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THE EFFECTS OF COHORT SIZE ON EUROPEAN EARNINGS

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The Effects of Cohort Size on European Earnings

by

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Abstract

I use the cross–country and time variation in the demographic structure of 11 European countries to study how changes in cohort size affect real earnings in Europe. This is an important question in the light of widespread population ageing. I find that cohort size has a negative and statistically significant effect on earnings, and that this effect is larger for the older age group – aged between 35 and 54 – than for the younger group – aged 20 to 34. I also find that earnings are more sensible to changes in cohort size in Southern Europe, which points to a lower degree of substitutability between individuals with the same education but different age. I argue that the uncovered lower substitutability in the Olive Belt of Europe is in line with the higher employment protection that its workers enjoy, at least compared to the workers located in Northern Europe. One important policy implication of this study is that the demographic shift away from the young and toward the old, a baby bust after a baby boom, is likely to tilt age – earnings profiles in favor of the young more in Southern than in Northern Europe.

Keywords: Cohort size, wages, Europe
JEL codes: J11, J31

Introduction

Europe is ageing. The decline in the birth rate as well as in the child and old age mortality rate since the 1970s have substantially changed the age structure of the EU15 population. Table 1 shows the level and the changes in cohort size, measured as the share of the population in the relevant age group to the population aged 15 to 64, for 13 European countries and two age groups, 20 to 34 and 35 to 50, between 1991 and 2004. With the exception of the UK, the general pattern is a decline in the size of the younger age group and an increase in the size of the older age group. These percentage changes are particularly marked in Germany, The Netherlands, Austria and Belgium.

Table 1. Cohort size. Levels in 2004 and changes between 1991 and 2004 (in percent). By age range.

	20-34 year-olds. 2004	*20-34 year-olds. 1991-04*	*35-50 year-olds. 2004*	*35-50 year-olds. 1991-04*
Germany	0.277	-22.21	0.458	14.75
Denmark	0.293	-12.72	0.432	4.24
The Netherlands	0.297	-19.14	0.446	12.24
Belgium	0.299	-14.01	0.447	15.76
France	0.308	-10.37	0.435	12.18
UK	0.302	8.05	0.427	-1.70
Ireland	0.358	2.47	0.392	5.74
Italy	0.310	-8.53	0.433	14.04
Greece	0.336	3.46	0.411	9.95
Spain	0.355	0.04	0.413	17.61
Portugal	0.337	0.85	0.412	11.37
Austria	0.297	-20.31	0.442	14.78
Finland	0.277	-14.16	0.444	2.53
North	0.294	-12.40	0.441	9.12
South	0.331	-3.45	0.422	14.43

Total	0.306	-9.51	0.438	10.79

Source: Eurostat Labor Force Survey. South includes Italy, Greece, Spain and Portugal.

Ageing affects the economy and the labor market in a number of ways. The actual and potential effects on productivity, skill development, employment and social security have attracted considerable attention, and have been reviewed by OECD, 1998, the European Commission, 2003, Johnson and Zimmermann, 1993, and Boersch-Supan, 2001, among others.

The empirical investigation of the relationship between cohort size and earnings was initially motivated by the entry of the baby–boom birth cohorts in the labor market during the 1970s (see for instance Welch, 1979). Korenman and Neumark, 2000, review the existing and largely US oriented empirical literature on this topic. Broadly, the studies on the US support the hypothesis that individuals born in large cohorts face depressed (real) earnings. Typically, demographic changes are measured by changes in the relative cohort size of an age group, say the young. Assuming that individuals born in the same age cohort are perfect substitutes, an increase in the relative cohort size of the young is expected – ceteris paribus - to deteriorate their earnings because of the higher competition they face in the labor market – a relative supply effect.

Empirical evidence on the response of real earnings to changes in demographics is scarce for European countries, mainly because of the lack of comparative data on earnings. This is unfortunate, because the well known differences in the flexibility of European and US labor markets would suggest that the response of earnings to changes in cohort size might differ substantially in the two economic areas[1]. Among the few European studies, Wright, 1991, replicates for Great Britain the approach by Welch, 1979, and finds that – ceteris paribus – large cohorts face lower earnings, although the effect does not persist as each cohort ages.

The comparative evidence on the effects of ageing on employment and unemployment in Europe and the US is more abundant than the evidence on the effects on wages. Korenman and Neumark, 2000, and more recently Jimeno and Palenzuela, 2002, investigate whether changes in cohort size have significantly affected

[1] See Bertola, Blau and Kahn, 2003. Differences in flexibility are associated to different institutional setups, which affect wage determination and employment adjustment.

relative unemployment rates. These authors use pooled cross–section data for a group of OECD countries and find evidence of a positive correlation between the youth unemployment rate and the youth cohort size. Ahn, Izquierdo and Jimeno, 2000, also find a positive relationship between the relative size of the youth population and youth unemployment in a sample of Spanish regions. Finally, Bertola, Blau and Kahn, 2005, show that demographic shocks, such as changes in cohort size, interacted with labor market institutions, contribute to explaining the difference in the aggregate unemployment rate between the US and Europe[2].

My paper adds to this literature by providing empirical evidence on the impact of cohort size on real earnings in Europe. My contribution is twofold. First, I cover a relatively large number of European countries (11). I use the seven waves (1995 to 2001) of the European Community Household Panel, a large survey of individuals living in EU15, which contains comparable information on individual earnings. Second, I show that the effects of cohort size are by no means homogeneous within Europe, and relate this heterogeneity to a key labor market institution, the degree of employment protection.

I show that an increase in cohort size affects negatively the (real) hourly earnings of European high school and college graduates, and relate this effect to the elasticity of substitution involving workers of different age but equal educational attainment. The larger the effect, the lower the substitutability. Perhaps not surprisingly, I find that substitutability is lower within the older age group. In line with the predictions spelled out by Stapleton and Young, 1988, I also find that college workers are less substitutable across age than high school graduates.

Perhaps more interestingly, I find that earnings respond significantly more to cohort size in Southern Europe, which points to the lower substitutability of workers in the Olive Belt of Europe. I argue that this lower substitutability can be understood once we realize that employment protection, which shelters jobs and reduces the underbidding of insiders by outsiders, is much higher along the Mediterranean Sea. One important policy implication I draw from this study is that a common demographic shock which hits Europe by reducing the cohort size of the young and by increasing the cohort size of

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[2] See also Jimeno and Palenzuela, 2002 and Shimer, 2001.

the old – a baby bust after a baby boom - is going to tilt the age – earnings profile in favor of the young more in Southern than in Northern Europe.

The paper is organized as follows. I start in Section 1 with the theoretical setup, which clarifies why cohort size and earnings should be related. I also discuss the empirical definition of cohort size. Section 2 is devoted to the data, and Section 3 to the description of the empirical strategy. The results are presented and discussed in Section 4. Conclusions follow.

1. The Theoretical Setup

Consider a perfectly competitive economy where firms operate the linear technology $Y_t = \phi_t N_t$, where Y is output, N is total employment in efficiency units, ϕ is labor productivity and the subscript *t* is for time. Total employment N is a CES function of college and high school employment

$$N_t = \left[\theta_{ct} N^{\sigma}{}_{ct} + \theta_{st} N^{\sigma}{}_{st}\right]^{\frac{1}{\sigma}} \quad [1]$$

Where θ are efficiency parameters, the subscript *c* is for college and *s* for high school, and -∞<σ<1 measures the ease of substitution between college and high school graduates. In this setup, the elasticity of substitution between high school and college graduates is $\Omega = \dfrac{1}{1-\sigma}$. Following Card and Lemieux, 2001, I assume that individuals in the same education group but with a different age are imperfectly substitutes. With age ranging from 1 to k, college and high school employment are described by the following sub-aggregates

$$N_{ct} = \left[\sum_{j=1}^{k} (\mu_{jt} N_{jct}{}^{\rho})\right]^{\frac{1}{\rho}} \quad [2]$$

$$N_{st} = \left[\sum_{j=1}^{k} (\nu_{jt} N_{jct}{}^{\eta})\right]^{\frac{1}{\eta}} \quad [3]$$

where μ and ν are efficiency parameters, *j* is for age, and $-\infty<\rho<1$ and $-\infty<\eta<1$ measure the ease of substitution between workers of different ages for each educational level. Letting w be the hourly real wage paid to each type of worker, and assuming that the product price is given and normalized to unity, profit maximization yields

$$w_{cjt} = \phi_t \mu_{jt} \theta_{ct} \left(\frac{N_{ct}}{N_t} \right)^{\sigma - 1} \left(\frac{N_{jct}}{N_{ct}} \right)^{\rho - 1} \qquad [4]$$

for college graduates, and similarly for high school graduates.

Equation (4) is the demand of college graduates of age *j.* Labor market equilibrium requires that we characterize supply. Let relative supply $\frac{P_{jct}}{P_{ct}}$ be exogenously given, where *P* is population. Then labor market equilibrium requires

$$\frac{N_{jct}}{N_{ct}} = \frac{P_{jct}}{P_{ct}} \qquad [5]$$

A supply shift which increases the relative share of the population with the same education and age reduces the hourly wage paid to the relevant group, because it increases the competition for a given number of jobs. Shifts in the demand curve can be driven by shifts in the efficiency parameters and by variations in the relative share of college graduates over total employment. Given supply, these shifts alter the equilibrium wage for the specific age cohort.

Replacing (5) in (4) and taking logs yields

$$\ln w_{jct} = \ln \phi_t + \ln \mu_{jt} + \ln \theta_{ct} + (\sigma - 1) \ln \frac{N_{ct}}{N_t} + (\rho - 1) \ln \frac{P_{jct}}{P_{ct}} \qquad [6]$$

where the ratio $\frac{P_{jct}}{P_{ct}}$ is the cohort size for college graduates. The above expression suggests that, conditional on average labor productivity ϕ, on efficiency parameters and the relative supply of college graduates, the relationship between the log wage of college graduates with age *j* and the log cohort size $\ln\frac{P_{jct}}{P_{ct}}$ is negative and larger in absolute value the smaller the elasticity of substitution between individuals with different age and the same education level. In the extreme case where individuals of different ages are perfect substitutes, ρ=1 and there is no relationship between the wage and cohort size. In this case, the wage of college graduates of age *j* depends solely on the relative supply of graduates, independently of their age.

To simplify the notation, let the subscript *e=c, s* indicate the education group the individual belongs to, and ignore for the moment the time subscript. Then the relevant literature (e.g. Welch, 1979, Card and Lemieux, 2001) defines the cohort size of individuals with age *j* and education *e* as $CS_{je} = \frac{P_{je}}{P_e}$. A feature of this definition is that an increase in P_{je} and thus in CS_{je} can result either from an increase in the size of the age group – a pure demographic effect - or from an increase in the relative share of the education group within the same age group – a relative education effect. Hence, the estimated effect of CS_{je} on earnings captures both the effect of demographics and the impact of educational shifts across age cohorts.

I also define the overall age cohort $CS_j = \frac{P_j}{P}$ as the weighted average of the education – specific age cohorts. An important feature of the overall age cohort is that it depends only on demographic factors, which makes it a good candidate instrument for CS_{je} in the empirical estimates of the relationship between earnings and cohort size discussed below.

While cohort size is defined for each single age, in practice it is overly restrictive to limit labor market competition to individuals of the very same age, and it is more reasonable to assume that people compete for jobs with individuals of *approximately* the same age, i.e. a bit younger or older. Therefore, I follow Welch, 1979, and Berger, 1984, and compute the size of the relevant age cohort as a moving average around the age of the individual concerned:

$$\overline{P}_{je} = \frac{1}{9}P_{(j-2)e} + \frac{2}{9}P_{(j-1)e} + \frac{3}{9}P_{je} + \frac{2}{9}P_{(j+1)e} + \frac{1}{9}P_{(j+2)e} \qquad [7]$$

In words, the cohort size is measured by a weighted average of the size of age – education cohort *je* in the selected group, P_{je}, and of the size of the two adjacent age cohorts with the same education, both younger and older, with weights declining with distance from the current cohort. The idea is that the relevant age-education cohort is composed of individuals within a 5–years age range, with the age of reference having the highest weight and the adjacent ages having weights that decline with the distance from the age of reference.

As remarked by Wright, 1991, the inverted V – weights imply that the degree of substitutability between workers of different ages decline the farther away, in terms of age, the surrounding cohorts are. Wright also argues that the V weights may appear as arbitrary, but are the logical first choice in the absence of a priori information on the degree of substitutability between adjacent age cohorts[3].

Next, I define

$$\overline{P}_{j} = \frac{1}{9}P_{(j-2)} + \frac{2}{9}P_{(j-1)} + \frac{3}{9}P_{j} + \frac{2}{9}P_{(j+1)} + \frac{1}{9}P_{(j+2)} \qquad [8]$$

as the weighted average of the size of age cohort *j*, after aggregating across education groups. The empirical definitions of cohort size used in the paper are then $CS_{je} = \frac{\overline{P}_{je}}{P_e}$ and $CS_j = \frac{\overline{P}_j}{P}$.

2. The Data

[3] In the empirical section, I also experiment with alternative specifications of the weights, with no relevant qualitative changes in the results.

My data are drawn from the December 2003 release of the *European Community Household Panel* (ECHP), a longitudinal survey modelled on the US Panel Study of Income Dynamics (PSID). This survey provides a wide range of information on individual income and socio-economic characteristics for all EU countries and aims to be representative both in cross-sections and longitudinally. Due to the common questionnaire, the information contained in the ECHP is, in principle, comparable across countries, which is its main strength. The ECHP data collection is made at the national level by National Data Collection Units (NDUs), while Eurostat provides centralized support and coordination.

The data include personal weights, which are intended to make the ECHP cross-sectionally representative (see the discussion in Peracchi, 2002). These weights need to be scaled for the calculation of population aggregates. The ECHP provides for this purpose an inflation factor, equal to the ratio of actual population to the sample size. I combine the personal weights with the inflation factor to compute, for each year, total population by age and education.

The ECHP data cover the period 1994-2001 for each country belonging to EU-15. Austria joined in 1995 and Finland in 1996. Unit non-responses and attrition rates in the ECHP are comparable with those of other longitudinal household surveys (see Peracchi, 2002). Nevertheless, due to small entry rates, attrition results in a reduction of the sample size that is increasing with time, and is highest in the transition from the first to the second wave (see Bassanini and Brunello, 2004). Because of this, I exclude the first wave. I also exclude from my sample Sweden, which has no wage data.

Since cohort size CS varies by educational attainment, I need information on age and completed education. The ECHP uses the ISCED classification and distinguishes between three levels of attainment: primary and lower secondary (ISCED 0-2), upper secondary (ISCED 3) and tertiary (ISCED 5-7). Because the quality of the information on education is rather poor for France and The Netherlands, I omit these two countries from my final sample[4]. Figure 1 shows the substantial heterogeneity within EU11 in educational attainment, with Northern countries having a very low share of poorly educated individuals, compared to the South of Europe. Given the common trend

[4] My sample includes Germany, Denmark, Belgium, the UK, Ireland, Italy, Greece, Spain, Portugal, Austria and Finland.

toward higher education in Europe, in the empirical analysis I shall focus my attention only on high school and college graduates.

I select male individuals – both employed and unemployed – aged between 20 and 50 and identify cohort with age, as explained in the previous section. As in Wright, I consider only males to avoid the selection problems associated to intermittent female labour force participation. Potential selection bias resulting from non random retirement decisions also guide me in eliminating from the sample individuals aged above 50[5]. Therefore, I end up with 31 age cohorts for each level of education[6]. I exclude individuals still at school and those who report having changed their educational attainment during the sample period. Furthermore, I restrict the age sample for those with tertiary education to individuals aged 25 to 50.

Figure 1. Population by educational attainment and country, 2001

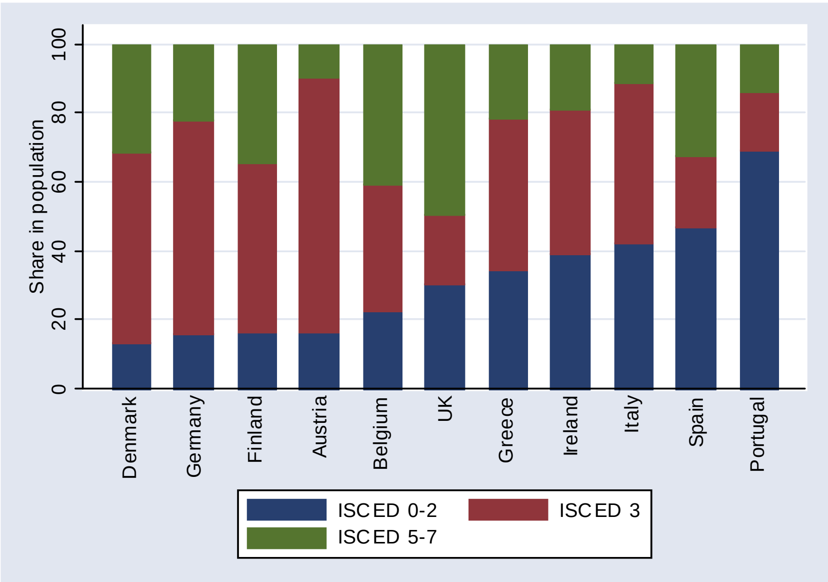

Figure 2 shows the average size of age cohorts for the 11 European countries (EU11) considered in this study and for the years 1996 and 2001. In spite of the relatively short span of time, the figure shows the demographic shift away from the younger and toward the older age cohorts[7].

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[5] I refer the reader to the discussion in Wright, 1999, for more details.
[6] In order to compute cohort size for the 31 age groups, I use data on individuals aged 18 to 52.
[7] The units in the vertical axis of Figures 2-4 are percentage points

Figure 3 illustrates the substantial heterogeneity in the relative size of age cohorts across European countries in 2001, an important feature of the data, given the limited time span available (see Korenman and Neumark, 2000, for a discussion of identification issues). I notice that the cohort size of individuals aged below 30 is significantly lower in Northern than in Southern Europe, with two noteworthy exceptions, Ireland and Italy.

Figure 2. Cohort Size (CS_j), average EU-11, 1996 and 2001. All education groups

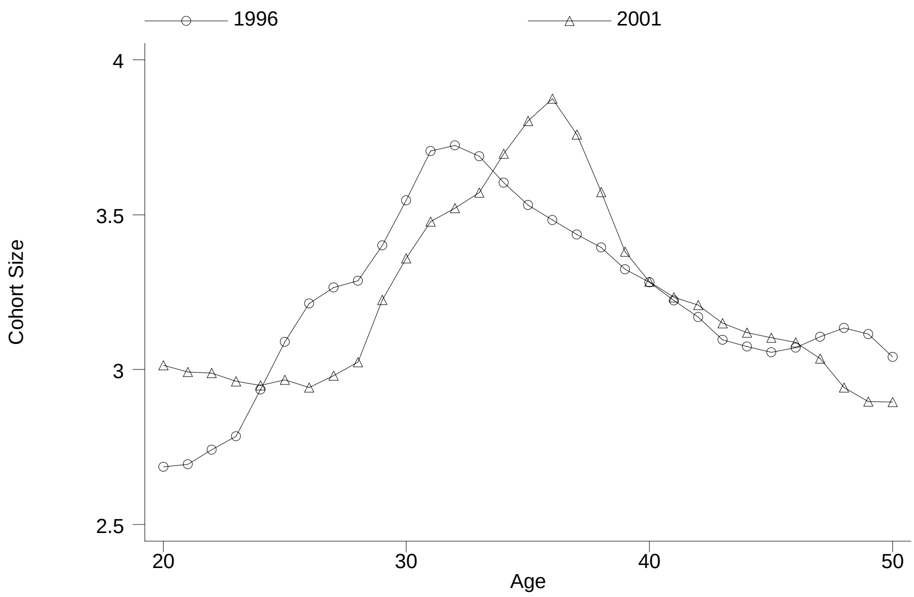

Figure 3: Cohort size (CS_j), by country, 2001. All education groups.

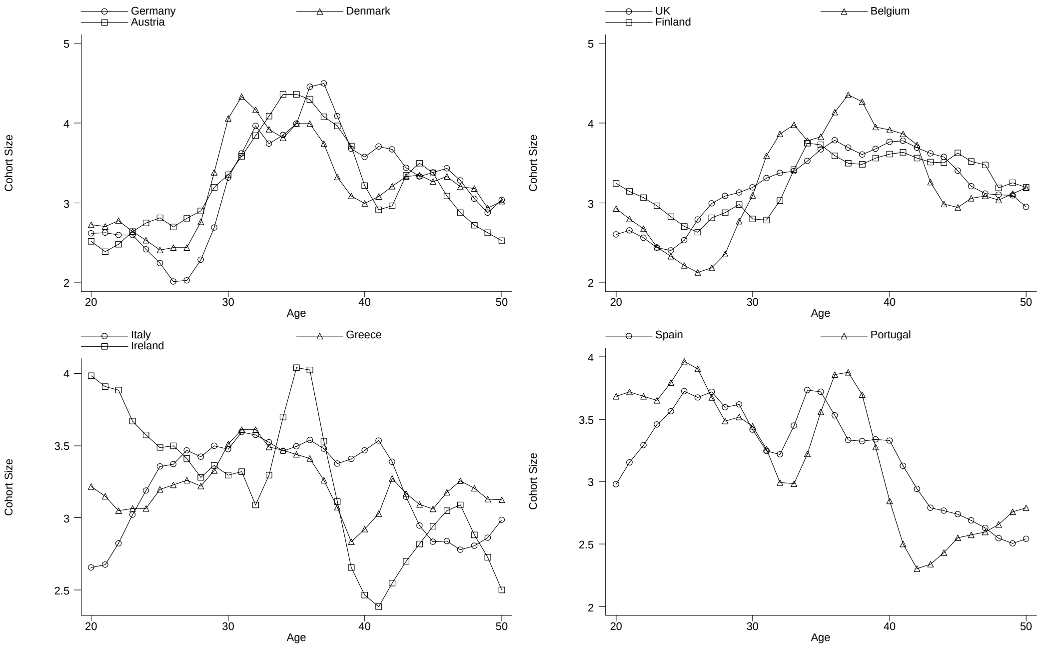

Figure 4 plots average EU11 cohort size CS_{je} by educational attainment and shows that the reduction in the size of the younger cohorts is sharper for the less educated, suggesting that the negative demographic shift illustrated in Figure 2 has been amplified by a shift of the young away from lower education.

Figure 4: Cohort size (CS_{je}), by country and education, 1996 and 2001.

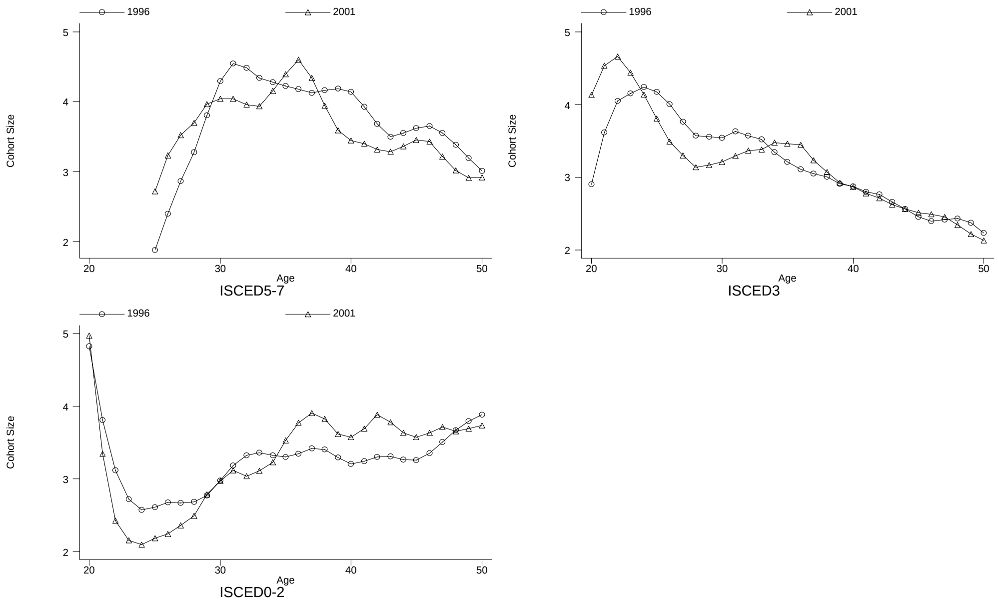

Table 2 shows the average change of cohort size between 1996 and 2001 for each education group and independently of education, after dividing the population in the sample into two age groups, those aged 20 to 34 (25 to 35 for college graduates) and those aged 35 to 50. Notice that the average decline in cohort size is highest (-9.62 percent) among the young and less educated, mainly because of the negative shift in relative education. To this decline corresponds the increase in the cohort size of college graduates aged 25 to 34, again driven by the increase in the educational attainment of the young. When we consider all education groups, average cohort size is almost constant between 1996 and 2001 among the individuals aged 20 to 34 and increases by 1 percent among those aged 35 to 50.

These numbers are not immediately comparable to those in Table 1, because of the different denominator, the exclusion of females, the shorter sample period, and the fact that we use weighted averages as in [7] and [8]. It might be instructive, however, to compare the variation of cohort size implied by ECHP and the European Labor Force Survey (ELFS), using as similar as possible a definition for both datasets. When I do so, it turns out that the estimated change of average cohort size between 1996 and 2001 is broadly similar: for the younger age group (20-34) this change is -5.08 in the ELFS data and -6.90 in the ECHP; for the older age group (35-50), it is +8.36 and +5.79 respectively.

Table 2. Average change in cohort size between 1996 and 2001, and decomposition of the change. By education and age range. EU11. Males only. Percentage changes. Source: ECHP

	ISCED 0-2 Age 20-34	ISCED 3 Age 20-34	ISCED 5-7 Age 25-34	ISCED 0-2 Age 35-50	ISCED 3 Age 35-50	ISCED 5-7 Age 35-50
$\partial \ln CS_{je}$	-9.62	1.05	5.18	8.52	-0.08	-7.94
$\partial \ln CS_{j}$	-0.04	-0.04	-5.76	1.14	1.14	1.14

3. Estimation strategy

Following Wright, 1999, I collapse individual data into means based on single – year age groups, the survey year and education, using as weights the personal cross-sectional weights provided by ECHP. I then compute cohort size for each age, as indicated in equations [7] and [8]. With 11 countries, 31 ages and 7 years, my sample consists of at most 2387 cells. This number is reduced in the empirical estimates, either because of missing values or because I only retain cells with at least three individuals.

After pooling the data from the 11 EU countries, the empirical counterpart of equation [6] is, for each educational group *e=1,2*

$$\begin{aligned}\ln w_{kjt} &= z + \alpha u_{kt} + \beta \ln CS_{kjt} + \gamma t + \delta t^2 + \sigma_1 AGE + \sigma_2 AGE^2 + \varphi AGE * t \\ &+ \varsigma D_k + \lambda D_k * t + \psi KM_{kt} + \varepsilon_{kjt}\end{aligned} \qquad [9]$$

where *z* is a constant, *w* is gross real hourly earnings, deflated with the national price index, *k* is for the country, t and t^2 are a linear and a quadratic trend, AGE is individual age, which I normalize to vary between 0 and 30, as in Wright, 1999[8], D is a vector of country dummies, and KM is the Katz and Murphy index of relative demand shocks[9]. The linear and quadratic trends, the interactions of the linear trend with age and with

[8] AGE takes the value 0 for age 20, 1 for age 21 and 30 for age 50.
[9] See Katz and Murphy, 1992. The index measures relative changes in employment growth across industries.

country dummies, and the Katz and Murphy index, which varies by country, time and education group, are included to proxy the shifts in average labor productivity, the efficiency parameters and the changes in the relative share of each education group, as in Card and Lemieux, 2001. The country and time specific unemployment rate is included to capture the fact that, when the economy deviates from perfect competition, a positive unemployment rate might emerge[10]. In the above specification, the parameter of interest is β.

Cohort size in [9] varies by country, age and time, because I pool the data across countries and estimate separate regressions by education level. Since the time dimension is too short to offer significant variation, I rely on the variation of cohort size by age and country to identify its effects on earnings. Therefore, in the specification of equation [9] I include as controls both country by time and age by time effects, but exclude age by country effects. If I include the latter, the relevant variation of cohort size in the data would be swept away.

Grouped data require that I use weighted regressions to account for heteroskedasticity. Following Wright, 1999, my weights are given by the number of individuals in each cell. Perhaps more importantly, a problem with equation [9] is that cohort size CS_{kjt} might be endogenous with respect to earnings. This will be the case if the members of a particular cohort obtain more education than they would otherwise do in order to avoid negative crowding out effects on their earnings if their age cohort is very large.

The solution proposed by Wright, 1999, is to replace education specific cohort size with the overall cohort size. The advantage of using the overall cohort size is that it is demographically determined, and therefore exogenous. Rather than following Wright, I use overall cohort size as instrument for education – specific cohort size. The correlation of these two variables is above 0.5 for both education groups, and the former qualifies as a valid instrument because of its exogeneity[11].

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[10] See the discussion in Nickell and Bell, 1995. The measure of relative demand shifts developed by Katz and Murphy, 1992, has been extensively used in the literature on skill biased technical change (see Card and DiNardo, 2002).

4. Results

Table 3 reports the estimated effect of cohort size on earnings for two education groups, high school and college graduates. I first report ordinary least squares, and then compare these results with IV estimates, where I instrument education specific cohort size with overall cohort size. I find that the impact of cohort size on earnings is negative and statistically significant. In absolute value, the OLS estimates are smaller than the IV estimates in the case of college graduates. The table suggests that a 10 percent increase in cohort size should reduce the gross hourly earnings of high school graduates by 0.7 percent. The expected reduction for college graduates is much larger, at 1.7 percent[12].

The substantially higher elasticity of earnings to cohort size in the case of college graduates is in line with Stapleton and Young, 1988, who argue that young workers are poorer substitutes for old workers in careers requiring college education than in careers requiring only high school[13]. This implies that a baby bust which reduces the size of the younger cohort is expected to increase relatively more the wage of the young and better educated, because they are less easily substitutable with older workers than high school graduates are.

Table 3. Estimated effect of cohort size on log earnings. Weighted regressions. All countries (EU-11). By education. OLS and IV.

[11] The F-test for the inclusion of the log of overall cohort size in the first stage regression of log cohort size on all exogenous variables is always well above 10. Results are available from the author upon request.

[12] These results are qualitatively robust to changes in the definition of cohort size which extends the number of adjacent ages to three and adapts the inverse V weights consequently (see Table A2 in the Appendix). They are also robust to changes in the definition of the sample, which excludes both part-timers and public sector employees (see Table A1 in the Appendix)

[13] Notice however that the difference between the estimated coefficients (0.175 and 0.070) is not statistically significant, as the 5 percent confidence intervals partially overlap.

	OLS	IV	OLS	IV
	ISCED 3	ISCED 3	ISCED 5/7	ISCED 5/7
age	0.042	0.042	0.070	0.073
	[24.04]**	[24.04]**	[19.79]**	[16.76]**
age squared	-0.001	-0.001	-0.001	-0.001
	[13.71]**	[13.61]**	[13.71]**	[11.52]**
age * trend	0.000	0.000	0.000	0.000
	[1.45]	[1.45]	[0.34]	[0.00]
trend	-0.011	-0.011	0.006	0.009
	[1.36]	[1.36]	[0.61]	[0.83]
trend squared	0.001	0.001	0.001	0.001
	[0.72]	[0.72]	[0.61]	[0.69]
katz - murphy index	-0.051	-0.051	0.164	0.159
	[0.48]	[0.48]	[1.50]	[1.44]
unemployment rate	-0.066	-0.067	0.177	0.188
	[0.86]	[0.87]	[2.17]*	[2.30]*
log cohort size	-0.071	-0.070	-0.116	-0.175
	[4.52]**	[3.67]**	[6.08]**	[3.38]**
Observations	2186	2186	1804	1804
R-squared	0.99	0.99	0.99	0.99

Note: robust T-statistics in brackets, with p<0.05 = *, p<0.01 = **. All regressions include a constant, country dummies, and the interactions between country dummies and trend.

The elasticity of substitution across ages and within the same educational attainment need not be constant, but could vary across age groups. For instance, a young college graduate aged 30 could be more easily substituted with another college graduate aged 34 than an older college graduate aged 40 with respect to somebody who is 44. Since older workers have been exposed longer to the labor market and are more likely to have accumulated more firm or sector specific skills, their substitutability is likely to be lower. We investigate whether this is the case by adding to the regression [9] the interaction of log cohort size with the dummy OLD, equal to 1 if the individual belongs to the older age group (35 to 50) and to 0 otherwise.

The addition of an interaction requires that we use an additional instrument, which we identify with the interaction of the overall log cohort size with the dummy OLD. The results for the two education groups are presented in the first and third column of Table 4. For both groups, we find evidence that the impact of cohort size on wages is higher, in absolute value, among older workers, which confirms their lower substitutability with other workers within the same age group.

Table 4. Estimated effect of different measures of cohort size on log earnings. All countries (EU-11). By age group. IV estimates.

	ISCED 3	ISCED 3	ISCED 5-7	ISCED 5-7
	I	II	III	IV
age	0.044	0.036	0.083	0.062
	[22.36]**	[18.10]**	[15.21]**	[12.41]**
age squared	-0.001	-0.001	-0.002	-0.001
	[13.68]**	[9.43]**	[11.44]**	[8.46]**
agetrend	0.000	0.000	0.000	0.000
	[1.47]	[2.12]*	[0.07]	[0.22]
trend	-0.010	-0.007	0.009	0.007
	[1.29]	[0.96]	[0.87]	[0.72]
trend squared	0.001	0.001	0.001	0.000
	[0.73]	[0.68]	[0.77]	[0.36]
katz murphy index	-0.050	-0.039	0.162	0.150
	[0.47]	[0.32]	[1.44]	[1.37]
unemployment rate	-0.066	-0.065	0.194	0.187
	[0.88]	[0.87]	[2.38]*	[2.25]*
log cohort size	-0.069	0.065	-0.173	0.054
	[3.65]**	[2.46]*	[3.37]**	[0.77]
log cohort size * OLD	-0.039		-0.036	
	[4.04]**		[3.38]**	
log cohort size * SOUTH		-0.332		-0.466
		[6.81]**		[5.87]**
Observations	2186	2186	1804	1804
R-squared	0.99	0.99	0.99	0.99

Note: see Table 3

I also expect that the degree of substitutability among workers of different age and the same education might vary across the countries of Europe, because these countries have important differences in their labor market institutions, which are known to affect labor market outcomes (see Layard and Nickell, 1999). A natural hypothesis is that the relationship between earnings and cohort size differs significantly between Northern and Southern Europe.

In order to verify this hypothesis, I first define the dummy SOUTH, which identifies the countries of Southern Europe, and interact this dummy with my measure of cohort size. The resulting estimates are presented in columns II and IV of Table 4. It is quite clear from these estimates that the sensitivity of earnings to log cohort size is significantly stronger in Southern than in Northern Europe. In the latter group of countries, the estimated coefficient of log cohort size is either not statistically significant – which would not reject the hypothesis of perfect substitution across ages – or statistically significant but with a positive sign, which is clearly inconsistent with our theoretical setup.

How do I explain the uncovered difference? I posit that the degree of substitutability between workers with the same education is lower in regimes with stronger employment protection, for two reasons. First, the presence of significant employment protection is often considered as a key source of the insider-outsider mechanism (see Lindbeck and Snower, 1988). When turnover costs are high, insiders can bargain for a relatively high wage without incurring the risk of being substituted by cheaper outsiders. Second, employment protection does not have clear-cut effects on average employment over the cycle, but reduces the relative size of inflows and outflows into and from employment, which include the substitution of workers of different age.

In terms of the theoretical model presented in Section 1, I submit that the two sub-aggregates [2] and [3] can be re-written as

$$N_{ct} = \left[\sum_{j=1}^{k} (\mu_{jt} N_{jct}{}^{\rho(EP)}) \right]^{\frac{1}{\rho(EP)}} \qquad [10]$$

$$N_{st} = \left[\sum_{j=1}^{k} (\nu_{jt} N_{jct}{}^{\eta(EP)}) \right]^{\frac{1}{\eta(EP)}} \qquad [11]$$

where *EP* is the index of employment protection (increasing when protection is higher). Moreover, I model $\rho(EP) = \rho_o + \rho_1 EP$ and $\eta(EP) = \eta_o + \eta_1 EP$: an increase in the degree of employment protection raises both η and ρ and reduces the elasticity of substitution across different ages for each educational level[14]. In terms of the empirical model [9], I add to the baseline specification the interactions of the index of employment protection with cohort size.

The employment protection index *EP* for the year 1995 is drawn from the comparative databank developed by Nickell and Nunziata, 2000. Unfortunately, their compiled index does not include Greece, but for the rest of the sample it is quite clear that Southern European countries – Italy, Spain and Portugal – have all a higher index of employment protection than the rest of the countries in Northern Europe. On average, the index is equal to 1.793 in the South and to 0.962 in the North of Europe. It is highest in Italy and Portugal and lowest in the UK. In the regressions, I divide the country – specific employment protection index by its mean, to facilitate the interpretation of results[15].

Both ordinary least squares and IV estimates of the augmented model are presented in Table 5. The evidence is broadly in favor of our hypothesis. First, the interaction between cohort size and employment protection always attracts a negative coefficient, as predicted by our hypothesis. Second, the interaction is always statistically significant. I conclude that the data offer support to the hypothesis that differences in employment protection affect the degree of substitutability of individuals with different age and similar educational attainment. Lower substitutability implies that in the countries belonging to the Olive Belt of Europe gross hourly earnings are more sensitive to changes in the demographics. Suppose that these countries are faced by the same demographic shock, which implies a reduction in the size of the younger age cohorts and an increase in the size of the older age cohorts. The effect of this shock is to flatten age – earnings profiles and reduce the impact of age seniority on pay. Our findings suggest that this effect is significantly larger in Southern Europe.

Conclusions

Will the ageing of the European labor force affect the distribution of earnings and favor the young at the expense of the old? Recent empirical literature argues that the answer of this question depends on the degree of substitutability of individuals of different age within each education group. The higher this substitutability, the lower the impact of changes in the distribution of the population by age on earnings: if older college graduates are perfect substitutes to young college graduates, a bust in the supply of the latter can be fully compensated by a boom in the supply of the former.

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[14] The assumption that the parameters in the CES sub-aggregates depends on regulation is not new. Blanchard and Giavazzi, 2003, use a similar idea to model the effects of product market deregulation on wages and employment.

[15] When evaluated at the sample average, EP is equal to 1.

Given demand, perfect substitutability eliminates the link between age – specific supply shifts and age – specific earnings.

Table 5. Estimated effect of different measures of cohort size on log earnings. All countries. By age group and education. With interaction with EP.

	ISCED 3	ISCED 3	ISCED 5-7	ISCED 5-7
	OLS	IV	OLS	IV
age	0.041	0.041	0.066	0.070
	[22.82]**	[21.87]**	[17.72]**	[15.24]**
age squared	-0.001	-0.001	-0.001	-0.001
	[13.49]**	[12.61]**	[12.14]**	[10.60]**
age * trend	0.000	0.000	0.000	0.000
	[1.83]	[1.98]*	[0.12]	[0.66]
trend	-0.012	-0.011	0.006	0.010
	[1.52]	[1.35]	[0.56]	[0.93]
trend squared	0.001	0.001	0.001	0.002
	[1.09]	[1.06]	[1.07]	[1.16]
katz murphy index	-0.083	-0.079	0.157	0.153
	[0.69]	[0.58]	[1.22]	[1.17]
unemployment rate	-0.050	-0.047	0.134	0.150
	[0.65]	[0.59]	[1.60]	[1.78]
log cohort size	0.075	0.328	0.181	0.142
	[1.50]	[2.81]**	[2.54]*	[1.16]
log cohort size * employment	-0.118	-0.339	-0.260	-0.301
protection index	[2.91]**	[3.59]**	[4.09]**	[3.06]**
Observations	1969	1969	1632	1632
R-squared	0.99	0.99	0.99	0.99

Note: see Table 3. Greece excluded from this regression.

I have argued that substitutability may depend on age, as older workers have accumulated a higher stock of specific human capital, and on labor market institutions, which affect the working of the labor market. I have focused in particular on employment protection measures, which are the source of insider power and act as a key obstacle to the substitution of incumbents with new entrants.

My empirical evidence exploits the cross–country variation in cohort size across 11 European countries and can be summarized as follows:

a) changes in cohort size negatively affect earnings, and this effect is larger among better educated individuals. This confirms the view that substituting an old college graduate with a young college graduate is likely to be more difficult than substituting high school graduates of different ages;

b) a 10 percent increase in cohort size is expected to reduce the gross hourly earnings of high school graduates by 0.7 percent. The expected reduction for college graduates is much larger, at 1.7 percent;

c) substitutability is more difficult within the group of older workers, aged 35 to 50, possibly because these workers have accumulated more firm and industry specific human capital;

d) substitutability is smaller in Southern Europe, where employment protection is stronger. Lower substitutability implies that a common demographic shock which shifts the population from the young to the old flattens age –earnings profiles to a larger extent in the Olive Belt of Europe.

On the one hand, high employment protection in Southern Europe benefits older workers there by sheltering them from the risk of job losses. On the other hand, by reducing the degree of substitutability between the old and the young, it makes the earnings of the old more sensitive to the relative increase in the elderly population, to the relative advantage of the young.

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Appendix

Table A1. Estimated effect of cohort size on log earnings. Weighted regressions. All countries (EU-11). By education. OLS and IV. Only full time workers in the private sector.

	OLS	IV	OLS	IV
	ISCED 3	ISCED 3	ISCED 5/7	ISCED 5/7
age	0.041	0.041	0.080	0.083
	[20.78]**	[20.71]**	[18.52]**	[14.54]**
age squared	-0.001	-0.001	-0.002	-0.002
	[13.38]**	[13.27]**	[13.94]**	[10.83]**
age * trend	0.000	0.000	0.000	0.000
	[0.95]	[0.93]	[0.76]	[0.94]
trend	-0.012	-0.012	0.009	0.011
	[1.46]	[1.45]	[0.71]	[0.85]
trend squared	0.001	0.001	0.002	0.002
	[0.76]	[0.75]	[1.12]	[1.18]
katz - murphy index	-0.122	-0.123	0.046	0.037
	[0.86]	[0.87]	[0.28]	[0.22]
unemployment rate	-0.053	-0.053	0.195	0.203
	[0.66]	[0.65]	[1.90]	[1.97]*
log cohort size	-0.054	-0.064	-0.183	-0.230
	[3.16]**	[2.98]**	[7.31]**	[3.25]**
Observations	1888	1888	1319	1319
R-squared	0.99	0.99	0.99	0.99

Table A2. Estimated effect of cohort size on log earnings. Weighted regressions. All countries (EU-11). By education. OLS and IV. Definition of cohort size with three adjacent ages rather than two.

	OLS	IV	OLS	IV
	ISCED 3	ISCED 3	ISCED 5/7	ISCED 5/7
age	0.042	0.042	0.072	0.076
	[24.19]**	[24.14]**	[20.28]**	[17.25]**
age squared	-0.001	-0.001	-0.001	-0.002
	[13.99]**	[13.96]**	[14.20]**	[12.14]**
age * trend	0.000	0.000	0.000	0.000
	[1.52]	[1.51]	[0.16]	[0.32]
trend	-0.010	-0.010	0.008	0.011
	[1.24]	[1.23]	[0.73]	[1.03]
trend squared	0.001	0.001	0.001	0.001
	[0.70]	[0.70]	[0.65]	[0.75]
katz - murphy index	-0.054	-0.054	0.163	0.157
	[0.51]	[0.52]	[1.49]	[1.41]
unemployment rate	-0.067	-0.067	0.179	0.194
	[0.87]	[0.87]	[2.22]*	[2.38]*
log cohort size	-0.089	-0.099	-0.146	-0.230
	[5.30]**	[4.86]**	[7.11]**	[4.15]**
Observations	2176	2176	1804	1804
R-squared	0.99	0.99	0.99	0.99