MAGKS

Aachen Siegen Gießen Marburg Kassel Göttingen

Joint Discussion Paper Series in Economics

by the Universities of

Aachen · Gießen · Göttingen
Kassel · Marburg · Siegen

ISSN 1867-3678

No. 46-2013

John Moffat and Duncan Roth

The Cohort Size-Wage Relationship in Europe

Coordination: Bernd Hayo • Philipps-University Marburg
Faculty of Business Administration and Economics • Universitätsstraße 24, D-35032 Marburg
Tel: +49-6421-2823091, Fax: +49-6421-2823088, e-mail: hayo@wiwi.uni-marburg.de

The cohort size-wage relationship in Europe°

John Moffat (Durham University)*
Duncan Roth (Philipps-Universität Marburg)+

Abstract

The demographic and education composition of European countries is changing: the population share of young individuals is declining while that of the highly educated is rising. This paper estimates the impact of cohort size on wages using data on 21 European countries covering 2007-2010 to cast light on the economic consequences of changes in the profile of the labour force. The effect of cohort size on wages is identified through an instrumental variables strategy which, in contrast to previous analyses of European data, addresses self-selection into geographical areas as well as into educational groups. The results support the hypothesis that cohort size has a negative effect on male wages, particularly for the highly educated. However, these negative cohort size effects are not persistent.

JEL classification J10, J21, J31

Keywords Cohort size; wages; causal effect; instrumental variables; EU-SILC

*John Moffat, Durham University, Department of Economics and Finance

+Duncan Roth, Philipps-Universität Marburg, Department of Economics
Tel: 0049-(0)6421-2823751, Email: rothd@staff.uni-marburg.de

° The authors would like to thank Bernd Hayo, Michael Kirk, Christian Traxler, Eckhardt Bode, the participants of the MACIE brownbag seminar and the MAGKS seminar as well as the participants of the 8th European Workshop on Labour Markets and Demographic Change for valuable comments.

1 Introduction

The demographic and educational composition of the European Union (EU) is changing. According to EU population projections, the population share of those aged over 65 will rise from 17.5% in 2011 to 29.5% in 2060 (European Commission, 2013). Within the population of working age, the largest fall in population share will be amongst those aged 40-45 (from 7.5% to 5.9%). However, older groups will see a far smaller fall than younger groups: the population share of those aged between 45 and 65 will decline by 3.3 percentage points while that of individuals aged between 20 and 40 will fall by 5.2 percentage points. At the same time, if current trends continue, the population of the EU will become better educated as, across the EU-27, the proportion of the population aged 25-64 with tertiary education increased from 19.5% to 27.7% between 2000 and 2012 (Eurostat, 2013). In this paper, we provide evidence on the impact of changes in the profile of the labour force on wages.

The analysis of the effects of cohort size – i.e. the relative size of a group of individuals sharing similar characteristics (such as gender, age and/or education) – on labour market outcomes was initially driven by a desire to understand the economic consequences of the entry of large cohorts of young workers into the US labour market (known as the baby boom cohorts) in the late 1960s. The literature has since been dominated by US research – a survey of which is provided by Korenman and Neumark (2000). The strand of the literature on the empirical relationship between cohort size and wages has broadly confronted three different questions:

1. Does cohort size have a negative impact on wages?
2. Are there differences in the size of the impact across educational groups?
3. Is the impact on wages permanent or temporary?

The central theoretical assumption that underlies the empirical analysis of cohort size effects is that identically educated individuals are only imperfectly substitutable across age, so that, depending on the degree of substitutability, increases in the size of a specific age(-education) group will have adverse effects mainly on the wages of workers in that group. This prediction arises from a perfectly competitive framework in which there is no unemployment and may not necessarily hold in a system of unionised wage bargaining in which larger cohorts have greater bargaining power and are therefore able to negotiate higher wages than smaller cohorts (Fertig et al., 2003). Nevertheless, US empirical research (e.g. Freeman, 1979; Welch, 1979; Leveson et al., 1980; Alsalam, 1985; Berger, 1985) has generally provided evidence in favour of the hypothesis that increases in cohort size reduces wages. Many studies (e.g. Welch, 1979; Leveson, 1980; Alsalam, 1985) also suggest that this cohort crowding effect is more pronounced for the highly educated. The "diminishing substitutability hypothesis" proposed by Stapleton and Young (1988) that substitutability between differently aged workers decreases with the level of education explains this finding.

Evidence on the third question is more mixed. Some studies suggest that depressed earnings are only a temporary phenomenon (e.g. Welch, 1979) as workers in larger cohorts experience faster earnings growth, while others (e.g. Berger, 1985) suggest that cohort size has a permanently depressing effect on wages. By contrast, Berger (1989) finds that large cohorts have initially higher earnings but that, over time, their earnings fall below those of smaller cohorts. He argues that this is due to the "diminishing substitutability hypothesis" which gives individuals in large cohorts less of an incentive to accumulate human capital than those in small cohorts. Larger cohorts therefore have higher wages than smaller cohorts when they are young but lower wages when they get older.

There is relatively little evidence on cohort size effects on wages in Europe. Wright (1991) uses UK data covering the period 1973-1982 to estimate the effect of cohort size on the average wage within groups of similarly aged and identically educated employed males. He finds that cohort size is negatively associated with average wages for males with intermediate and higher qualifications. However, these effects are only temporary, lasting for the first five years after assumed labour market entry for the intermediate qualifications group and for 11 years for the high qualifications group.[1] In line with US studies, his findings suggest that cohort size effects are more negative for the more educated group. Mosca (2009), using Italian data for male workers from the European Community Household Panel (ECHP), obtains results that also indicate that cohort size is associated with depressed earnings although her empirical model does not address the consequences of self-selection into cohorts. Rather different results are obtained in two papers that use Swedish data. Klevmarken (1993), using three waves (1984, 1986, 1988) of the Swedish Household Market and Nonmarket Activities (HUS) panel data set, regresses average hourly male earnings by age group on a measure of age-specific relative cohort size and on its interactions with educational indicator variables and age and finds that none of the cohort size-related variables are significant.[2] Dahlberg and Nahlum (2003) use representative longitudinal data from various registers and find that cohort size has a positive and significant effect on male wages which exists, albeit to different extents, across gender and education groupings.[3] Most recently, Brunello (2010) provides an analysis of the cohort size-earnings relationship using ECHP comprising data for the period 1995-2001 from 11 countries. Collapsing individual observations of employed and unemployed males into age-education-specific averages, he regresses average hourly earnings on the relative cohort size of age-education groups and other control variables. Instrumental variables (IV) estimation using age-specific cohort size as an instrument shows that cohort size depresses wages and does so to a larger extent for more educated individuals.

Interpreting the results of previous empirical studies is complicated by the potential endogeneity of the cohort size variable which arises from individual self-selection into specific cohorts. While most of the recent literature has acknowledged that the cohort size variable is endogenous due to self-selection of individuals into specific cohorts, it has focused mainly on self-selection into educational groups through gaining qualifications as a source of endogeneity. By contrast, self-selection into geographical areas through migration to economically attractive areas remains unaddressed in cross-country European studies. Such an omission may be important due to the existence of free movement of individuals within the EU. One of the main contributions of this paper is therefore the use of an IV strategy which has not previously been applied to cross-country European data. We identify the causal effect of cohort size by employing birth rates from the year in which individuals were born as an instrument arguing, as Korenman and Neumark (2000) have done, that this variable is able to address both sources of endogeneity.

[1] From the data provided in Wright (1991) it is unclear whether the estimated negative effects are statistically significant over these periods.
[2] Due to the inclusion of interactions between cohort size and other variables in Klevmarken's (1993) model, the marginal effect of cohort size on wages is a function of a number of coefficients and explanatory variables. As marginal effects are not presented, it is not clear whether their estimated cohort size effects are statistically significant.
[3] Dahlberg and Nahum (2003) use birth rates as a proxy for cohort size which means that their estimates are not direct estimates of the impact of cohort size on wages.

Using this approach, the paper addresses all three of the questions outlined above with the use of the European Union Statistics on Income and Living Conditions (EU-SILC) dataset. It differs from much of the existing literature by conducting the analysis at the level of the individual rather than using grouped data at the level of the age-education group. This allows us to control better for confounding influences on wages. We also allow for the impact of cohort size on wages to vary nonlinearly over age by including an interaction between cohort size and age squared in addition to an interaction between cohort size and age in our models. As far as we are aware, only Berger (1989) has included an interaction between cohort size and age squared in his model which is surprising as he found this term to be significant.

The next section provides a description of the data set, the empirical specification and the identification strategy. The results are presented and discussed in the third section. The final section concludes.

2 Estimation

2.1 Data

The data are taken from the 2010 release (version 1 of August 2010) of the EU-SILC survey which consists of cross-sectional and time-series data at the individual and household level from 24 European countries over the period 2007-2010.[45]

The measure of educational attainment in EU-SILC is the International Standard Classification of Education (ISCED) which assigns every individual a value from 0 (pre-primary education) to 5 (first stage of tertiary education)[6] based on the ISCED-97 classification.[7] In addition to ISCED 5, individuals with educational attainment ISCED 3 (secondary education) and ISCED 2 (lower secondary education) are used in the analysis. Compared to the remaining groups - ISCED 0, ISCED 1 (primary education) and ISCED 4 (post-secondary non-tertiary education) - the aforementioned categories include the vast majority of observations in the data set. While it would have been possible to merge individuals from the smaller categories into the closest of the larger groups, this may distort the results as such individuals are likely to be less substitutable with individuals in the larger group.

Individuals over the age of 45 are excluded from the analysis, to avoid any effects from non-random retirement decisions, as discussed in Brunello (2010), and because the annual birth rate data which is necessary for the construction of our instrument is not available before 1960.[8] Following the earlier literature, females are also excluded from the analysis to avoid

[4] The set of countries comprises Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Greece, Iceland, Italy, Hungary, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Spain, Sweden, and United Kingdom (UK).

[5] Observations from the UK are excluded from the empirical analysis because the measure of educational attainment is missing for a higher proportion of observations and observations from the Netherlands and Slovenia are excluded because information on the degree of urbanisation is not included.

[6] Due to top-coding of the educational variable, the data does not differentiate between individuals in category ISCED 5 and ISCED 6 (second stage of tertiary education).

[7] The more recent 2011 classification which differentiates between a larger set of educational categories is not used in the 2010 release of the EU-SILC data set.

[8] Also excluded are those individuals that are not recorded as either employed or unemployed during the period 2007-2010 and those individuals that are not available to the labour market because they are still in education, have already retired or are associated with specific institutional occupations (e.g. the military).

confounding decisions about labour market participation with effects from cohort size on wages.

In order to estimate cohort size effects from the time when individuals can be expected to first enter the labour market, individuals with an ISCED 2 or ISCED 3 background are included in the sample from the age of 20 but individuals with an ISCED 5 background are included from the age of 25 as entry into the labour market will be delayed for this group. To ease interpretation of the cohort size coefficients, age is rescaled by subtracting 20 from the actual age for ISCED 2 and ISCED 3 individuals and 25 for ISCED 5 individuals.

If individuals of different ages are not substitutable, the cohort size variable could be defined simply as the ratio of the number of individuals of age *j* with education *e* in country *k* at time *t* to the number of individuals with education *e* in country *k* at time *t*. But since it is likely that individuals compete for jobs with individuals in the same educational group of a similar, but not necessarily the same age, following Brunello (2010) and Wright (1991), the numerator of the cohort size variable is calculated as a weighted average of the number of individuals in a country with the same education that are two years younger, one year younger, the same age, one year older and two years older as follows[9]:

$$CS_{jekt} = \frac{\left(\frac{1}{9}\right)N_{(j-2)ekt}+\left(\frac{2}{9}\right)N_{(j-1)ekt}+\left(\frac{3}{9}\right)N_{jekt}+\left(\frac{2}{9}\right)N_{(j+1)ekt}+\left(\frac{1}{9}\right)N_{(j+2)ekt}}{N_{ekt}} \qquad [1]$$

A discussion of the weighted cohort size variable including the use of inverted V-shaped weights can be found in Wright (1991).[10] The cohort size variables are separately estimated for educational attainment groups ISCED 2, 3 and 5. In order to construct an accurate estimate of the cohort size measure, it is necessary to weight the data using probability weights so that the cohort size variable is not a function of the sampling frame of the survey. Appropriate weights are provided in the EU-SILC data set.

In order to identify the causal effect of cohort size on hourly wages, the cohort size variable will be instrumented by the birth rate from the year of birth of a given age cohort. For each cohort, age and time determine the year of birth, thereby allowing the cohort size variable for any cohort to be matched with a corresponding lagged birth rate value. Analogous to the construction of the cohort size variable, the instrument is constructed as follows:

$$BR_{(t-j)k} = \frac{\left(\frac{1}{9}\right)B_{(t-j-2)k}+\left(\frac{2}{9}\right)B_{(t-j-1)k}+\left(\frac{3}{9}\right)B_{(t-j)k}+\left(\frac{2}{9}\right)B_{(t-j+1)k}+\left(\frac{1}{9}\right)B_{(t-j+2)k}}{N_{(t-j)k}} \qquad [2]$$

$B_{(t-j)k}$ represents the number of births in year t - j in country k and $N_{(t-j)k}$ is the population in year t - j in country k. The annual birth rate data series is obtained from the World Bank's publicly accessible online data base.[11]

[9] Since labour markets may not be defined at the national level it would have been interesting to supplement our country-level analysis with regional analysis using the more consistently sized first level of the Nomenclature of Territorial Units for Statistics (NUTS 1). Due to the unavailability of a sufficiently long series of birth rate data at the NUTS 1 level, this approach was not feasible.

[10] We also tried specifications which included the cohort size of adjacent age groups as regressors, thereby allowing individuals in adjacent ISCED groups to have an impact on wages. Due to the high degree of collinearity between the different cohort size variables, their effects could not be identified separately.

[11] Up to 1986, birth rates for the Czech Republic are only available at 5 year intervals. The values for the missing years were constructed by linear interpolation.

Table 1: Variable Definitions

Variable	Definition	Source
Wage	Hourly wage in Euros, adjusted by a purchasing power parity (PPP) factor, calculated by dividing annual gross wage by average number of hours worked per week times 52	EU-SILC
Cohort size	See Eq. 1 and related discussion	EU-SILC
Married	Dummy variable coded one if the individual is married	EU-SILC
Part-time	Dummy variable coded one if the individual works part-time	EU-SILC
Self-employed	Dummy variable coded one if the individual is self-employed	EU-SILC
Occupation	Dummy variables for each of the following occupational groupings: 1. Legislators 2. Senior officials and managers 3. Professionals 4. Technicians and associate professionals 5. Clerks, Service workers and shop and market sales workers 6. Skilled agricultural and fishery workers 7. Craft and related trades workers 8. Plant and machine operators and assemblers 9. Elementary occupations	EU-SILC
Urban	Dummy variables for residence in an intermediate area and a thinly populated area	EU-SILC
Country	Dummy variables for residence in particular countries (see footnotes 4 and 5 for a list of countries included in the analysis)	EU-SILC
Age	Age of individual minus 20 for ISCED 2 and 3, 25 for ISCED 5	EU-SILC
Year	Dummy variables for 2008, 2009 or 2010	EC-SILC
Unemployment	National unemployment rate of people aged over 25	Eurostat
Birth rate	See Eq. 2 and related discussion	World Bank

2.2 Empirical model

In contrast to much of the existing literature the effect of cohort size is to be estimated using individual data rather than grouped data[12] as this allows us to control better for individual-level characteristics that determine wages. Consequently, the dependent variable is defined as the hourly wage rate of individual *i* with educational attainment *e* in age group *j* and country *k* at time *t*.

The central explanatory variables are the natural logarithm of the previously defined cohort size variable, the interaction of this variable with an individual's age and the interaction of this variable and squared age. Inclusion of the interaction terms allows for the effect of cohort size on wages to change as the individual ages. In the absence of a clear theoretical prediction on how cohort size effects develop with individual age, this specification is desirable. The model therefore addresses the question of whether cohort size effects are persistent.[13] To our knowledge, no other study has addressed the question of persistence for a set of European countries.

The set of control variables includes individual-level regressors (indicators for individuals being self-employed, working part-time, being married and occupational indicator variables), age-specific regressors (age and squared age), country-specific regressors (country dummies), time-specific regressors (year dummies), age-by-time regressors (interactions between the year dummies and age as well as between the year dummies and squared age) and country-by-time regressors (the national unemployment rate, interactions between the year dummies and

[12] Examples for the latter type of analysis can be found in Brunello (2010), Wright (1991), Berger (1983), Welch (1979) and Freeman (1979) among others.

[13] It should also be noted that this specification nests the one in which cohort size effects are constant over age, the latter arising if the interaction terms are found to be statistically insignificant.

the country dummies). Further details on these variables are given in Table 1. The equation to be estimated therefore takes the following form:[14]

$$\ln[w_{ijkt}] = \alpha_1 \ln[CS_{jkt}] + \alpha_2 \ln[CS_{jkt}] XAge_{jkt} + \alpha_3 \ln[CS_{jkt}] XAge_{jkt}^2 + \boldsymbol{\beta X_{ijkt}} + u_{ijkt} \quad [3]$$

[15]

The coefficients of interest are α_1, α_2 and α_3. Statistical (in-)significance of the associated variables and the signs of their coefficients will provide a basis on which to address the questions of whether, firstly, cohort size indeed exerts a depressing effect on an individual's wage rate and, secondly, whether this effect is persistent. The elasticity of wages with respect to cohort size is calculated as follows:

$$\frac{\partial \ln[w_{ijkt}]}{\partial \ln[CS_{jkt}]} = \hat{\alpha}_1 + \hat{\alpha}_2 Age_{jkt} + \hat{\alpha}_3 Age_{jkt}^2 \quad [4]$$

The marginal effect of cohort size on wages is a function of the estimated coefficients $\hat{\alpha}_1$, $\hat{\alpha}_2$ and $\hat{\alpha}_3$ as well as the individual's age. Based on the previously described rescaling of the age variable, $\hat{\alpha}_1$ captures the effect of cohort size on wages upon the individual's (assumed) entry to the labour market.

The relationship between individual wages and cohort size is estimated separately for each educational attainment class (ISCED 2, ISCED 3 and ISCED 5). Because surveyed individuals are not a random sample of the population of individuals, all models are estimated using the probability of being sampled, provided as part of the EU-SILC dataset, as weights.

2.3 Identification

Individuals are not randomly allocated into age-education cohorts, but can be assumed to self-select into cohorts through either acquiring a specific level of education or migrating to specific geographical areas. As a result, the cohort size variable is expected to be endogenous to the wage rate and estimation of Eq. 3 by ordinary least squares (OLS) will give inconsistent estimates of the impact of cohort size on wages. The direction of bias is likely to be positive as high wages will induce self-selection into educational groups and geographical areas, thereby leading to an increase in the corresponding cohort size variable.

To identify the causal effect of cohort size on wages, IV estimation is employed using the annual birth rate at the time of birth of an age cohort as an instrument for the cohort size variable. Since this variable will have explanatory power for the cohort size variable and can be assumed to be uncorrelated with the error term in Eq. 3, it qualifies as a valid instrument.

While some recent papers (e.g. Mosca, 2009) do not address the endogeneity of cohort size, others, such as Wright (1991) and Brunello (2010), acknowledge self-selection into educational groups but implicitly disregard self-selection due to migration. Both use age-specific cohort size as a proxy variable or as an instrument for age-education cohort size. Being determined solely by demographic factors, they argue that this variable does not suffer from the same endogeneity problem as the age-education cohort size measure. While we agree that this adequately deals with endogeneity due to self-selection into education groups, the instrument does not deal with endogeneity arising from self-selection into geographic

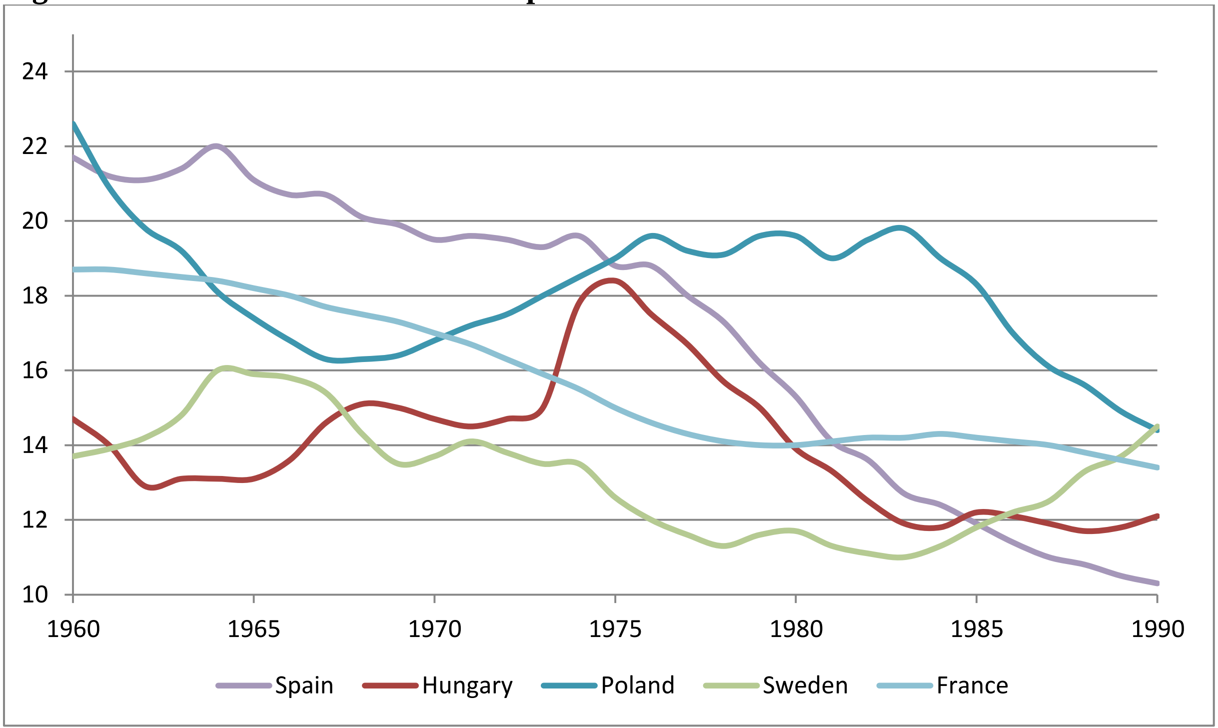
[14] The model also includes a constant.

[15] We also experimented with including Age_{jkt}^3 and $\ln[CS_{jkt}]XAge_{jkt}^3$ but these terms were not statistically significant in any of the specifications.

areas and, consequently, their estimated cohort size effects may be overstating the true effects.[16]

In his discussion of Klevmarken's (1993) paper, Börsch-Supan (1993) identifies that lack of variation in the data due to the availability of only three waves of observations as the likely reason for why cohort and age effects could not be identified separately. Likewise, Korenman and Neumark (2000) stress the importance of cross-national variation for the identification of cohort size effects as reliance on time-series variation alone may lead to the confounding of period and cohort effects, especially in the case of limited longitudinal variation. In light of the short time period available in EU-SILC, the data set's advantage rests in the availability of cross-country data. As fertility patterns, i.e. the timing of baby booms and baby busts, have developed differently across European countries during the post-war period, cohort sizes differ across countries. This cross-sectional variation can therefore be exploited to identify the effect of cohort size on wages. Fig. 1 provides a graphical representation of this cross-sectional variation in birth rates across some of the countries included in the dataset.

Figure 1: Birth rates for selected European countries



Birth rates are the number of live birth rates per 1,000 population

3 Results

Table 2 shows the coefficients of the three cohort size-related variables – the natural logarithm of cohort size, the interaction between cohort size and age and the interaction between cohort size and squared age – for each of the three education groups which have been estimated by OLS and two-stage-least squares (2SLS).

[16] Because the birth rate at the year of birth does not vary over time for a given individual, IV estimation of a fixed effects (FE) model of Eq. 3 using this instrument is infeasible. However, this limitation does not invalidate our instrument because it will also be uncorrelated with any time-invariant components of the error term.

A full set of results can be found in Table A1 of the appendix.

Table 2: Cohort size coefficients obtained from weighted regression (OLS and 2SLS)

Dependent Variable: *Ln*[Wage]	ISCED 2 OLS	ISCED 2 2SLS	ISCED 3 OLS	ISCED 3 2SLS	ISCED 5[a] OLS	ISCED 5[a] 2SLS
***Ln*[Cohort Size]**	0.101 (0.067)	0.135 (0.107)	0.321*** (0.064)	0.388** (0.160)	0.198** (0.085)	0.881*** (0.272)
***Ln*[Cohort Size] X Age**	-0.033** (0.013)	-0.047** (0.019)	-0.095*** (0.011)	-0.158*** (0.020)	-0.029 (0.022)	-0.364*** (0.126)
***Ln*[Cohort Size] X Age^2**	0.002*** (0.001)	0.002 (0.001)	0.004*** (0.001)	0.008*** (0.001)	0.001 (0.001)	0.019*** (0.007)
N	15,520	15,520	50,829	50,829	24,853	24,853
R^2	0.642	0.641	0.780	0.779	0.670	0.657
Test of joint significance of cohort size variables[b]	4.23***	8.70**	26.05***	72.86***	2.13*	10.82**
χ^2-test for underidentification[c]	-	294.30***	-	1419.35***	-	118.97***

Cluster-robust standard errors are given in parentheses.
*/**/*** denotes significance at the 10%/5%/1% level
[a] The age variable equals 0 for individuals aged 20 in ISCED group 2 and 3 and for individuals aged 25 in ISCED group 5
[b] The tests for joint significance are based on the F-distribution for OLS estimation and on the χ^2-distribution for 2SLS estimation.
[c] The χ^2 value shows the Kleibergen-Paap LM test-statistic for underidentification of the model.

The coefficients shown in Table 2 suggest that cohort size is a significant determinant of individual wages for most of the education groups. For males with an ISCED 3 or an ISCED 5 background the coefficients on the cohort-size variables obtained from 2SLS are almost all individually significant at the 1% level. For males at the ISCED 2 level, only the interaction between cohort size and age is statistically significant. For each educational group the cohort size variables are jointly significant at either the 5% level (ISCED 2) or the 1% level (ISCED 3 and ISCED 5).

The first-stage statistics do not show a weak instrument problem for any of the ISCED groups. Table 3 reports Shea's partial R^2 which shows the explanatory power of the instruments for each of the three endogenous variables after accounting for any correlation between the instruments and the exogenous regressors.

Table 3: Shea's partial R^2

	ISCED 2	ISCED 3	ISCED 5
***Ln*[Cohort Size]**	0.460	0.171	0.076
***Ln*[Cohort Size] X Age**	0.417	0.304	0.023
***Ln*[Cohort Size] X Age^2**	0.200	0.247	0.020

The partial R^2 is comparatively low for individuals with higher education. This result is not surprising as it would be expected that the better educated are more geographically mobile and that there is consequently a weaker association between birth rate and cohort size for these individuals within a specific country (see e.g. Bonin et al., 2008). Nevertheless, tests for underidentification reject the null hypothesis that the instruments are uncorrelated with the endogenous regressors for all educational groups.[17] Furthermore, tests for the joint

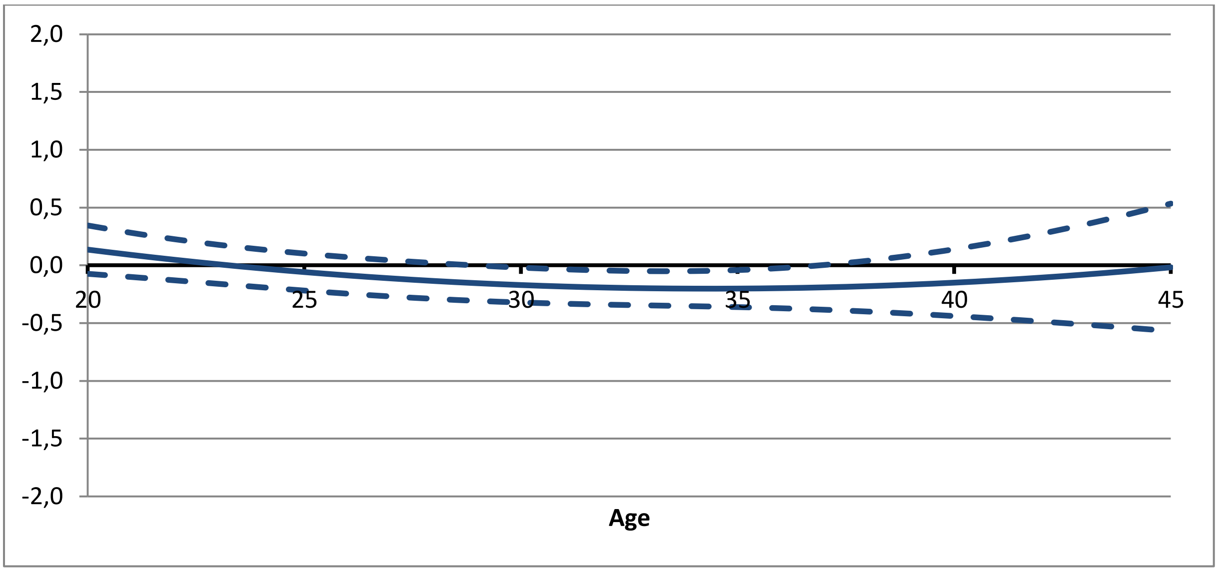
[17] The test statistics take into account that the structural model's error terms are assumed to be clustered.

significance of the cohort size-related variables in the structural equation that are robust to the instruments being weak reveal that the former are significant at the 1% level for ISCED 3 and ISCED 5 and at the 5% level for ISCED 2.[18]

The marginal effects of cohort size on individual earnings, as derived in Eq. 4, represent the basis for assessing whether increases in cohort size lead to decreased earnings and whether, if such effects are present, they are permanent or temporary. Since the marginal effects are functions of age, Fig. 2 plots the point estimates of the marginal effect of cohort size on wages as well as the upper and lower limit of the 95% confidence interval for each education group against age. Fig. A1 of the appendix shows the implied age-log wage profiles for different values of the cohort size variable for each educational group.

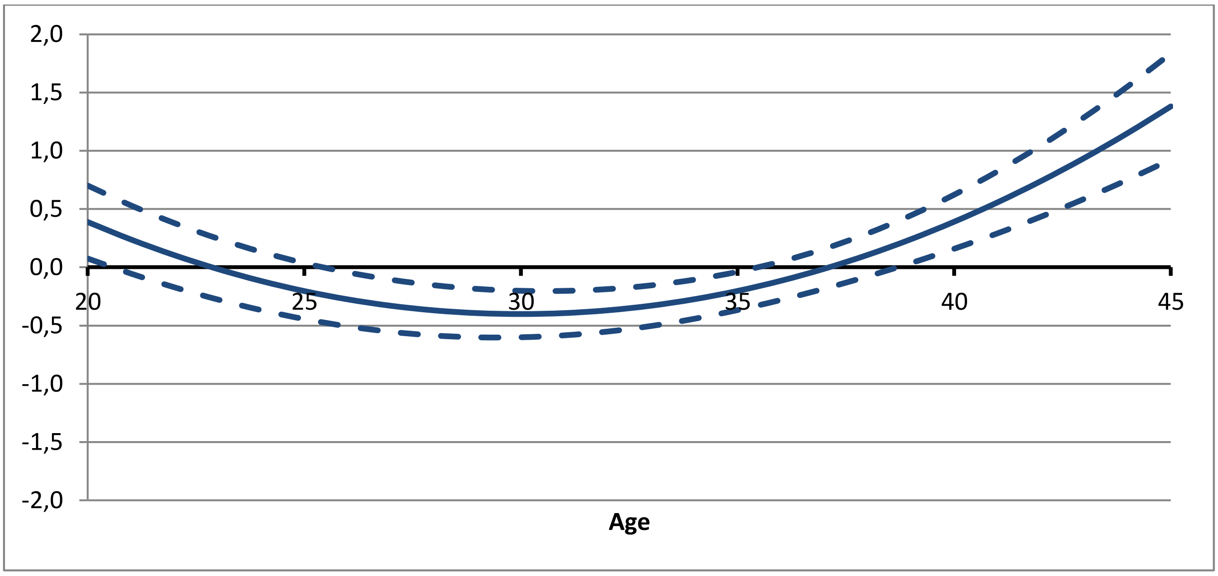
Figure 2: Marginal effects of cohort size and 95% confidence interval

ISCED 2

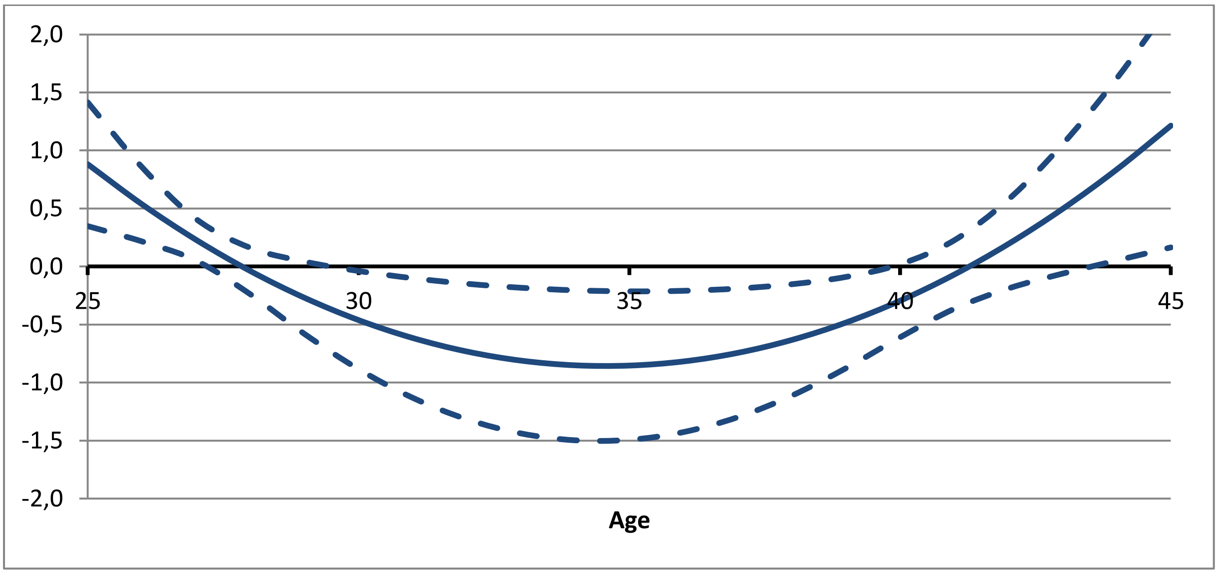


[18] The test statistics take into account that the structural model's error terms are assumed to be clustered. Results can be obtained from the authors upon request. Cluster-robust F-statistics for the weak instruments test are 117.56 (ISCED 2), 897.80 (ISCED 3) and 43.38 (ISCED 5). It should be noted, though, that the corresponding critical values from Stock and Yogo (2005) do not include the case of a just-identified model with 3 endogenous regressors.

ISCED 3



ISCED 5



The marginal effects profiles are highly nonlinear for all educational groupings. Regardless of educational attainment the shape of the point estimates indicate that members of large cohorts experience positive effects on wages on initial entry into the labour market. However, these effects rapidly become negative and then remain so for more than ten years. After the negative marginal effects subside, for ISCED 3 and ISCED 5, they become positive and quantitatively large as individuals approach the age of 45.

While the marginal effects show a similar development over age across all educational groups, the profiles differ with respect to the size of the negative effects. Specifically, cohort size appears to have a larger negative effect on wages in higher educational groupings. The point estimates at the ISCED 5 level reach a peak of -0.854 (age 35) compared to -0.401 (age 30) for ISCED 3 and only -0.202 (age 34) for ISCED 2. The period of significant negative effects last for approximately 10 years for individuals with tertiary and completed secondary education and is slightly shorter (8 years) for individuals with an ISCED 2 background. Comparing the shape of the marginal effects profiles across different educational groups, our results confirm earlier findings that the negative effects of cohort crowding increase with the level of education and are therefore in line with the hypothesis that substitution of identically educated but differently aged individuals is less feasible in higher educational groupings.

The first section of our marginal effects profiles is therefore consistent with the explanation of Berger (1989) who obtains similar findings using a comparable specification. He argues that since the negative effects of cohort size on wages are more pronounced for the highly educated, cohort size decreases the returns to investment into human capital and individuals in larger cohorts therefore have less of an incentive to accumulate human capital than those in smaller cohorts. Consequently, individuals in larger cohorts experience initially relatively high earnings but then lower earnings growth. In support of the hypothesis that cohort size reduces investment in human capital, Fertig et al. (2009), using data from the German Socioeconomic Panel (GSOEP), find that membership of a large cohort makes male individuals less likely to acquire tertiary education. However, these positive effects observed as individuals approach the age of 45 are more difficult to explain. We hypothesise that, due to higher levels of unionisation among older individuals in Europe (see e.g. Visser, 2006), older, larger cohorts are able to negotiate higher wages because they have greater bargaining power than smaller cohorts.

The estimated marginal effects of cohort size on male wages can be put into perspective by comparison with the results obtained by Brunello (2010) who also uses cross-country European data. Table 4 provides a comparison of the largest negative marginal effect as well as the average of the marginal effects over age.

Table 4: Comparison of marginal effects for Males

	ISCED 3		**ISCED 5**	
	Brunello	**Own**	**Brunello**	**Own**
Peak marginal effect	-0.070	-0.401	-0.175	-0.854
Average marginal effect[a]	-0.070	+0.133	-0.175	-0.219

[a] Our average marginal effects are calculated using the share of individuals in each age category included in the regression as weights.

Unlike the approach taken here, Brunello (2010) assumes that cohort size effects are constant with respect to age. His estimates suggest that a 1% increase in cohort size is associated with a 0.070% decrease in average earnings for ISCED 3 males and a 0.175% decrease for ISCED 5 males. In contrast, the empirical approach of this paper controls for confounding effects at the individual level and also allows cohort size effects to change as the individual ages. Our results suggest that the marginal effects of cohort size are indeed age-specific and that effects at specific ages can be more than five times as large as the time-invariant marginal effects obtained by Brunello (2010).

4 Conclusion

The aim of this paper has been the identification of the causal effect that the size of the age-education cohort to which an individual belongs exerts on wages. It is assumed that labour markets are segmented by educational attainment and that within each educational class differently aged workers represent distinct factors of production which are only imperfectly substitutable for each other. As such, increases in the size of a specific age-education group will have adverse effects on the wages of workers in that group.

In order to test this hypothesis empirically observations from the 2010 release of the EU-SILC survey at the household and the individual level for 21 European countries spanning the time period 2007-2010 are used. Identification of the causal effect of cohort size on wages is complicated by the fact that an individual's cohort is likely to be the result of individual self-selection into specific educational groups and into specific geographic areas – decisions which can be assumed to be affected by the individual's expectations regarding the wage rates available in the corresponding educational groups or geographic areas. Cohort size is therefore treated as an endogenous variable. In order to identify the causal effect of cohort size on individual wages, instrumental variables estimation is applied using birth rates at an individual's year of birth as an instrument. In order for the development of the cohort size effects over an individual's working life to be determined by the data rather than by a priori assumptions, interactions of cohort size with age and with squared age are included to allow the assessment of whether any effects are permanent or temporary.

Cohort size and its interactions with age represent individually and jointly significant determinants of an individual's wages for each educational level. The resulting marginal effects profiles are similar across educational groups: individuals in large cohorts are predicted to enter the labour market with higher earnings compared to individuals in smaller cohorts. Shortly after entering the labour market, though, marginal effects first turn negative, but, in the case of ISCED 3 and ISCED 5, the effects are predicted to become positive again. The profiles differ between educational groups with respect to the extent of the negative values of the point estimates which increase considerably with the level of education. The finding that the negative effects of cohort size increase with education is in line with previous studies and is consistent with the hypothesis that substitutability across age decreases with education.

A possible explanation for the initially positive marginal cohort size effects that turn negative as the individual ages is that individuals in large cohorts select themselves into careers that involve less human capital accumulation. The reason for reduced investment can be seen in the fact that the returns to human capital accumulation are depressed by cohort size, thereby lowering the incentive to undertake such an investment. At later ages, though, this effect appears to be dominated as cohort size is predicted to exert a positive effect on wages. We suggest that this may be the result of higher levels of unionisation among older workers providing greater bargaining power to larger cohorts. However, further research on the mechanism underpinning the link between cohort size and wages is needed before a final explanation for the development of the marginal effects profiles can be given.

5 References

Alsalam N. (1985). The Effect of Cohort Size on Earnings: an Examination of Substitution Relationships. *Working Paper 21*. University of Rochester Center for Economic Research Rochester

Berger M. (1985). The Effect of Cohort Size on Earnings Growth: A Reexamination of the Evidence. *Journal of Political Economy 93*(3), 561-573

Berger M. (1989) Demographic Cycles, Cohort Size, and Earnings. *Demography 26*(2), 311-321

Bonin H., Eichhorst W., Florman C., Hansen M., Skiöld L., Stuhler J., Tatsiramos K., Thomasen H., Zimmermann K. (2008). Geographic mobility in the European Union: Optimising its economic and social benefits. *IZA Research Report 19*. Institute for the Study of Labor, Bonn

Börsch-Supan A. (1993). Discussion of On ageing and earnings. In Johnson, P., Zimmerman, K. (Eds), *Labour Markets in an Ageing Europe* (pp. 178-181). Cambridge University Press, Cambridge.

Brunello G. (2010). The effects of cohort size on European earnings. *Journal of Population Economics 23*(1), 273-290

Dahlberg S., Nahum R. (2003). Cohort Effects on Earnings Profiles: Evidence from Sweden. *Working Paper Series 2003: 11*. Uppsala University, Department of Economics, Uppsala

Fertig M., Schmidt C. (2003). Gerontocracy in Motion. *IZA Discussion Paper 956*. Institute for the Study of Labor, Bonn

Fertig M., Schmidt C., Sinning M. (2009). The impact of demographic change on human capital accumulation. *Labour Economics 16*(6), 659-668

Freeman R. (1979). The Effect of Demographic Factors on Age-Earnings Profiles. *The Journal of Human Resources 14*(3), 289-318

Klevmarken N.A. (1993). On ageing and earnings. In Johnson, P., Zimmerman, K. (Eds), *Labour markets in an ageing Europe* (pp. 151-177). Cambridge University Press, Cambridge.

Korenman S., Neumark D. (2000). Cohort crowding and youth labor markets: a cross-national analysis. In Blanchflower, D.G., Freeman, R.B. (Eds), *Youth employment and joblessness in advanced countries* (pp.57-106). University of Chicago Press, Chicago.

Leveson I., Newitt J., United States Dept. Health Education and Welfare, Hudson Institute (1980). *Generational Crowding: Economic, Social and Demographic Effects of Changes in Relative Cohort Size*. Hudson Institute, Washington D.C.

Mosca I. (2009). Population Ageing and the Labour Market: Evidence from Italy. *Labour 23*(2), 371-395

Stapleton D., Young D. (1988). Educational Attainment and Cohort Size. *Journal of Labor Economics 6*(3), 330-361

Stock J., Yogo M. (2005). Testing for Weak Instruments in Linear IV Regression. In Andrews, D., Stock, J. (Eds), *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg* (pp. 80-108). Cambridge University Press, Cambridge.

Visser J. (2006). Union membership statistics in 24 countries. *Monthly Labor Review 129*, 38-49

Welch F. (1979). Effects of Cohort Size on Earnings: The Baby Boom Babies' Financial Bust. *Journal of Political Economy 87*(5), 65-97

Wright R. (1991). Cohort size and earnings in Great Britain. *Journal of Population Economics 4*(4), 295-305

6 Appendix

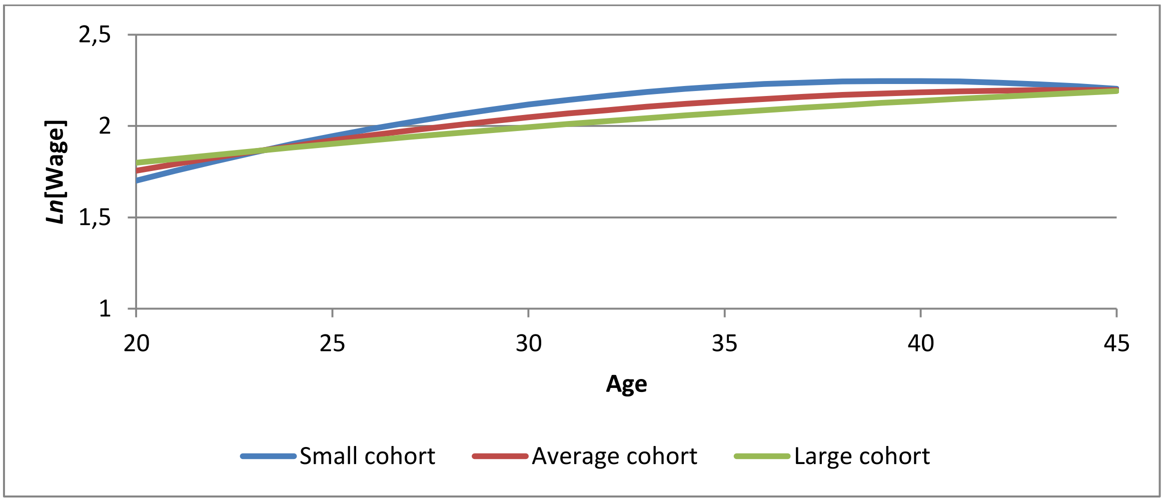
Table A1: OLS and 2SLS regressions results[19]

	ISCED 2 OLS	2SLS	ISCED 3 OLS	2 SLS	ISCED 5 OLS	2SLS
Ln [Cohort size]	0.101 (0.067)	0.135 (0.107)	0.321*** (0.064)	0.388** (0.160)	0.198** (0.085)	0.881*** (0.272)
Ln [Cohort Size] X Age	-0.033** (0.013)	-0.047** (0.019)	-0.095*** (0.011)	-0.158*** (0.020)	-0.029 (0.022)	-0.364*** (0.126)
Ln [Cohort Size] X Age^2	0.002*** (0.001)	0.002 (0.001)	0.004*** (0.001)	0.008*** (0.001)	0.001 (0.001)	0.019*** (0.007)
Age	-0.081 (0.051)	-0.139* (0.072)	-0.285*** (0.043)	-0.510*** (0.075)	-0.022 (0.076)	-1.184*** (0.439)
Age^2	0.005** (0.002)	0.005 (0.004)	0.012*** (0.002)	0.027*** (0.003)	0.000 (0.004)	0.064*** (0.024)
Self-employed	-0.800*** (0.080)	-0.805*** (0.080)	-0.719*** (0.043)	-0.718*** (0.043)	-0.817*** (0.059)	-0.816*** (0.059)
Married	0.054*** (0.019)	0.057*** (0.019)	0.090*** (0.010)	0.092*** (0.010)	0.148*** (0.015)	0.150*** (0.015)
Part-time	-0.141*** (0.043)	-0.139*** (0.043)	-0.177*** (0.034)	-0.173*** (0.034)	-0.143*** (0.048)	-0.126*** (0.049)
Unemployment rate	-0.136 (0.087)	-0.161* (0.087)	-0.204*** (0.044)	-0.195*** (0.045)	-0.056 (0.067)	-0.019 (0.070)
<u>Occupation dummies</u>						
Senior officials and managers	0.007 (0.157)	-0.000 (0.156)	-0.012 (0.046)	-0.017 (0.046)	-0.102*** (0.025)	-0.096*** (0.025)
Professionals	-0.051 (0.098)	-0.056 (0.098)	-0.087** (0.038)	-0.085** (0.038)	-0.283*** (0.026)	-0.279*** (0.026)
Technicians and associate professionals	-0.135 (0.090)	-0.135 (0.090)	-0.210*** (0.038)	-0.210*** (0.038)	-0.340*** (0.037)	-0.341*** (0.038)
Clerks, Service workers and shop and market sales workers	-0.226** (0.092)	-0.229** (0.092)	-0.307*** (0.038)	-0.306*** (0.038)	-0.497*** (0.035)	-0.480*** (0.036)
Skilled agricultural and fishery workers	-0.444*** (0.102)	-0.445*** (0.102)	-0.589*** (0.056)	-0.587*** (0.056)	-0.886*** (0.122)	-0.875*** (0.125)
Craft and related trades workers	-0.202** (0.089)	-0.207** (0.089)	-0.261*** (0.037)	-0.258*** (0.037)	-0.408*** (0.033)	-0.405*** (0.034)
Plant and machine operators and assemblers	-0.135 (0.088)	-0.141 (0.088)	-0.225*** (0.036)	-0.223*** (0.037)	-0.457*** (0.044)	-0.448*** (0.044)
Elementary occupations	-0.376*** (0.089)	-0.381*** (0.089)	-0.464*** (0.039)	-0.460*** (0.039)	-0.716*** (0.061)	-0.711*** (0.061)
<u>Urbanization dummies</u>						
Intermediately populated	-0.034 (0.021)	-0.034* (0.021)	-0.021* (0.012)	-0.020* (0.012)	-0.041** (0.016)	-0.042** (0.016)
Thinly populated	-0.046** (0.020)	-0.048** (0.020)	-0.074*** (0.011)	-0.073*** (0.011)	-0.098*** (0.017)	-0.100*** (0.017)
Constant	3.126*** (0.407)	3.316*** (0.535)	4.008*** (0.288)	4.175*** (0.654)	3.461*** (0.347)	5.629*** (0.893)
N	15,520	15,520	50,829	50,829	24,853	24,853
R^2	0.642	0.641	0.780	0.779	0.670	0.657

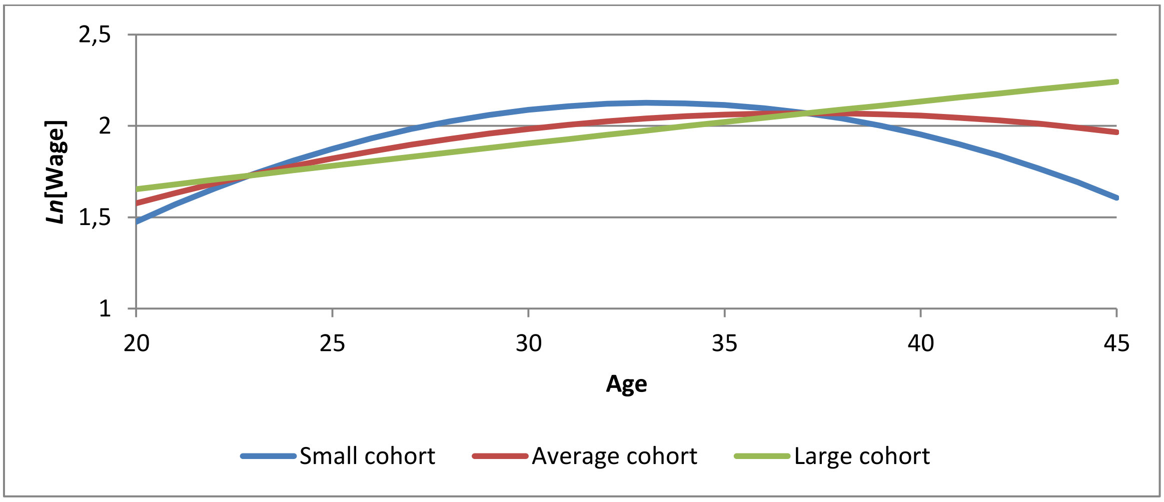
[19] Year, country, year-by-age, year-by-squared age and year-by-country effects are not reported. Results can be obtained from the authors upon request.

Figure A1: Predicted log wages[20]

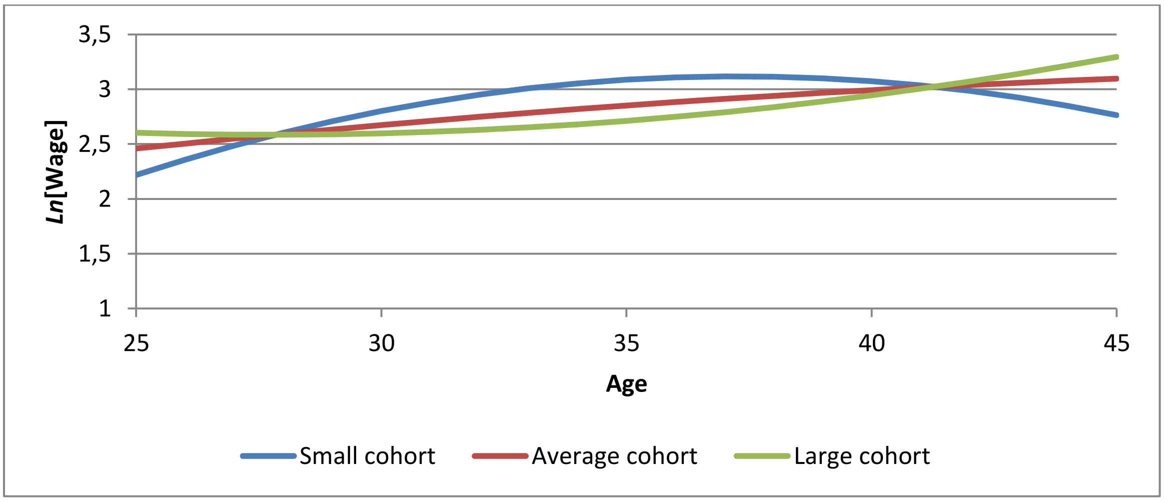
ISCED 2



ISCED 3



ISCED 5



[20] In predicting the values of *Ln*[Wage] all control variables are set equal to their mean. The value of cohort size varies between its mean ("average cohort"), its mean plus one standard deviation ("large cohort") and its mean minus one standard deviation ("small cohort").