by the level of institutional set-up of tertiary education, measured by the degree of university autonomy, five years before.

At the bottom of the table, I report the F-statistic of the excluded instruments. It oscillates between 35 and 171, above the conventional threshold of 10 for strong instruments. Thus, there should be no concerns about potential biases in the second stage due to the use of weak instruments.

The second stage results are presented in Table 4. I compare OLS and IV es-

[33]See also Hanushek and Woessmann (2012).

[34]See for example Lee (1999) or Card and Lemieux (2001).

[35]Five years is the standard length of a university cycle. Moreover, this mismatch increase as well the validity of the instrument used as it avoids any problem of reverse causality. For this reason the sample observed is partially reduced a delimited to 2005, since the data on the tertiary education institutions arrive up to 2005.

timates of the college wage premium, replacing relative supply with the university autonomy instrument. More specifically, columns 1 and 2 show the baseline specification where college wage premium is regressed on a demand index and a supply index. Columns 3 and 4 add labour market institutions such as minimum wage, EPL and union density as additional controls.[36] The estimated IV coefficients of relative supply are negative, strongly significant and larger in magnitude than the OLS. OLS estimates give a relative supply coefficient of -0.011, while IV estimates are substantially larger in both the specifications (-0.018 and -0.024), implying a positive bias. The Angrist-Pischke robust F-statistics for excluded instruments confirm that the instrument is a strong predictor of the relative supply as I already know from the regressions in Table 3. Additionally, in the IV estimates, the sign and the significance of the coefficients of the labour market institutions are very close to what has been found in the original OLS estimates. Institutions play a minor role in this reduced sample. The most relevant institution is the minimum wage, which has a negative and significant effect on the college wage premium -similar in size to the OLS one. Collective bargaining instruments seem not to be relevant in compressing the college wage premium, as their effect is almost zero. A few conclusions can be drawn from this set of estimates. First, there is clear empirical evidence that relative supply has a negative effect on college wage premium in Europe: being exposed to a higher relative supply of graduates has caused a reduction in the college wage premium, that is, the relative advantage of the relatively higher educated people. Second, the comparison between OLS and IV estimates suggests that the OLS estimates are upward biased. The story behind these results could be the following: relatively more college graduates should earn relatively less, due to increased supply. The increase in supply may also have an indirect effect through a compositional effect on unobserved ability. Average quality (ability) of college graduates could decrease relatively to high school graduates' ability, due to the expansion of relative supply, and this may result in lower wage premia but this is mere speculation because I do not have any measure to control for ability.

5 Robustness checks

To check the validity of my results I have run a series of robustness checks. Firstly, to avoid potential issues stemming from sample selection bias that might affect female labour force participation, I ran the analysis separately for men and women. A prominent stylized fact in this literature has been that the college wage premium for women is higher than the college wage premium for men: see, for example, Chiappori, Iyigun, and Weiss (2009) and Goldin, Katz, and Kuziemko

[36]The richer specification -i.e. the one including the other controls used in the OLS estimations, such as the, public employment and R&D intensity, has been omitted since these variables do not appear relevant.

(2006). The general conclusion is that "women receive a higher increase in wages than men when they acquire college or advanced degrees".[37] Following Olivetti and Petrongolo (2008), neglecting selection into employment may lead to serious bias in the estimation of women's wage equations. Results of both OLS and 2SLS are shown in Tables 5 and 6. Table 5 presents OLS estimates of wage inequality separately for males and females. Column (1) and (3) reproduce the baseline model, whereas columns (2) and (4) add the whole set of controls. Results are in line with previous findings, with relative supply negatively and significantly correlated with college wage premium and relative demand positively associated. The role of relative supply and demand is much stronger for men: the effect of supply is almost double than for women while the effect of the demand is significant only for males. These results are in line with the literature dealing with sample selection and gender wage gap. Specification (1) of Table 5 reveals that university autonomy is significantly associated with relative supply in the first stage. This effect appears stronger for women. A possible explanation is that women in this period have seen a much higher increase in relative supply than men. Specifications (2) and (3) show the OLS and the second stage estimates, respectively. The second-stage estimates of the wage inequality model confirms previous findings: institutionally induced changes in relative supply are negatively and significantly related, and affect college wage premium for men. These results are a confirmation of the existence of stronger non-random selection for women into employment: women who are employed tend to have relatively high-wage characteristics.

Additionally, since the focus of this paper is on the role of the supply in the evolution of college wage premium, I differentiate between countries with a high (initial) relative supply of graduates and countries with low (initial) relative supply of graduates, measured at the beginning of the period, 1994. Denmark, Finland, Ireland, Spain, France and Belgium are countries that were experiencing high percentage of people achieving higher education in the 1990s. On the other hand, countries, such as Italy, the UK, Portugal, Germany, Greece and Austria had lower graduate rates at the beginning of the period analysed. Looking at the values of this ratio in 1994, I divide the set of countries into two regions: countries with a high or low relative supply of graduates. Countries characterized by a lower stock of highly educated individuals experienced even higher growth in attainment levels, thus suggesting a catching-up phenomenon. Certainly, the evolution of the relative supply trend has differed in the two sets of countries, therefore, I expect differences in the evolution of the college wage premia as well: Figure 5 shows that college wage premium has evolved very differently among countries with a high and low relative supply of graduates. The college wage premium in high relative supply countries has been decreasing slowly over time, while in low relative supply countries it has been experiencing a fast growing trend. I replicate the analysis separately for the two

[37] Chiappori, Iyigun, and Weiss (2009)

sets of countries, and I show supportive evidence of what has been found pooling the countries, in both the OLS and 2SLS estimates. Again, there is evidence of a negative and significant effect of relative supply on the college wage premium, and this is true also correcting for the endogeneity of labour supply. The negative effect of relative supply is higher in countries with a low relative supply of graduates. Results of OLS estimates are shown in Table 7: the coefficient of the relative supply indicator is slightly higher in countries with a lower supply of graduates (-0.02 vs. -0.008). Countries with a high relative supply of skilled workers present a higher and significant relative demand indicator in the baseline and in the richer specifications, whereas in countries with a lower relative supply, the standard relative demand measure does not appear to be a significant determinant of wage inequality. Table 8 presents the first-stage estimates of the effect of tertiary education reforms, namely the estimated coefficients on the instrument in the regression of relative supply. In this case too, instruments appear strong and significant, and robust F test statistics support the relevance of the instruments. Table 9 compares results of OLS and IV estimates. Again there is evidence of a negative and significant effect of relative supply on college wage premium, and this is true also correcting for the endogeneity of labour supply. Estimated IV coefficients of relative supply are negative, strongly significant and larger in magnitude than the OLS for low relative supply countries, however this is not the case for high relative supply countries. According to these estimates, the OLS coefficient of relative supply is -0.01 in the preferred specification in high relative supply countries, and -0.019 in countries with a low relative supply of graduates. The IV estimates are substantially larger in low relative supply countries and in both the specifications (-0.075 in the baseline model and -0.076 in the richer specification), implying a positive bias. In addition, I have also run pooled regressions removing one country at time. In this case too, excluding one country at time, results are in line with the ones obtained pooling all the countries together.[38]

6 Conclusions

While there has been intense debate over about the contribution of the increase of higher education participation to the widening wage inequality in the US, its evolution in Europe has been given little attention.

This paper aims at analysing changes in the wage premium associated with a college degree using a large european dataset obtained harmonizing two different sources. More specifically, I am interested in how the college premium has evolved across time. I try to offer some insights into this topic by looking at the supply and demand for skills. I analyse the effects of the recent strong increase in participation rates on returns to college and inequality in Europe. I have constructed a dataset

[38]Results are omitted but are available upon request.

which covers 15 years and exploited cross country variation in relative supply, demand and labour market institutions to look at their effects on the trend in the college wage gap.

Observing the evolution of the college wage premium, a striking difference emerges with respect to the american scenario. A potential explanation of the observed declining/stable trend in the college wage premium in Europe is indeed the increase in educational attainment over the period and the low leading effect of demand. The fall in the skill premium is intuitively the first outcome of a classic supply and demand effect. In particular, it could be that the demand was not able to compensate for the increase in the labour supply of skilled workers. To check whether this is the case, I look at the potential sources of wage inequality, including supply and demand factors as well as institutional indicators. I address possible concerns of endogeneity of relative supply by an instrumental variable strategy. Results show that demand and supply factors explain a lot of the variation, and that institutions are not the main driver: the estimates reveal the important effect of the increased relative supply on the evolution of college wage premium while relative demand appears to play a minor role. The minimum wage is an institutional constraint deserving more attention. The main policy implication of these findings is that increasing accessibility to tertiary education in Europe can not only lower the disparities among different education groups but can also lower the college wage premia, possibly due to the implied changes in ability composition across education groups. Moreover, the institutional explanation holds as well; it is apparently possible to protect low-skilled workers against market-forces by establishing the proper institutions, specifically those concerning minimum wages.

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A Appendix

A.1 Theoretical framework

Following the conventional conceptual framework of this literature[39], I model the relative wage dynamics as a combination of supply and demand factors and labor market institutions.

From a theoretical perspective there is the need to account separately for the relative wage of two types of workers. Consider an extended version of the CES production function with two labor inputs that are imperfect substitutes: low educated (or unskilled) and high educated (or skilled). Assume that firms in each economy use the following simple production function where output depends on employment:

[39]In their paper, Katz and Murphy (1992), used a demand and supply of skills framework to analyse the change in wage inequality over time. The same framework has then been used by Katz and Autor (1999), Goldin and Katz (2007) and Leuven, Oosterbeek, and van Ophern (2004) to look at differences in skills groups across countries. All these studies focus exclusively on demand side modeling

$$Y_{ct} = e^{\phi_{ct}} N_{ct} \tag{3}$$

with Y being the total output produced, N the employment in efficiency units, c the country, t the time and ϕ a country and time specific productivity shock, a parameter denoting total factor productivity.

Employment is made by two groups of workers, skilled and unskilled labor, which are employed according to

$$N_{ct} = [(e^{\alpha_{lct}} L_{ct})^{\rho} + (e^{\alpha_{hct}} H_{ct})^{\rho}]^{\frac{1}{\rho}} \tag{4}$$

α is an efficiency parameter indicating the productivity of a particular type of worker (L,H) in country c at time t, it is an index of the technological efficiency of a worker as it is factor augmenting technical change parameter capturing changes in input quality over time. H_{ct}, L_{ct} are the quantities employed of college equivalent (skilled labor) and high school equivalent (unskilled labor).

It is assumed that the economy is at full employment, that means the total effective aggregate labor supply of each labor group is employed in the industries of the economy. Another assumption is that H_{ct}, L_{ct} are exogenous. That is the aggregate supply does not depend on its relative average wage.

$\rho = 1 - 1/\sigma$, is a time-invariant production parameter, where σ is the aggregate elasticity of substitution between labor inputs. The low quality and high quality workers are gross substitutes if $\sigma > 1$ and $\rho > 0$, whereas they are gross complements if $\sigma < 1$ and $\rho > 0$.

Skill neutral technological progress raises both $e^{\alpha_{lct}}$ and $e^{\alpha_{hct}}$ by the same proportion. Whereas, skill biased technical changes involve the increase of $\frac{e^{\alpha_{hct}}}{e^{\alpha_{lct}}}$

Competitive labor markets are assumed, so college equivalent and high school workers are paid their marginal products, then profit maximisation with respect to N_{ict} (with $i = L, H.$) yields to

$$w_{ict} = e^{\phi_{ct} + \alpha_{ict}} \left[\frac{N_{ict}}{N_{ct}} \right]^{\rho - 1}$$

where w_{ict} is the real wage for labor input i in country c at time t.

In other terms, efficient utilisation of different skill groups requires that the relative wages are equated to the relative marginal products. The relative wage of high skill to low skill workers can be written as

$$w = \frac{w_{ct}^{H}}{w_{ct}^{L}} = \left(\frac{e^{\alpha_{hct}}}{e^{\alpha_{lct}}} \right)^{\frac{\sigma - 1}{\sigma}} \left(\frac{H_{ct}}{L_{ct}} \right)^{-\frac{1}{\sigma}} \tag{5}$$

which is equal to:

$$lnw = \rho \left(\frac{\alpha_{hct}}{\alpha_{lct}} \right) - \frac{1}{\sigma} ln \left(\frac{H_{ct}}{L_{ct}} \right) \tag{6}$$

The relative wage of different educational groups is generally used as a measure of between groups inequality. $\left(\frac{H_{ct}}{L_{ct}}\right)$ represents the relative supply of skilled versus unskilled labor, and $\left(\frac{\alpha_{hct}}{\alpha_{lct}}\right)$ the skill bias technological change. This can be rewritten as

$$ln\left(\frac{w_{ct}^{H}}{w_{ct}^{L}}\right) = \frac{1}{\sigma}\left[D_t - ln\left(\frac{H_{ct}}{L_{ct}}\right)\right] \tag{7}$$

where D_t indexes relative demand shifts which favour high skilled workers and it is measured in log quantity units.

Equation (6) can lead to a very simple and intuitive demand-supply interpretation. Given a skill bias technical change, the substitution effect is such that the skill premium increases when there is a scarcity of skilled relative to unskilled workers.

Relative demand changes can be due to shifts in product demand, SBTC and non-neutral changes in the relative changes in relative prices/quantities of non-labor inputs, so marginal productivity and elasticity.

The relative demand is shifted by the bias of the technological change:

$$\frac{\partial lnw}{\partial\left(\frac{\alpha_{hct}}{\alpha_{lct}}\right)} = \frac{\sigma - 1}{\sigma}$$

This means that, given the relative supply, if there is skill biased technological change (i.e. technological shock shifting the demand line outwards) the wage premium will increase.

Similarly, for a given "skill bias", $\left(\frac{\alpha_{hct}}{\alpha_{lct}}\right)$, an increase in the relative supplies $\left(\frac{H_{ct}}{L_{ct}}\right)$ lowers relative wages with elasticity σ.

Following the reasoning above, the evidence of a negative relationship between college premium and relative supply of skills in the recent period in Europe can be interpreted as an increase in the relative supply of college skills, under the assumption of stable demand's conditions. In short, there are the main forces that operates in this framework: the relative supply and the relative demand of more-educated workers. When these two forces fail in explaining the wage differentials, the pattern can be reconciled by institutional factors such as change in union density/strength and wage setting policies. Labor market institutions, indeed, differently alter the outside option of skilled and unskilled workers thus affecting wage differential as well as relative labor demand.

A.2 Data Appendix

College wage premium: It is defined as the ratio of wage rates between college and high school graduates. I obtain college wage premium data at the age cohort-country-year level from the European Community Household Panel

(ECHP) and the European Union Survey on Income and Living Conditions (EU-SILC). The ECHP started in 1994 and lasted until 2001 and reports wages in national currencies, while the EU-SILC covers 2004-2009 and contains wages in Euros.

Supply Index: This index is created using OECD data. It is a measure of relative supply and it is calculated separately by gender in each country, yearly, as the ratio of college graduates to high school graduates (ISCED 5/ISCED 3).

Demand Index: This index is created using EUKLEMS data. It is a measure of relative demand and it is calculated for each country, yearly, considering hours worked by high-skilled persons engaged (share in total hours) by industries relative to hours worked by middle skilled workers.

R&D intensity: Data are drawn from the OECD-STAN database which provides information on imports, R&D and value added in the manufacturing sector from 1973-2009. Using these data I manage to build a proxy for technology using data on total manufacturing for R&D and value added for all countries.

Minimum Wage: This is the ratio of the statutory minimum wage to the median wage in each country. The measure is provided by the OECD. Germany, Denmark, Finland and Italy have no statutory minimum wage.

Employment Protection Legislation (EPL): The employment protection legislation consists on a set of norms and procedures followed in case of dismissal of redundant workers. The OECD indicators of employment protection are synthetic indicators of the strictness of regulation on dismissals and the use of temporary contracts. These indicators are compiled from 21 items covering three different aspects of employment protection: Individual dismissal of workers with regular contracts, additional costs for collective dismissals and regulation of temporary contracts. Range {0, 6} increasing with strictness of employment protection.

Net Union Density: Union density expresses union membership as a proportion of the eligible workforce. Normally, union density rates are standardised by the calculation of union membership as a proportion of the wage and salary earners in the same year (preferably on the basis of some annual average year data). The data are drawn from the ILO website.

Public Sector employment: Data are collected from the laborsta.ilo.org website (ILO). These are data covering all employment of general governmental sector plus employment of publicly owned enterprises and companies. It covers all persons employed directly by those institutions. Based on this data, I compute an index of "public sector employment" by calculating the percentage of public employees over total working population, yearly, by country.

To address any further concern regarding the presence of endogeneity, I then implement an IV strategy. The potentially endogenous relative supply variable is instrumented using the "tertiary education institutional set-up" variables. Data are taken from Braga, Checchi, and Meschi (2013) and contains information about the degree of university autonomy in the different countries.

The reforms carried out in Europe since 1980 generally aimed at increasing the autonomy of the higher education institutions, particularly in the case of the universities, in relation to the planning and delivery of higher education. However, the degree of autonomy given to higher education institutions varied enormously between countries and between the university and non-university sectors.

Index of university autonomy measures autonomy at tertiary level in the following dimensions: budget, recruitment, organization, logistic, courses organization, self -evaluation and development plans. This data is taken from Braga, Checchi, and Meschi (2013) who used Eurydice (2000) "Two decades of reforms in higher education in Europe: 1980 Onwards" (p.91) as source. It is a continuous measure from 0 to 1, which is simply a normalized sum of indexes characterizing seven separate dimensions (budget, recruitment, organization, logistic, courses organization, self-evaluation and development plans), which are then rescaled in order to retain unitary variation.

Full autonomy in the different areas is understood as meaning that the institutions are able to: freely spend any income derived from government grants, fees and contracts; decide on the employment of academic staff and their salaries (even if all legal requirements for minimum qualifications and minimum salaries have to be met); be responsible for internal management without the obligation to include specific external members on governing boards or similar bodies; own buildings and equipment used for teaching purposes; freely change course structure and content; determine when and how to assess the quality of their educational provision and, finally, determine any policy significantly affecting the institution's future development. The majority of countries studied have a high degree of autonomy over a wide range of their activities. Course planning is the area where most of the countries suffered restrictions in institutional autonomy, followed by development planning, budget spending and employment of teaching staff. Self-evaluation is the area where all countries except the French Community of Belgium, Denmark, Greece and France had full autonomy. Countries where universities had (and have) the least autonomy are Germany, France and Austria.

Table A1: Timing of reforms on university autonomy and degree of autonomy enjoyed by higher education institutions

Country	Budget spending	Recruitment	Organization	Logistic	Course planning	Self evaluation	Development planning
Austria	1993*	1993*	1993	none	1997*	1993	none
Belgium (fr)	1998	1995	pre 1980*	1991	1994	pre 1980*	none
	1996	1996	1996*	pre 1980*	1995*	pre 1980*	none
Belgium (nl)	1991*	1991*	1991*	1991*	1991*	1991	1991*
	1994*	1994*	1994*	1994*	1994*	1994	1994*
Germany	none	none	pre 1980	pre 1980*	pre 1980*	1990	pre 1980
Denmark	1993	pre 1980	1993	1993*	pre 1980	1992*	1993*
Finland	1988-1994	pre 1980	1986	1988	pre 1980*	pre 1980	1997
	1991	1991	1991	1991	1991*	1991	1991
France	pre 1980*	none	1984*	1989*	pre 1980*	1989*	1984
Greece	1997*	1982*	1982	pre-1980	1982	1997*	1982*
Ireland	pre 1980	pre 1980	pre 1980	pre 1980	pre 1980	pre 1980	pre 1980
Italy	1983	1998*	1989	1993	1990*	1993	none
Spain	1983	1988*	1983	1983	1983*	1991	1983
Portugal	1988	1988*	1988*	1997	1989	1994	1997
UK	pre 1980	pre 1980	pre 1980	pre 1980	pre 1980	pre 1980	pre 1980
	1992	1992	1992	1992	1992	1992	1992

Notes: The table shows the years in which relevant legislations in the main areas of university autonomy change, implementing full autonomy, for the different countries analyzed. The asterisk indicates that institutional autonomy is not complete but is determined by a framework of rules and conditions laid down by the government or any other authority.
Source: Eurydice (2000) p.91.

Tables and figures

Table 1: Descriptive statistics

	Males		Females	
	ECHP	EUSILC	ECHP	EUSILC
Panel A: Demographics				
College graduates	0.30	0.32	0.39	0.43
High school graduates	0.36	0.42	0.36	0.39
High school dorp outs	0.34	0.25	0.26	0.18
Years of education	12.69	13.60	13.11	14.20
Log wage	9.52	9.97	9.23	9.66
N	100, 591	148,018	77,622	132,085
Panel B: Education premium				
College wage premium	1.64	1.54	1.55	1.45
Age 25-30	1.35	1.19	1.43	1.30
Age 31-36	1.58	1.44	1.56	1.48
Age 37-40	1.67	1.61	1.58	1.48
Age 41-45	1.70	1.68	1.63	1.54
Age 46-50	1.76	1.71	1.64	1.61

Notes: ECHP data cover the period 1994-2001, EUSILC data the period 2004-2009.
Source: Author's computations on EUSILC and ECHP DATA

Table 2: The college wage premium- pooled countries

	(1)	(2)	(3)	(4)
Relative supply	-0.0108^{***}	-0.0120^{***}	-0.0124^{***}	-0.0127^{***}
	(0.0019)	(0.0018)	(0.0023)	(0.0021)
Relative demand	0.0061^{**}	0.0086^{**}	0.0081^{**}	0.0083^{**}
	(0.0028)	(0.0038)	(0.0034)	(0.0034)
Males	-0.0022^{***}	-0.0023^{***}	-0.0023^{***}	-0.0023^{***}
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Minimum wage		-0.0216^{***}	-0.0236^{***}	-0.0230^{***}
		(0.0051)	(0.0049)	(0.0063)
EPL		0.0001	−0.0000	−0.0000
		(0.0003)	(0.0003)	(0.0002)
Union density		-0.0001^{**}	-0.0001^{***}	-0.0001^{**}
		(0.0000)	(0.0000)	(0.0000)
R&D intensity			0.0003^{***}	0.0003^{***}
			(0.0001)	(0.0001)
Public sector employment				−0.0042
				(0.0056)
R-squared	0.363	0.372	0.376	0.376
Observations	1415	1415	1415	1415

Notes: The table reports OLS estimates of the evolution of wage inequality. The dependent variable is college wage premium. All regressions include a full set of country, year, survey and age cohorts dummies. Clustered standard errors using bootstrap in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. EPL denotes employment protection legislation. Column (1) shows the baseline model- a' la Katz and Murphy, column (2) adds labor market institutions. Column(3) and (4) add, respectively R&D intensity and the % of public employment.

Table 3: 1st stage - pooled countries

	(1)	(2)	(3)
Uni. autonomy	0.102***	0.087***	0.096***
	(0.007)	(0.011)	(0.010)
Institutions	*No*	*No*	*Yes*
Year FE	*Yes*	*Yes*	*Yes*
Age cohort FE	*Yes*	*Yes*	*Yes*
Country FE	*No*	*Yes*	*Yes*
R-squared	0.266	0.703	0.731
Observations	995	995	995
F-stat	35.49	171.97	152.25
F-stat p-value	0.000	0.000	0.000

Notes. The table reports first stage estimates of the IV estimation for wage inequality. The dependent variable is relative supply of graduates. An index measuring the level of university autonomy by country and year is used as instrument. Included but not shown are all the exogenous controls such as relative demand, males and survey dummies. Clustered standard errors using bootstrap in parenthesis. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: 2SLS Estimates of wage inequality- pooled countries

	Baseline model		*+ labor Market Institutions*	
	OLS	*IV*	*OLS*	*IV*
Relative supply	-0.010^{***}	-0.018^{**}	-0.011^{***}	-0.024^{*}
	(0.002)	(0.007)	(0.002)	(0.011)
Relative demand	0.004	0.006	0.007^{*}	0.009^{*}
	(0.003)	(0.004)	(0.003)	(0.004)
males	-0.002^{***}	-0.002^{***}	-0.002^{***}	-0.002^{***}
	(0.000)	(0.000)	(0.000)	(0.000)
Minimum wage			-0.017^{***}	-0.023^{**}
			(0.005)	(0.007)
EPS			0.000	0.000
			(0.000)	(0.000)
Union density			-0.000	-0.000^{*}
			(0.000)	(0.000)
Angrist-Pischke F test		55.090		53.345
R-squared	0.392	0.384	0.397	0.375
Observations	995	995	995	995

Notes: OLS and IV estimates of wage inequality are reported. The sample is reduced to the period 1994-2005. The dependent variable is college wage premium. Relative supply is instrumented by an indicator measuring university autonomy. All regressions include a full set of country, year, survey and age cohort dummies. Clustered standard errors using bootstrap in parenthesis.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: OLS Estimates- Males and females.

	Males		*Females*	
	(1)	(2)	(3)	(4)
Relative supply	-0.0146^{***}	-0.0188^{***}	-0.0088^{***}	-0.0111^{***}
	(0.0049)	(0.0052)	(0.0027)	(0.0030)
Relative demand	0.0128^{***}	0.0098^{**}	-0.0004	0.0073
	(0.0037)	(0.0039)	(0.0049)	(0.0060)
R&D intensity		0.0002		0.0004^{***}
		(0.0002)		(0.0001)
Minimum wage		-0.0135^{**}		-0.0330^{***}
		(0.0058)		(0.0086)
EPL		-0.0004		0.0004
		(0.0003)		(0.0004)
Union density		-0.0001^{*}		-0.0001^{**}
		(0.0000)		(0.0000)
public employees		0.0022		-0.0085
		(0.0055)		(0.0080)
R-squared	0.286	0.307	0.331	0.362
Observations	690	690	725	725

Notes: The table reports OLS estimates of the evolution of wage inequality separately by gender. The dependent variable is college wage premium. All regressions include a full set of country, year, survey and age cohorts dummies. Clustered standard errors using bootstrap * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. EPS denotes employment protection legislation. Column (1) and (3) show the baseline model- a' la Katz and Murphy, columns (2) and (4) add labor market institutions, R&D intensity and the % of public employment.

Table 6: College wage premium for males and females- Instrumental variable estimates

	(1) Relative supply (FS)	(2) CWP (OLS)	(3) CWP (2SLS)
Panel A: Males			
Uni. autonomy	0.062***		
	(0.009)		
Relative demand	0.050	0.009*	0.013*
	(0.036)	(0.004)	(0.005)
Relative supply		−0.016***	−0.049*
		(0.005)	(0.021)
Controls	*Yes*	*Yes*	*Yes*
Angrist-Pischke F test			21.990
R-squared			0.270
Observations	490	490	490
F-stat	249.89		
F-stat p-value	0.000		
Panel B: Females			
Uni. autonomy	0.119***		
	(0.015)		
Relative demand	0.025	0.006	0.007
	(0.039)	(0.007)	(0.006)
Relative supply		−0.007*	−0.015
		(0.003)	(0.012)
Controls	*Yes*	*Yes*	*Yes*
Angrist-Pischke F test			50.680
R-squared	0.824	0.375	0.370
Observations	505	505	505
F-stat	98.165		
F-stat p-value	0.000		

Notes. The table reports first stage estimates, OLS and 2SLS estimations for wage inequality for the two subsamples of men (Panel A) and women (Panel B). The dependent variable is relative supply of graduates in the first column and college wage premium (CWP) in columns 2 and 3. The index of university autonomy is the instrument. All the exogenous controls of the full specification are included, in particular institutions (EPL, minimum wage, union density), country, year, age cohort and survey dummies. Clustered standard errors using bootstrap in parenthesis. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: OLS Estimates- High and Low relative supply countries

	High Relative Supply Countries		*Low Relative Supply Countries*	
Relative supply	-0.0079^{***}	-0.0084^{***}	-0.0211^{***}	-0.0198^{***}
	(0.0024)	(0.0024)	(0.0034)	(0.0037)
Relative demand	0.0118^{**}	0.0206^{***}	0.0035	0.0033
	(0.0046)	(0.0070)	(0.0039)	(0.0045)
males	-0.0020^{***}	-0.0020^{***}	-0.0025^{***}	-0.0025^{***}
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
R&D intensity		0.0008^{***}		-0.0006^{**}
		(0.0002)		(0.0002)
Minimum wage		0.0136		-0.0232^{**}
		(0.0100)		(0.0093)
EPL		0.0010^{*}		-0.0006
		(0.0005)		(0.0006)
Union density		-0.0000		0.0000
		(0.0000)		(0.0001)
public employees		-0.0511^{***}		-0.0483^{*}
		(0.0109)		(0.0272)
R-squared	0.361	0.389	0.408	0.424
Observations	795	795	620	620

Notes: The table reports OLS estimates of the evolution of wage inequality. The dependent variable is college wage premium. All regressions include a full set of country, year, survey and age cohorts dummies. Clustered standard errors using bootstrap * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. EPS denotes employment protection legislation. Column (1) and (3) show the baseline model- a' la Katz and Murphy, columns (2) and (4) add labor market institutions, R&D intensity and the % of public employment.

Table 8: Relative supply equation: 1st stage

	High Relative Supply Countries		*Low Relative Supply Countries*	
Uni. autonomy	0.118***	0.180***	0.083***	0.067***
	(0.016)	(0.016)	(0.009)	(0.014)
Institutions	*No*	*Yes*	*No*	*Yes*
Year FE	*Yes*	*Yes*	*Yes*	*Yes*
Age cohort FE	*Yes*	*Yes*	*Yes*	*Yes*
Country FE	*Yes*	*Yes*	*Yes*	*Yes*
R-squared	0.588	0.661	0.778	0.784
Observations	545	545	450	450
F-stat	42.06	79.77	145.80	133.55
F-stat p-value	0.000	0.000	0.000	0.000

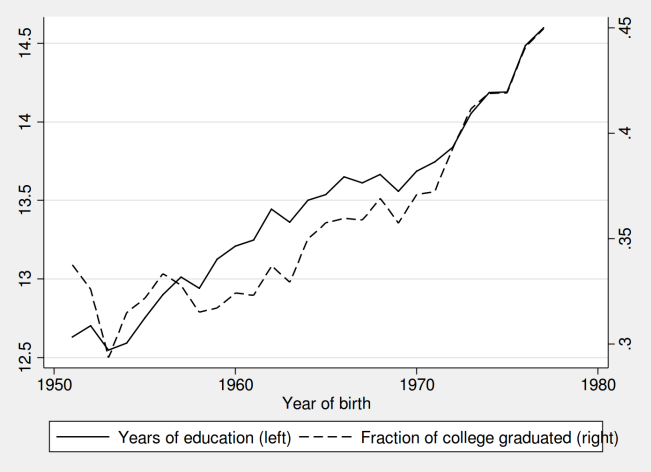
Notes. The table reports first stage estimates of the IV estimation for wage inequality. The dependent variable is relative supply of graduates. The set of tertiary education reforms are the instruments. All the exogenous controls such as dummy for males, relative demand and institutions. All regressions include a full set of country, year, survey and age cohorts dummies. Clustered standard errors using bootstrap in parenthesis. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: 2SLS Estimates- High and Low relative supply countries

	Baseline model		*+ labor Market Institutions*	
	OLS	*IV*	*OLS*	*IV*
Panel A: High Relative Supply countries				
Relative supply	-0.009^{***}	-0.012	-0.010^{***}	-0.010
	(0.002)	(0.008)	(0.003)	(0.009)
Relative demand	0.005	0.006	0.009	0.009
	(0.007)	(0.007)	(0.010)	(0.009)
Institutions			Yes	Yes
Angrist-Pischke F test		45.139		54.077
R-squared	0.390	0.388	0.397	0.397
Observations	545	545	545	545
Panel B: Low relative supply countries				
Relative supply	-0.018^{***}	-0.075^{*}	-0.019^{***}	-0.076^{*}
	(0.005)	(0.029)	(0.005)	(0.032)
Relative demand	0.004	0.009	0.006	0.012^{*}
	(0.004)	(0.005)	(0.004)	(0.006)
Institutions			Yes	Yes
Angrist-Pischke F test		20.559		12.083
R-squared	0.427	0.284	0.429	0.288
Observations	450	450	450	450

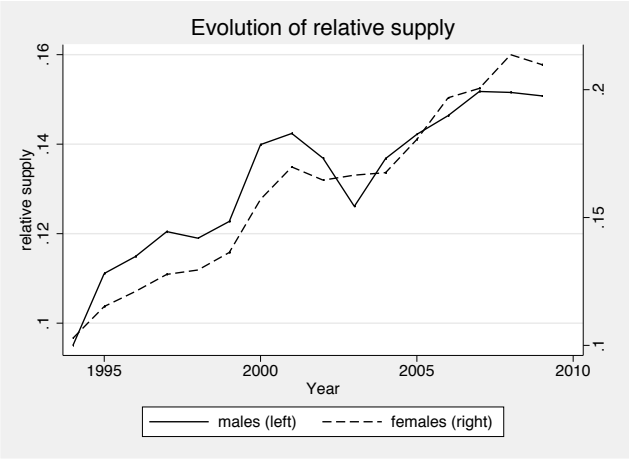
Notes: OLS and IV estimates of wage inequality are reported. The sample is reduced to 1994-2005. The dependent variable is college wage premium. Relative supply is instrumented by a set of indicators measuring university autonomy. All regressions include a dummy for males and a full set of country, year, survey and age cohort dummies. Clustered standard errors using bootstrap in parenthesis.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Figure 1: Increasing trend in higher education by cohorts



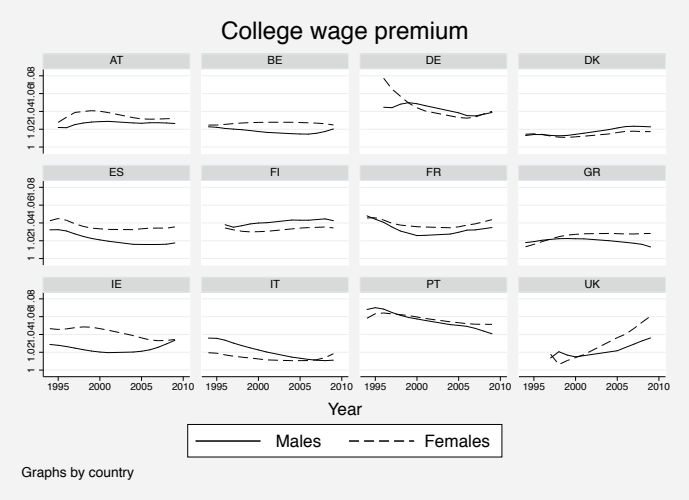
Notes: The figure shows the percentage of each cohort currently undertaking higher education and the average amount of years of education achieved by each cohort.
Source: Author's computations on EUSILC and ECHP DATA

Figure 2: Evolution of relative supply



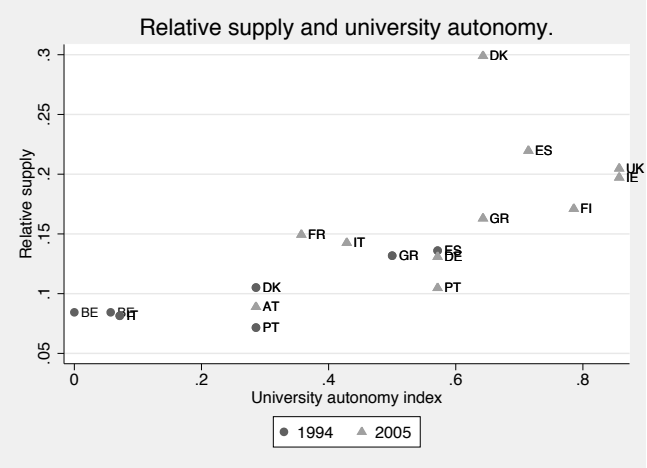
Notes: The figure shows the evolution of the relative supply index separately by gender.
Source: Author's computations on EUSILC and ECHP DATA

Figure 3: Evolution of college wage premium by country



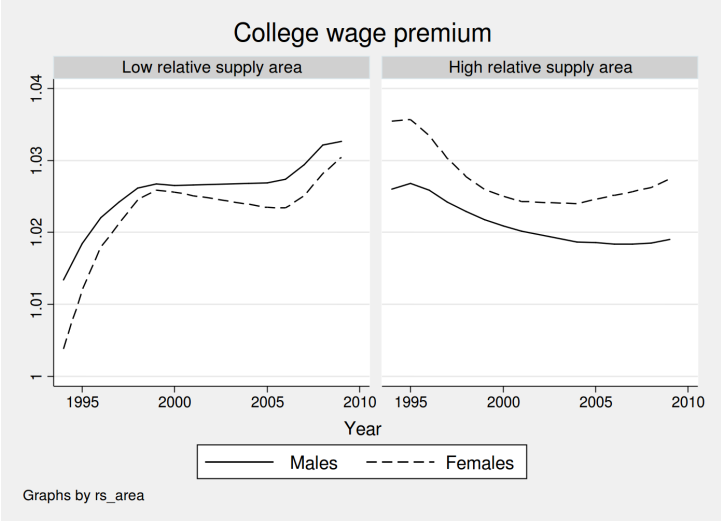
Notes: The figure shows the trend of the college wage premium in the countries analyzed.
Source: Author's computations on EUSILC and ECHP DATA

Figure 4: University autonomy and relative supply



Notes: The figure shows the association between the level of university autonomy and the relative supply measured after 5 years, in 1994 and 2005, in different european countries.
Source: Author's computations on OECD and institutional data from Braga, Checchi and Meschi (2013).

Figure 5: Evolution of college wage premium in the two set of countries



Notes: The figure shows the evolution of college wage premium separately for countries with a high and low relative supply of graduates.
Source: Author's computations on EUSILC and ECHP DATA