The cohort size-wage relationship in Europe

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Abstract

This paper estimates the impact of cohort size on wages using data on young males in European regions covering 2004-2010. 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 suggest that cohort size has a significant negative effect on male wages for individuals with secondary education – the largest group – but not for individuals with less than secondary education or tertiary education. This effect is underestimated if self-selection into geographical areas is not addressed.

JEL classification J10, J21, J31, R23

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

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1 Introduction

The demographic and educational composition of the European Union (EU) is changing. While the working-age population share is forecast to fall by 2030 (European Commission, 2014), among the population of working age, older groups will see a far smaller fall in population share than younger groups. At the same time, if current trends continue (Eurostat, 2015), the population of the EU will become better educated. In this paper, we provide evidence on the impact of changes in the experience and education profile of the labour force on the wages of men at the start of their career.

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/experience 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). One question which has been the focus of much research is whether cohort size has a negative impact on wages. To address this question, the early literature proposed a production function with workers of different age or experience representing distinct factors of production (Freeman, 1979; Welch, 1979; Berger, 1983; Connelly, 1986; Stapleton and Young, 1988; and more recently Brunello, 2010). While the proposed models differ with respect to whether they allow for substitution across education, a common assumption is that within each educational group, workers of different age/experience are only imperfectly substitutable. Welch (1979) motivates the assumption of imperfect substitutability across experience levels by proposing a career-phase model in which differently experienced workers perform different tasks.

In a perfectly competitive economy in which factors of production are paid their marginal product, diminishing marginal productivity implies that an increase in the quantity of a specific production factor will reduce its returns. If workers with different levels of experience within a specific educational group are only imperfectly substitutable, an increase in the size of a specific experience-education group will affect mainly the wages of workers in this group. This is shown formally by Card and Lemieux (2001) and Brunello (2010). A large amount of North American empirical research (e.g. Freeman, 1979; Welch, 1979; Leveson *et al.*, 1980; Alsalam, 1985; Berger, 1983; Berger, 1985; Dooley, 1986; Sapozhnikov and Triest 2007; Morin, 2015) has provided evidence in favour of the hypothesis that increases in the size of an experience-education group (i.e. cohort size) reduces wages.

However, Fertig and Schmidt (2003) point out that the effect of an increase in cohort size on wages is less clear in economies in which wages are rigid or the outcome of a bargaining process between employer associations and unions: if wages are rigid, changes in cohort size are likely to cause changes in experience-education-specific (un-)employment rates rather than wages; if they are the result of a bargaining process, a large cohort size has greater bargaining power which could mitigate the previously discussed negative effects of cohort size on wages. More formally, Michaelis and Debus (2011) specify a model in which output is produced by old and young workers and where age-specific wages and unemployment rates are determined by interaction between unions and firms in a right-to-manage framework. Their model suggests that changes in the size of age groups will usually lead to adjustment in age-specific wages, but when changes in the population structure also affect the weights that unions attach to the preferences of both groups, adjustment will take place through changes to age-specific unemployment. Once the framework of analysis is not restricted to a perfectly competitive set-up, the effects of changes in cohort size on wages are consequently ex ante uncertain.

Another question that has been addressed in the literature is whether the effect of cohort size on wages differs across educational groups. Stapleton and Young's (1988) "diminishing substitutability hypothesis" proposes that substitutability across experience decreases with a worker's level of education. Building on Welch's (1979) career phase model, they argue that transition through the different career stages is more rapid for workers with less education as less training is required to perform the transition. Consequently, tasks of differently experienced workers are less differentiated for lower levels of education and workers are more easily substitutable across experience levels. In line with the "diminishing substitutability hypothesis", many studies (e.g. Welch, 1979; Leveson, 1980; Alsalam, 1985; Brunello, 2010) find that the effects of changes in cohort size are more pronounced for the highly educated.

Our focus is on individuals at the beginning of their careers. It is therefore important to note that 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 due to "diminishing substitutability", individuals in large cohorts have 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), using UK data covering the period 1973-1982, finds that cohort size is negatively associated with wages for males with intermediate and higher qualifications with larger effects for the more educated group. However, these effects are only temporary, lasting for five years after assumed labour market entry for the intermediate qualifications group and 11 years for the high qualifications group. Also for the UK, Nickell (1993) finds a negative effect of cohort size on the relative earnings of young men using time series data covering 1961-1989. Mosca (2009), using Italian data for male workers from the European Community Household Panel (ECHP), obtains results that also support the negative relationship between cohort size and earnings. Opposing 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) data set, regresses average hourly male earnings by age group on a measure of age-specific relative cohort size and interactions with educational indicator variables and age and finds that none of the cohort size-related variables are significant. Dahlberg and Nahlum (2003) use longitudinal data from various registers and find that cohort size has a positive and significant effect on male wages which exists, to different extents, across gender and education groupings.[1] More recently, Brunello (2010) provides an analysis of the cohort size-earnings relationship using ECHP comprising data for the period 1995-2001 from 11 countries. 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. Most of the recent literature has acknowledged that

[1] 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.

cohort size is endogenous due to self-selection into educational groups through gaining qualifications. By contrast, self-selection into geographical areas through migration to high-wage 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 European Union (EU). One of the main contributions of this paper is therefore the use of an IV strategy that addresses this issue. Another contribution is the use of the Nomenclature of Territorial Units in Statistics (NUTS) region rather than the country as the spatial unit. This is advantageous as it provides greater variation in the measure of cohort size that facilitates the identification of the cohort size effect. Moreover, labour market regions have been constructed empirically on the basis of observed commuting patterns for several European countries (e.g. Eckey *et al.*, 2006). These entities are generally delineated at a sub-national level and, while a comparable system is not available for the whole of Europe, NUTS 1 regions should provide a better approximation than countries to actual labour markets.

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 various releases of the European Union Statistics on Income and Living Conditions (EU-SILC) survey which consists of cross-sectional and time-series data at the individual and household level for a large number of European countries.[2] Different features of EU-SILC are described in Iacovou *et al.* (2012) and in Berger and Schaffner (2015). The primary purpose of this survey, which is the successor to ECHP, is to provide information on the distribution of income and social exclusion in Europe. However, EU-SILC also contains several variables related to labour market outcomes, which in combination with the range of individual-level data makes it a suitable dataset for our purposes. Sampling weights are provided to account for the fact that the data does not constitute a random sample.

In contrast to ECHP, EU-SILC is a rolling panel, so individuals are not observed throughout their working life, but are followed for a maximum of 4 years in most countries. For a specific country and year, individual observations are grouped into sub-samples called *rotational groups*. In most countries, there are four rotational groups per year (there are 9 per year in France, 8 per year in Norway and 1 per year in Luxembourg). A typical longitudinal release covers four years, but will not contain data from all rotational groups. Instead, one rotational group is followed for four years, a second for three years and a third for two years (see Berger and Schaffner, 2015 for an illustration of this structure). Appending observations from different releases therefore allows an increase in the total sample size: starting from the 2011 release, which covers the years 2008-2011, we use the 2010 release to add observations from a new rotational group for the years 2007-2010 for each available country. We continue adding observations in this way back to the 2005 release, resulting in a final dataset that spans the years 2004-2011.[3]

[2] Data from the following longitudinal releases is used: 2005-1 from 15-09-2007, version 2006-2 from 01-03-2009, 2007-5 from 01-08-2011, 2008-4 from 01-03-2012, 2009-3 from 01-08-2012, 2010-3 from 01-08-2013 and 2011-1 from 01-08-2013.

[3] Notice that not all countries provide observations for the whole period.

This procedure makes it necessary to scale down the sampling weights since these are constructed on the basis of the number of rotational groups in a release (for each country-year combination). To assess the quality of the weights we estimate the size of the population in each region-year-age cell and compare these estimates with the corresponding values as reported by Eurostat. Where these two quantities are not identical, the weights of all observations within a cell are scaled so that they yield the true population size. The results reported in Section 3 are, however, robust to using the unadjusted weights.

A further issue is that the variables in EU-SILC refer to different periods. In the case of the labour-market variables, the number of hours worked refers to the time of the interview, while the income variables are based on the *income reference period*, which is defined as the preceding calendar year for all countries except Ireland and the UK. To ensure that the variables refer to the same year, we replace the wage data in the sample by its leading value. This implies that data from the year 2011 cannot be used and that only those individuals that are observed in adjacent years can be retained. In terms of countries our final sample includes observations from Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, France, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, Malta, Norway, Poland, Romania, Slovakia, Spain and Sweden.[4] For each of these countries EU-SILC provides information on an individual's residence at the NUTS1 level. This piece of information is crucial as it allows construction of the cohort-size variable at the regional level. The countries listed above provide us with a total of 56 NUTS1 regions.

2.2 Empirical model

The dependent variable of our model is given by the natural logarithm of the purchasing power parity (PPP)-adjusted hourly wage of individual i in experience group j, with educational qualification e, residing in region r at time t, w_{ijert}. This variable is constructed by first adjusting annual wage income for inflation using the GDP deflator (base year: 2010). This variable is then divided by the country-specific PPP-factor from the base year, as provided by Eurostat (see Friedrich, 2015). This quantity is then divided by the number of hours usually worked per week, which are multiplied by the number of weeks per year and the fraction of the year spent working as reported by the individual. To reduce the risk of measurement error due to changes in the number of hours worked over the year, we restrict our sample to those individuals that have been working either exclusively full-time or exclusively part-time during the income reference period.

The main explanatory variable is the relative size of the experience cohort to which the individual belongs. This variable's specification follows from the assumptions made about the group with whom the individual is substitutable. First, we follow the literature (Card and Lemieux, 2001, Brunello, 2010) in assuming that substitutability is possible within but not across educational categories. The level of education in EU-SILC is given by the 1997 system of the International Standard Classification of Education (ISCED-97) which allows for cross-country comparisons of educational qualifications. This variable assigns a value from 0 (pre-primary education) to 5 (first stage of tertiary education) to every individual. Because of top-coding, individuals with ISCED 6 (second stage of tertiary education) cannot be identified separately but are subsumed into category 5. We follow Brunello (2010) in combining individual categories into larger educational groupings: ISCED 0-2 includes all individuals

[4] Observations from the following countries are excluded: Ireland and the UK (income reference period is not the preceding calendar year as it is for other countries); Germany, the Netherlands and Portugal (no information on region of residence); Croatia (due to unavailability of data, the instrumental variable cannot be constructed); Slovenia (information on the degree of urbanisation missing); Finland and Iceland (year of birth as well as all age-related variables are not recorded precisely, presumably for disclosure reasons).

with at most lower secondary education, ISCED 3-4 combines upper secondary and post-secondary non-tertiary education and ISCED 5 contains individuals with completed tertiary education.

Second, we assume that individuals compete for jobs within regions rather than countries. This approach is preferable for two reasons. First, it allows the use of inter-regional variation in cohort size to identify the former's effect on wages. More substantively, we argue that labour markets are more likely to exist at a sub-national level because of limitations to mobility or because information about job opportunities decreases with distance from an individual's place of residence. Ideally, we would base cohort size on spatial entities which are delineated in a way that the working population residing in such an area would be exclusively employed there and vice-versa. But while such functional units have been designed for individual countries (see Eckey *et al.*, 2006 for Germany), no comparable units have been defined for the European level. But the fact that functional labour markets tend to be found to be relatively small suggests that the use of NUTS1 regions as approximations of regional labour markets is preferable to the use of countries.

Finally, we choose to define cohort size in terms of labour market experience rather than age. Within an educational grouping, years of work experience provides a measure of the human capital that individuals have had a chance to accumulate on the job. The use of experience thus provides a better measure of substitutability in the labour market than age and also ties in with Welch's (1979) proposed career-phase model in which workers with different levels of experience differ in terms of the tasks they can perform, making them only imperfectly substitutable. However, results comparable to those presented in Section 3 are obtained when an age-specific cohort-size variable is used.[5]

If individuals are not at all substitutable across experience groups, the appropriate cohort-size variable would be defined simply as the ratio of individuals of experience j with education e in region r at time t, N_{jert}, relative to the number of all individuals with education e in region r at time t, N_{ert}. But since it is likely that individuals are substitutable if they have similar but not necessarily the same level of experience, we follow Wright (1991) and Brunello (2010) in calculating the numerator of the cohort-size variable as a weighted average of the number of individuals with up to two years more or two years less work experience[6]:

$$CS_{jert} = \frac{(1/9)N_{j-2,ert} + (2/9)N_{j-1,ert} + (3/9)N_{jert} + (2/9)N_{j+1,ert} + (1/9)N_{j+2,ert}}{N_{ert}} \quad [1]$$

Because official statistics regarding the size of education-experience groups at a regional level are not available, these quantities are estimated from the EU-SILC dataset using the adjusted sampling weights. For each of the three educational groups, the sample from which cohort size is calculated includes males and females who are either employed or unemployed. Given that our focus is on individuals in the early stages of their career, a large share of inactive individuals are in the process of acquiring education and including those observations would, for example, mean including all individuals enrolled in tertiary education in the construction of cohort size for ISCED grouping 3-4, which in turn would lead to an artificial jump in cohort size once these individuals had completed education and entered the ISCED 5 grouping. The inactive are therefore excluded from the construction of the cohort size

[5] The results of this and all subsequently mentioned robustness checks are available upon request.
[6] Notice that the use of V-shaped weights implies that substitutability decreases with the difference in experience levels (see Wright, 1991 for a discussion). Comparable results to those presented in Section 3 are obtained when different specifications of the numerator are used.

variable. However, comparable results are obtained when cohort size is constructed from all individuals regardless of their economic status.

The sample from which the cohort-size variable is constructed is restricted to the working-age population (age groups 16-65) within each educational grouping. Cohort size is computed for up to 11, 9 and 4 years of experience for ISCED 0-2, ISCED 3-4 and ISCED 5, respectively. These upper limits are imposed for two reasons: first, our interest lies in individuals who are at an early stage of their career. Second and as discussed in Section 2.3, we want to ensure that the age groups which are used as instruments for the experience-based cohort-size variable do not contain individuals who are older than 15 in order to rule out issues of regional self-selection. Furthermore, the denominator includes individuals with up to 47, 45 and 41 years of experience in the case of ISCED 0-2, ISCED 3-4 and ISCED 5. These values are derived from assuming education-specific ages at entry into the labour market of 18, 20 and 24, respectively. In Section 2.3 we discuss how these assumptions fit the actual data from the regression sample.

Since there is an upper and a lower limit to experience, the construction of cohort size has to be adjusted at the corners of this range by reallocating the weights that would otherwise have been attached to the experience groups outside the specified range. At the lower limit, cohort-size for experience groups 0 and 1 are constructed as follows (with corresponding constructions at the education-specific upper limits):

$$CS_{0,ert} = \frac{(6/9)N_{0,ert}+(2/9)N_{1,ert}+(1/9)N_{2,ert}}{N_{ert}} \qquad [1a]$$

$$CS_{1,ert} = \frac{(3/9)N_{0,ert}+(3/9)N_{1,ert}+(2/9)N_{2,ert}+(1/9)N_{3,ert}}{N_{ert}} \qquad [1b]$$

In terms of control variables, $\boldsymbol{x_{ijrt}}$, we include a constant, individual-level regressors (indicators for working part-time, being married, the degree of urbanisation of the place of residence, and occupational indicator variables), experience-related regressors (experience and squared experience), region-specific regressors (region dummies), time-specific regressors (year dummies) and region-by-time regressors (the regional unemployment rate). Further details on these variables as well as descriptive statistics are given in Tables A1 and A2 in the Appendix.

Our empirical model, which we estimate separately for each level of education (ISCED 0-2, ISCED 3-4, ISCED 5), is given by Equation 2 (throughout the remainder of the paper the *e* subscript is dropped):

$$\ln[w_{ijrt}] = \alpha CS_{jrt} + \boldsymbol{\beta x_{ijrt}} + u_{ijrt} \qquad [2]$$

We exclude female observations from the estimation of Equation 2 to avoid the issue of selected labour market participation. To account for the sampling design weighted regressions are performed. Finally, as the main regressor in our model is defined at a higher level of aggregation than the dependent variable, standard errors are clustered at the level of the region-experience cell (see Moulton 1990).

2.3 Identification

An obstacle to identifying the wage effect of cohort size using ordinary least squares (OLS) estimation is that individuals are not necessarily randomly allocated into cohorts. Rather membership of a specific cohort is potentially the result of individual self-selection into educational groups or regions. This would be the case if an individual's expectation about future wages affected the decision to acquire a specific level of education (thereby affecting education-specific cohort size) or if labour market prospects induced migration into a different region (thereby affecting region-specific cohort size). Due to the comparatively low costs of moving between regions (as opposed to countries) the second type of self-selection is of particular concern although freedom of movement of labour within the EU implies that migration between countries may also be significant. OLS is likely to underestimate the depressing effect of cohort size, if individuals select into educational groups or regions that are characterised by higher wages. To identify the effect of cohort size on wage consistently we therefore employ IV estimation.

Recent contributions to the literature on cohort-size effects on wages either do not address the issue of endogeneity (Mosca, 2009) or acknowledge self-selection into educational groups, while implicitly disregarding self-selection through migration (Sapozhnikov and Triest, 2007; Brunello, 2010).[7] The latter studies use contemporaneous age-specific cohort size as an instrument which is not differentiated by education. We argue that this approach suffers from the disadvantage of not addressing individual self-selection from migration. To assess this hypothesis we construct an instrumental variable (IV1) that corresponds to the one described above:

$$IV1_{gkt} = \frac{(1/9)N_{(g-2)rt} + (2/9)N_{(g-1)rt} + (3/9)N_{grt} + (2/9)N_{(g+1)rt} + (1/9)N_{(g+2)rt}}{N_{rt}} \quad [3]$$

Subscript *g* refers to age and the numerator is a weighted average of the number of individuals in a region that are two years younger, one year younger, the same age, one year older and two years older. Our preferred instrument (IV2) deals with both self-selection into educational groupings and self-selection into geographical areas. It is the relative size of the age group in the region that is fourteen years younger, fourteen years ago. Since the first year of sampling is the year 2004 and regional population data are available for most NUTS1 regions from the year 1990 onwards, fourteen years represents the longest feasible lag. Comparable instruments have been employed in the analysis of cohort-size and unemployment (Korenman and Neumark, 2000; Shimer, 2001; Garloff *et al.*, 2013; Moffat and Roth, 2014).

$$IV2_{jrt} = \frac{(1/9)N_{g-2-14,rt-14} + (2/9)N_{g-1-14,rt-14} + (3/9)N_{g-14,rt-14} + (2/9)N_{g+1-14,rt-14} + (1/9)N_{g+2-14,rt-14}}{N_{rt-14}} \quad [4]$$

This variable is a natural predictor for our cohort-size variable as, in the absence of migration and natural changes in population, the individuals on which the instrument is based will be the same as those on which education-specific cohort-size is based, only that they are observed at different points in time. This association between the endogenous cohort-size variable and the instrument is supported by the first-stage test-statistics.

In addition to not varying across education, both of the above instruments are defined in terms of age rather than experience. This requires us to specify a link between an individual's age and years of experience. We do this with imputed age values which are defined as the sum of

[7] In contrast, Morin (2015) uses a natural experiment given by a reform to the educational system in a specific Canadian province to identify cohort-size effects.

assumed entry age (18, 20 and 24 for educational groupings ISCED 0-2, ISCED 3-4 and ISCED 5) and number of years of experience. We compare actual and imputed age and find that the distribution of true age is centred on the imputed age values in the majority of cases. We prefer matching cohort size and the instrument using an imputed age rather than actual age as this ensures that individuals in the same experience cohort are assigned the same value of the instrument, thereby avoiding identification of cohort-size effects from within-cohort variation in the instrument. To avoid the inclusion of an age group where individuals may make their own decisions about where to reside, the age groups in the instrument are restricted to be no older than 15. This implies an upper age limit of 29 for those in the sample and we therefore exclude observations from the regression who are older than 29 (though raising the limit to 32 does not affect the results).

3 Results

Table 1 shows the coefficients of cohort size, experience and experience squared for each of the three education groups obtained by OLS, two-stage-least squares (2SLS) estimation using the instrument of Brunello (2010) and Wright (1991) – in the column headed IV1 – and 2SLS using an instrument based on lagged population sizes – in the column headed IV2. A full set of results can be found in Table A2 of the appendix.

Table 1. Cohort size coefficients obtained from weighted regression (OLS and 2SLS)

	ISCED 0-2			ISCED 3-4			ISCED 5		
	OLS	**IV1**	**IV2**	**OLS**	**IV1**	**IV2**	**OLS**	**IV1**	**IV2**
Cohort Size	-1.42 (1.11)	-0.95 (3.22)	-2.54 (2.67)	-0.21 (0.94)	-3.91 (3.50)	-12.02** (4.70)	-1.87 (1.56)	-3.65 (7.44)	-1.94 (7.66)
Experience	0.08*** (0.01)	0.08*** (0.01)	0.08*** (0.01)	0.05*** (0.01)	0.06*** (0.01)	0.07*** (0.01)	0.10*** (0.03)	0.11** (0.05)	0.10** (0.05)
Experience ^{2}	-0.00*** (0.00)	-0.00*** (0.00)	-0.00*** (0.00)	-0.00*** (0.00)	-0.00*** (0.00)	-0.00*** (0.00)	-0.01* (0.00)	-0.01 (0.01)	-0.01 (0.01)
N(inds)	7,364	7,364	7,364	19,785	19,785	19,785	4,973	4,973	4,973
N(cells)	2,180	2,180	2,180	2,499	2,499	2,499	1,338	1,338	1,338
N(clusters)	596	596	596	553	553	553	319	319	319
F-stat		115.81***	124.82***		53.24***	44.63***		27.37***	21.43***
ME (std)	-1.71%	-1.14%	-3.05%	-0.17%	-3.28%	-10.07%**	-2.28%	-4.46%	-2.37%

***/**/* indicate significance at the 1%/5%/10% level, respectively. Standard errors are clustered at the region-experience level. N(inds): number of individual observations. N(cells): number of region-experience-year cells. N(clusters): number of clusters. F-stat refers to the first-stage F-statistic on the significance of the instrument in the first-stage regression of the endogenous cohort-size variable. ME(std) shows the percentage change in the hourly wage for a change in cohort size by one standard deviation.

Each of the three specifications produces negative cohort-size coefficients for all ISCED groups and, with the exception of ISCED 5, the coefficients of model IV2 are more negative than those of either OLS or IV1. This finding is in line with the previous discussion that due to their inability to account for self-selection through migration into high-wage areas the identification strategies of the latter models will underestimate the negative wage effect of cohort size.

In the case of ISCED 0-2 we find that none of the cohort-size coefficients is statistically significant. From a theoretical perspective (see Card and Lemieux, 2001; Brunello, 2010), this finding is compatible with individuals with difference levels of experience in this educational category being easily substitutable for each other. Accordingly, the estimated effect of an increase in cohort-size of one standard deviation on an individual's wage is comparatively small at -3% for specification IV2. In contrast, we find that cohort size has a considerable and statistically significant effect on the wages of individuals with completed secondary and post-secondary, non-tertiary education (ISCED 3-4): based on specification IV2, an increase in cohort size of one standard deviation decreases the wages of individuals in the affected cohort by 10%, ceteris paribus. The fact that the estimated effect is larger for ISCED 3-4 than for ISCED 0-2 is in line with Stapleton and Young's (1988) diminishing substitutability hypothesis that differently aged/experienced workers are less easily substitutable at higher levels of education.

The results for ISCED 5 do not display a similar pattern: though all coefficients are negative, the point estimates of specification IV2 are smaller than the corresponding results for ISCED 3-4 as well as the coefficients from IV1 in the same educational group. Moreover, none of the coefficients on cohort size are statistically significant. The only other study of which we are aware which has found larger negative cohort size effects for those with secondary education than those with tertiary education is Dooley (1986) who obtained this result using Canadian data.

There are several potential reasons for this finding. From an empirical perspective, the comparatively small number of experience cells (5) reduces the variation from which the effect of cohort size can be identified (as evidenced by the number of region-year-experience or region-experience cells in the case of ISCED 5). The size of the standard errors in the IV estimations is also a consequence of the instrument's decrease in predictive power with respect to cohort size (as evidenced by the comparatively small values of the F-statistic). From an economic perspective, the smaller size of the coefficients may be explained by greater segmentation of the labour market at higher levels of education. In other words, individuals with higher levels of education operate in more heterogeneous labour markets and are therefore less substitutable with individuals with the same level of education, irrespective of their level of experience. An alternative explanation is that individuals, once they have attained tertiary education, are more affected by the mechanism discussed by Berger (1989) that leads individuals in larger cohorts to obtain less human capital and therefore relatively high wages when young. This would be the case if, as seems likely due to opportunities to pursue postgraduate education or receive advanced on-the-job training, individuals with ISCED 5 have more scope for differentiated levels of human capital than individuals with ISCED 0-2 or ISCED 3-4. If those with ISCED 5 in large cohorts choose not to take these opportunities, there then will be a weaker relationship between cohort size and wages within this group. Another possibility is that the effect of cohort size occurs more through unemployment than wages for individuals with tertiary education. However, it is unclear why the wages of those with tertiary education would be more rigid or more influenced by unions so we regard the previous explanations for our inability to find significant and negative effects for this group as more credible.

The first-stage F-statistics are above the rule-of-thumb value of 10 for each educational group, suggesting that there is no problem of weak instruments. The size of the test statistics decreases with the level of education which implies that lagged age-structures are a better predictor for education-specific cohort size of the less educated. A possible reason is that geographic mobility increases with the level of education. The experience variables show the standard positive but diminishing effect of experience on wages. If experience dummies are used, this pattern is also found and the estimated effects of cohort size are very similar to those reported above. The coefficients of the other control variables (reported in Table A3) are also in line with expectations. Specifically, higher regional unemployment is associated with lower wages while being married and living in a more urbanised environment have a positive effect on wages. The coefficients on the occupational dummies are also statistically significant and of the expected pattern.

To put our results for ISCED 3-4 into perspective, we compare them with those of Brunello (2010), who uses a dataset and empirical model that is comparable to the one used in this paper. One difference between the two analyses is that his data is aggregated at the level of the country-year-age cell, while this analysis is based on individual-level variables. However, estimating Equation 2 after averaging all variables over the observations within a region-year-experience cell and weighting the regression by the number of observations per cell (adjusted for the sampling weights, see Angrist and Pischke, 2009), we obtain results that are very similar to those shown in Table 1. Another difference is Brunello's (2010) use of a log-log specification. When we adopt this approach, we find that an increase in cohort size by 1% is predicted to decrease the mean wage of individuals in that cohort by 0.098% (IV1). This result is comparable to the predicted change of -0.069%, as estimated by Brunello (2010) for those aged below 35 in educational group ISCED 3-4. However, employing our preferred instrument (IV2) yields a predicted decrease of -0.288%, four times the size of the effect found by Brunello (2010). Notwithstanding the possibility that the difference is due to differences in the sampling period and range of countries included in the analysis, this supports our contention that, as discussed previously, the contemporaneous age-cohort size is unable to deal with self-selection through migration and use of this instrument leads to an underestimation of the true cohort-size effect.

4 Conclusion

The aim of this paper has been the identification of the causal effect of cohort size on the wages of young men at the start of their career in Europe. Ex ante, the direction of this effect is unclear. If labour markets are perfectly competitive and differently aged workers are only imperfectly substitutable within each educational group, members of larger cohorts can be expected to receive lower wages as a result of their lower marginal productivity. However, in an environment of imperfect competition, increases in cohort size may have no or only a limited effect on wages if these are sufficiently rigid (in which case (un-)employment rates would be expected to change) or even a positive effect if larger cohorts are able to exert larger bargaining power. Identification of this effect is complicated by the fact that an individual's cohort is likely to be the result of self-selection into educational groups and self-selection into geographic areas. Unlike earlier papers that have looked at this question using cross-country European data, our approach addresses both types of self-selection by using the size of the population 14 years younger, 14 years ago as an instrument for cohort size. We also use regions rather than countries as the spatial unit since this provides greater variation in the cohort size variable and are also likely to provide a better approximation of actual labour markets than countries.

Our results show that cohort size represents a significant and negative determinant of wages for young males with secondary but not for those with less than secondary or tertiary education. This suggests that the projected fall in the share of young people in the labour force will increase the wages of those with secondary education – the largest group in the labour force. The finding that those with lower levels of education do not experience a negative effect is consistent with the 'diminishing substitutability hypothesis'. We suggest that the failure to find a significant effect for those with tertiary education may be due to greater market segmentation among the more highly educated or greater scope for obtaining different levels of human capital after the completion of formal education. The effect of cohort size is not found to be statistically significant for any of the educational groupings if the IV strategy does not address the potential for self-selection through migration. This implies that the earlier work on the cohort size-wage relationship which did not address this source of endogeneity may have underestimated the true effect.

5 References

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6 Appendix

Table A1. Variable Definitions

Variable	Definition	Source
Wage	Hourly wage in Euros, adjusted by a purchasing power parity factor (see the appendix of Friedrich, 2015 for details)	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 defines himself as part-time	EU-SILC
Self-employed	Dummy variable coded one if the individual defines himself as self-employed	EU-SILC
Occupation	Dummy variables for each of the following occupational groupings defined according to the International Standard Classification of Occupations, (ISCO) - 88: 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 The omitted category is those in the armed forces	EU-SILC
Urbanisation	Dummy variables for residence in the following: 1. An 'intermediate' area - an area with a population density of more than 100 inhabitants per square kilometre (km) and either a population of at least 50,000 inhabitants or adjacent to a 'densely populated' area of at least 500 inhabitants per square km and a population of least 50,000 inhabitants 2. A 'thinly populated' area - an area with fewer than 100 inhabitants per square km and a population of less than 50,000 inhabitants The omitted category is densely populated – an area with a population density of more than 500 inhabitants per km and a population of at least 50,000 inhabitants.	EU-SILC
Experience	Years of experience	EU-SILC
Unemployment	National unemployment rate of people aged over 25	Eurostat
Region Dummies	Dummy variables for residence in particular region (see footnote 6 for a list of countries included in the analysis)	EU-SILC
Year Dummies	Dummy variables for 2005, 2006, 2007, 2008, 2009 or 2010	EC-SILC

Table A2. Descriptive statistics

	ISCED 0-2		ISCED 3-4		ISCED 5	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Wage	7.31	3.89	7.11	4.54	10.01	6.20
Cohort size	0.03	0.01	0.03	0.01	0.04	0.01
Cohort size (instrument 1)	0.02	0.00	0.02	0.00	0.02	0.00
Cohort size (instrument 2)	0.02	0.00	0.02	0.00	0.02	0.00
Experience	5.10	3.16	4.41	2.58	2.70	1.52
Unemployment	8.44	4.31	7.49	3.40	7.89	3.58
Married	0.14	0.34	0.16	0.37	0.13	0.33
Part-time	0.08	0.27	0.05	0.21	0.07	0.25
Occupation dummies						
1. Armed forces	0.01	0.11	0.03	0.16	0.01	0.07
2. Legislators	0.00	0.06	0.01	0.10	0.05	0.21
3. Senior officials and managers	0.01	0.09	0.02	0.13	0.40	0.49
4. Professionals	0.03	0.18	0.13	0.33	0.23	0.42
5. Technicians and associate professionals	0.03	0.17	0.07	0.25	0.10	0.30
6. Clerks, service workers and shop and market sales workers	0.10	0.30	0.14	0.35	0.06	0.25
7. Skilled agricultural and fishery workers	0.03	0.16	0.02	0.14	0.01	0.09
8. Craft and related trade workers	0.40	0.49	0.32	0.47	0.07	0.25
9. Plant and machine operators and assemblers	0.17	0.37	0.17	0.38	0.04	0.21
10. Elementary occupations	0.22	0.42	0.10	0.29	0.03	0.17
Urbanisation dummies						
1. Densely populated	0.37	0.48	0.41	0.49	0.60	0.49
2. Intermediately populated	0.27	0.44	0.22	0.42	0.18	0.38
3. Thinly populated	0.37	0.48	0.37	0.48	0.22	0.41
Observations	7,364		19,785		4,973	

Table A3. OLS and 2SLS regression results

	ISCED 0-2			ISCED 3-4			ISCED 5		
	OLS	**IV1**	**IV2**	**OLS**	**IV1**	**IV2**	**OLS**	**IV1**	**IV2**
Cohort size	-1.42	-0.95	-2.54	-0.21	-3.91	-12.02**	-1.87	-3.65	-1.94
	(1.11)	(3.22)	(2.67)	(0.94)	(3.50)	(4.70)	(1.56)	(7.44)	(7.66)
Experience	0.08***	0.08***	0.08***	0.05***	0.06***	0.07***	0.10***	0.11**	0.10**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.05)	(0.05)
Experience^2	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.01*	-0.01	-0.01
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Unemployment	-0.00	-0.00	-0.00	-0.02***	-0.02***	-0.02***	-0.00	-0.01	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
Married	0.07***	0.08***	0.07***	0.07***	0.06***	0.05***	0.12***	0.12***	0.12***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
Part-time	0.01	0.01	0.01	0.03	0.03	0.02	0.02	0.03	0.02
	(0.05)	(0.05)	(0.05)	(0.04)	(0.03)	(0.03)	(0.07)	(0.07)	(0.07)
Occupation									
Legislators	-0.05	-0.05	-0.05	0.02	0.01	0.01	0.22	0.21	0.22
	(0.14)	(0.14)	(0.14)	(0.06)	(0.06)	(0.06)	(0.20)	(0.20)	(0.20)
Senior officials	-0.12	-0.12	-0.12	-0.01	-0.00	-0.00	0.19	0.19	0.19
	(0.11)	(0.11)	(0.11)	(0.07)	(0.06)	(0.06)	(0.20)	(0.19)	(0.19)
Professionals	-0.24***	-0.24***	-0.24***	-0.04	-0.04	-0.04	-0.01	-0.01	-0.01
	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)	(0.20)	(0.19)	(0.19)
Technicians	-0.23***	-0.23***	-0.23***	-0.10**	-0.11**	-0.11**	-0.02	-0.02	-0.02
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.20)	(0.19)	(0.19)
Clerks	-0.34***	-0.34***	-0.34***	-0.22***	-0.22***	-0.23***	-0.19	-0.19	-0.19
	(0.06)	(0.05)	(0.06)	(0.05)	(0.05)	(0.05)	(0.20)	(0.20)	(0.20)
Skilled agricultural and fishery workers	-0.31***	-0.31***	-0.32***	-0.28***	-0.28***	-0.28***	-0.23	-0.24	-0.23
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.22)	(0.22)	(0.22)
Craft and related trade workers	-0.26***	-0.26***	-0.26***	-0.19***	-0.19***	-0.20***	-0.06	-0.05	-0.06
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.19)	(0.19)	(0.19)
Plant and machine operators	-0.13***	-0.13***	-0.13***	-0.14***	-0.14***	-0.14***	-0.06	-0.06	-0.06
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.21)	(0.20)	(0.20)
Elementary occupations	-0.30***	-0.30***	-0.30***	-0.24***	-0.24***	-0.24***	-0.17	-0.18	-0.17
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.21)	(0.21)	(0.21)
Urbanisation									
Intermediately	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.03	-0.03	-0.03
	(0.03)	(0.03)	(0.03)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.03)
Thinly	-0.05**	-0.05**	-0.05*	-0.06***	-0.06***	-0.06***	-0.03	-0.03	-0.03
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.03)
Constant	2.00***	1.97***	2.05***	2.42***	2.54***	2.78***	2.28***	2.33***	2.28***
	(0.12)	(0.19)	(0.16)	(0.08)	(0.12)	(0.16)	(0.24)	(0.31)	(0.31)
Dummies									
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations									
Individuals	7,364	7,364	7,364	19,785	19,785	19,785	4,973	4,973	4,973
Cells	2,180	2,180	2,180	2,499	2,499	2,499	1,388	1,388	1,388
Clusters	596	596	596	553	553	553	319	319	319
R^2	0.41	0.41	0.41	0.58	0.58	0.57	0.42	0.42	0.42
F-stat		115.81***	124.82***		53.24***	44.63***		27.37***	21.43***

***/**/* indicate significance at the 1%/5%/10% level, respectively. Standard errors are clustered at the region-experience level. Observations refer either to the number of individuals, the number of region-year-experience cells or the number of clusters (region-experience cells) in the sample. F-stat refers to the first-stage F-statistic on the significance of the instrument in the first-stage regression of the endogenous cohort-size variable.