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*Research Article*

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**Dimiter Philipov**

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# Ageing dynamics of a human-capital-specific population: A demographic perspective

**Dimiter Philipov**[1]

**Anne Goujon**[2]

**Paola Di Giulio**[3]

## Abstract

### BACKGROUND

Research on how rising human capital affects the consequences of population ageing rarely considers the fact that the human capital of the elderly population is composed in a specific way that is shaped by their earlier schooling and work experience. For an elderly population of a fixed size and age-sex composition, this entails that the higher its human capital, the greater the total amount of public pensions to be paid.

### OBJECTIVE

The main purpose of this paper is to analyse the link between human capital and retiree benefits and its effect on population ageing from a demographic viewpoint.

### METHODS

We construct an old age dependency ratio (OADR), in which each person, whether in the numerator or the denominator, is assigned the number of units corresponding to his/her level of human capital. Based on data for Italy, we study the dynamics of this human-capital-specific OADR with the help of multistate population projections to 2107.

### RESULTS

Our results show that under specific conditions a constant or moderately growing human capital may aggravate the consequences of population ageing rather than alleviate them.

[1] Wittgenstein Centre for Demography and Global Human Capital (IIASA, VID/ÖAW, WU), Austria. E-Mail: dimiter.philipov@oeaw.ac.at.
[2] Wittgenstein Centre for Demography and Global Human Capital (IIASA, VID/ÖAW, WU), Austria.
[3] Wittgenstein Centre for Demography and Global Human Capital (IIASA, VID/ÖAW, WU), Austria.

**CONCLUSIONS**
With those findings, the authors would like to stimulate the debate on the search for demographic and/or socio-economic solutions to the challenges posed by population ageing.

## 1. Introduction

Many authors consider an increase in human capital as a major factor for alleviating the negative effects of population ageing (Chawla, Betcherman, and Banerji 2007; Lee and Mason 2010, 2011; Fougère and Mérette 1999; Lutz, Sanderson, and Scherbov 2004). In the macro-economic framework, the classical works on human capital by Theodore Schultz (e.g., 1961) and Gary Becker (e.g., 1964) are followed by the new growth theory, whose proponents, among them Lucas (1988) and Romer (1990), view human capital as an input that increases the labour force's productivity (Skirbekk 2008). They believe that this will stimulate long-term economic growth and thus also facilitate the allocation of the resources required for the retired population (Kemnitz and Wigger 2000). From a demographic viewpoint, the increase in human capital will offset the shrinking working-age population, as those most educated tend to work longer and retire at later ages (Crespo Cuaresma, Lutz, and Sanderson 2009; Lutz, Crespo Cuaresma, and Sanderson 2008; Lutz, Goujon, and Wils 2008; Lutz and KC 2011; Striessnig and Lutz 2014). Advocates of the neo-classical view (Mankiw, Romer, and Weil 1992) are, however, convinced that human capital will affect the productivity growth rate in the short run, while its return will decrease in the long run. In the same vein, Börsch-Supan (2003) argues that a rise in human capital cannot fully compensate population decline.

Research on how rising human capital affects the consequences of population ageing does not explicitly consider the impact of the elderly population's human capital that is shaped by earlier schooling, training and work experience. Retirees' human capital, utilised during their working lives, is decisive for the level of their income. In this paper we consider public pensions of a pay-as-you-go scheme as a proxy for the income of the older population[4]. Hence, for an elderly population of a fixed size and age-sex composition, the total amount of public pensions to be paid increases with the level of its human capital. In a cohort perspective, a rise in the human capital of the

[4] This assumption is made to simplify the discussion. Pay-as-you-go is the preponderant pension scheme in Italy and in many other European countries. The validity of our inferences for other pension schemes requires analyses that are beyond the scope of this paper.

working-age population will generate economic growth, but upon retirement it will also increase the economic burden by a corresponding rise in pensions.

The main purpose of this paper is to analyse the link between human capital and retiree benefits and its effect on population ageing from a demographic viewpoint. Our research method is based on the construction of a population disaggregated by age (as of age 20) and sex where all individuals are weighted according to the level of their respective human capital. We defined the weights for the working-age population by using earning functions and the weights for the elderly population by using human-capital-specific public pension levels. Striessnig and Lutz (2014) apply education-weighted dependency ratios with the purpose to determine the optimal fertility needed to achieve the lowest total dependency ratio. In their calculation they assume the retirement benefits to be the same across all education categories; productivity of human capital is assumed to differ with the ratio of 1 : 1.25 : 1.5 between primary, secondary and tertiary education (Striessnig and Lutz 2014: Appendix table A1). Instead, we infer these ratios by applying earning functions for the working population and empirical data for the retirees.

We examined the dynamics of ageing by using a human-capital-specific old age dependency ratio (OADR) relying on multi-state population projections by levels of education. We applied the method to the population of Italy where changes among cohorts in terms of educational attainment have been radical. In Italy, the share of adults with tertiary education is lower than in many other EU countries. It is expected to rise considerably in line with the target of “at least 40% of 30–34–year-olds completing third-level education” stated in the European Union’s Europe 2020 programme for the present decade (European Commission 2010a). The Appendix provides more information on the Italian context.

Our analysis of how human capital affects ageing is not based on forecasts, but on population projections. We also want to emphasise that these projections permit us to examine the effect of one specific force – namely human capital – on ageing under the *ceteris paribus* assumption, i.e., net of the effect of any other factors such as economic growth, level of un/employment, economic in/activity, ability to work and health, part-time employment, wage and pension differentials by length of working life, pension schemes, savings and spending, consumption patterns, labour-force participation of elderly people, age at retirement and entry into the labour force. Indeed, the future impact of the human-capital-specific OADR on population ageing can be strongly linked with most of these factors. However, before adding these additional factors in the analysis, we need to know how human capital affects ageing and whether it is strong enough to be considered in rigorous analyses of the future of population ageing. Our analysis is purely demographic, and extends inferences based on the use of the conventional OADR.

## 2. Data and methods

We used the European Union Statistics on Income and Living Conditions (EU-SILC) for Italy, 2007, made available in the 2008 wave (IT-SILC XUDB 2010 - version December 2011. For more information on EU-SILC see: http://epp.eurostat.ec.europa.eu/portal/page/portal/microdata/eu_silc [consulted on 10 Dec. 2013].). Launched in 2003, EU-SILC was the first longitudinal micro-level survey that provided comprehensive data on income and a broad range of other social and economic information across all 28 Member States of the enlarged EU and a number of other countries. We used the information on respondents aged 20–64 who work full-time (16,765, representing 70% of total working population) or who are aged 65 and above and receive a public pension (10,464 persons). The selection of full-time respondents is based on their self-defined current economic status; income is the self-declared individual gross income obtained by gainful work. We computed the gross public pension received by a respondent as the sum of old-age benefits, survivor's benefits and disability benefits, for all those who receive a public pension. All private pensions were excluded. Education is indicated as the highest education level attained, using the following categories of the International Standard Classification of Education: ISCED 0–2 (junior-secondary and below), ISCED 3–4 (completed upper-secondary and post-secondary non tertiary), ISCED 5–6 (tertiary education). In this paper, we refer to these three levels also as low, middle and high education.

Table 1 shows the populations aged 20–64 and 65+ and their incomes/pensions disaggregated by three education levels. The population with low levels of education is the largest in both age groups. However, educational improvements are visible across the different cohorts. The old-age population has significantly lower levels of education than the younger cohorts: In 2007, only 15% of the 65+ population had an upper secondary or higher education, as compared to 54% in the 20–64 and 75% in the 20–24 age group in the same year (not shown in the Table). Until the end of the 1970s, educational enrolment in Italy increased most at the lower secondary level. It was only at the beginning of the 1990s that the transition to upper-secondary education became the norm for students.

Table 1 also shows that income and pensions[5] significantly differ by education level: The median annual pension received by retirees with a high education is more than twice that received by their low-educated peers. This differentiation validates our research topic. The pension median levels observed in 2007 are the result of the different pension reforms that were actuated in Italy starting gradually from the 1990s

[5] The median income and pension are computed for all those who receive, respectively, a positive income and a positive pension. People aged less than 65 who receive no income or have a negative income, and people aged more than 64 with no public pension are therefore excluded from the calculation.

(see appendix for more detail). The median income levels observed in table 1 reflect the distribution by age and education of the working population. As much as 43% of the total income produced by highly educated people was actually earned by the population aged 50 and over, with people aged 20–39 (about 43% of the total working population with high education level) having a median income of actually 22500 euros (data not shown). For further details on income level see section 2.2.

**Table 1: Population 20+ and median value of income/pension by three levels of education, Italy, 2007**

| | Numbers (in thousands) | | Percentages | | Income per year, median (Euro) | Pension per year, median (Euro) |
|---|---|---|---|---|---|---|
| **Level of education** | **Age group 20–64** | **Age group 65 and higher** | **Age group 20–64** | **Age group 65 and higher** | **Age group 20–64** | **Age group 65 and higher** |
| Low (ISCED 0–2) | 16,714 | 10,033 | 46 | 85 | 18,892 | 10,749 |
| Middle (ISCED 3–4) | 13,140 | 712 | 41 | 11 | 22,259 | 19,495 |
| High (ISCED 5–6) | 4,718 | 282 | 13 | 4 | 27,769 | 27,445 |
| Total | 34,572 | 11,027 | 100 | 100 | 21,383 | 11,741 |

*Source*: ISTAT (2008) and ISTAT (2007); for income and pensions: EU-SILC 2008

## 2.1 Multistate education-specific population projections

The multi-state population projections used in this research are based on the projections developed by Goujon (2009) in the framework of the MicMac project,[6] which implement the calculation of transition probabilities between four levels of education (ISCED 0–1, ISCED 2, ISCED 3–4 and ISCED 5–6). For the purposes of this paper, the first two education states were aggregated into one (ISCED 0–2) in the result section. The initial year is 2007 and the base-year population was taken from the 2007 Labour Force Survey for Italy (ISTAT 2007); projections were made until 2057 for the first phase and prolonged to 2107 for the second phase, according to the main demographic assumptions presented in Table 2.

[6] The MicMac project was funded under the 6th Framework Programme of the European Union. Details about the projection can be found in Deliverable 3 of the project. See: www.nidi.nl/Content/NIDI/output/micmac/micmac-d3.pdf [last viewed on January 16, 2014].

**Table 2: Fertility, mortality and migration assumptions, Italy, 2007, 2057, and 2107**

| Variable | Total and by education | 2007 | 2057 | 2107 |
|---|---|---|---|---|
| Total Fertility Rate | *Total* | *1.4* | *1.6* | *1.6* |
| | ISCED 0-1 | 1.7 | 2 | 2 |
| | ISCED 2 | 1.4 | 1.6 | 1.6 |
| | ISCED 3-4 | 1.4 | 1.6 | 1.6 |
| | ISCED 5-6 | 1.4 | 1.6 | 1.6 |
| Male life expectancy at age 0 | *Total* | *78.7* | *86.1* | *86.6** |
| | ISCED 0-1 | 76.1 | 81.7 | 81.7 |
| | ISCED 2 | 77.0 | 82.9 | 82.9 |
| | ISCED 3-4 | 82.2 | 88.1 | 88.1 |
| | ISCED 5-6 | 82.5 | 88.4 | 88.4 |
| Female life expectancy at age 0 | *Total* | *84.0* | *90.8* | *91** |
| | ISCED 0-1 | 82.6 | 88.2 | 88.2 |
| | ISCED 2 | 83.7 | 89.6 | 89.6 |
| | ISCED 3-4 | 85.8 | 91.7 | 91.7 |
| | ISCED 5-6 | 86.0 | 91.9 | 91.9 |
| Net migration male (in thousands) | *Total* | *196* | *97* | *84* |
| | ISCED 0-1 | 97 | 50 | 50 |
| | ISCED 2 | 38 | 18 | 13 |
| | ISCED 3-4 | 42 | 20 | 14 |
| | ISCED 5-6 | 18 | 9 | 6 |
| Net migration female (in thousands) | *Total* | *237* | *94* | *79* |
| | ISCED 0-1 | 104 | 42 | 42 |
| | ISCED 2 | 45 | 18 | 13 |
| | ISCED 3-4 | 58 | 22 | 16 |
| | ISCED 5-6 | 29 | 11 | 8 |

* Although the mortality rates by education are constant after 2050, the overall life expectancy changes between 2050 and 2107 because the weight of the different populations in the different education categories changes. Table 2 shows the life expectancies in 2107 according to the trend scenario.

In our analysis, changes in fertility corresponded to the medium variant of the ISTAT projections (ISTAT 2008), further disaggregated until 2050 by educational attainment according to estimates by KC et al. (2010). After 2050, fertility rates and education differentials remained constant. Mortality was disaggregated by education using estimates for 2008, which show that male life expectancy at age 30 is 48 years for men with low education, 52.9 years for men with middle education and 53.1 years for men with high education. The corresponding life expectancies for women are 54, 56.6 and 56.7 years, respectively (European Commission 2010b: 39, Table I.3.7), i.e., a significant difference was observed between the first and the second levels. The differential in life expectancy at birth by education shown in Table 2 was obtained from United Nations standard life tables, applied to the ISTAT 2008 overall life expectancy projection assumptions until 2050 and kept at this level thereafter. Figures for the net number of migrants were based on the latest projections by ISTAT to 2065 (ISTAT 2011, central scenario) and the rate of decrease estimated by ISTAT for net-migration between 2064 and 2065 was kept constant across the rest of the projection period (to 2107), i.e., fewer migrants as the population declines[7]. Migration was also disaggregated by education according to Docquier, Lowell, and Marfouk (2009) for population ages 25+. The distribution of migrants for ages up to 24 followed that of the Italian population.

Although the mortality rates by education are constant after 2050, the overall life expectancy changes between 2050 and 2107 because the weight of the different populations in the different education categories changes. Table 2 shows the life expectancies in 2107 according to the trend scenario.

Our projections were based on two scenarios for the educational transition rates: a constant and a trend scenario. The constant version assumed that the rates observed during the last period of observation (2004–2007) remain unchanged. The trend scenario was set by using transitions across three periods (1995–1999, 2000–2003 and 2004–2007) and extrapolating them until the 2050s. The following targets for reaching maximum transition rates were set along the projection period:

- Maximum value for transitions from ISCED 0–1 to ISCED 2 is 1.0 (i.e., all pupils have at least junior secondary education); achieved in 2032 for men and in 2027 for women.

[7] Although it might be discussed whether a country with a declining population will turn or not to immigration to replace the missing productive population, migration tends to be very volatile, and hardly predictable, hence most – if not all – projection exercises (by national statistical institutions and international organizations, like the United Nations Population Division) tend to lower progressively net migration figures compared to the base year through the projection period and have them converging to 0. Moreover, many European countries faced with the economic crisis tend to lean presently towards more restrictions on immigration.

- Maximum value for transitions from ISCED 2 to ISCED 3–4 is 0.85 (as targeted by the EU in its Lisbon strategy); achieved in 2037 for both sexes.
- Maximum value for transitions from ISCED 3–4 to ISCED 5-–6 is 0.45 (i.e., reach the target set in the Europe 2020 strategy document, levels comparable to those currently reached in the United States; achieved in 2040 for both sexes.

In order to validate our results, we compared the population by age, sex and education obtained from the projections in 2012 in the trend and constant scenarios to that of the Italian Labour Force Survey (LFS) values for the same year. The results were very close in terms of total population by large age groups and sex, and also in terms of levels of education, i.e., the overall difference was less than 5%. It is interesting to see that the 2012 'real' distribution according to the 2012 LFS was closer to that of the constant scenario than to that of the trend scenario.

Table 3 shows the projection results in the first phase of 50 years. We compared the results of the projections to that of ISTAT (2011) available until 2065 and the difference is negligible in all years: Below 1% difference in total population in 2065 between the constant/trend scenario and the ISTAT central scenario. The difference between ISTAT and our projections is slightly larger in the middle of the ISTAT projection period (2020 to 2045) due most likely to different age schedules of migration but never exceeds 2.5%. The age composition (proportion 0–14, 15–64, 65+, and 85+) is also not affected by the introduction of education.

Comparisons with Table 1 show that even in the constant scenario the proportion of the aged population with lower than secondary education (ISCED 0–2) will decline considerably as a result of the recent increases in enrolment rates among younger cohorts. The trend scenario yields a considerably higher education level in the working-age population than the constant scenario.

**Table 3: Distribution of the population 20+ by three levels of education, under constant and trend scenario assumptions, Italy 2057, percentages**

| | Constant scenario | | Trend scenario | |
|---|---|---|---|---|
| **Level of education** | **Age group 20–64** | **Age group 65 and higher** | **Age group 20–64** | **Age group 65 and higher** |
| Low (ISCED 0–2) | 28.5 | 32.9 | 17.4 | 32.7 |
| Middle (ISCED 3–4) | 52.9 | 47.6 | 21.1 | 46.0 |
| High (ISCED 5–6) | 18.6 | 19.5 | 61.4 | 21.3 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 |

*Source*: Authors' calculations

### 2.2 Human-capital-specific age composition of the working-age population

Let us recapitulate what we have done so far. In the first step, we projected the age, sex and education composition of the population. In this framework, each individual contributes exactly one unit to the overall distribution, irrespective of his/her age, sex or level of education. In the next step, we differentiate the units according to the achieved level of human capital. To this end, we apply earning functions to the working-age population (ages 20–64). This can be done in at least two different ways: The first approach is education-specific, considers the number of years spent in school and differentiates persons according to the length of their schooling. As the latter hardly ever changes after age 30, it has the disadvantage that the human capital accumulated per person will not change in the remaining lifespan. The approach is appropriate when education is the sole item of interest in the estimation of human capital.

The second approach, advocated by Mincer (1974), seemed more appropriate for our purposes. It considers work experience in addition to the length of schooling. Hence, human capital can grow throughout the working life of all individuals. We applied a simple form of Mincer's earning function to the three educational levels separately for men and women. We prefer to use the term 'income function' here as the function is estimated based on income from labour before taxes. This function assumes that labour income is positively correlated with schooling and work experience (the longer the schooling/work experience, the higher the income). We linked each level of education with an average number of years spent in school, and work experience with age: the higher the age, the longer the work experience. However, we wanted to take into account the fact that human capital based on work experience accumulated at the end of working life might be outdated and mark a relative decline. Therefore, the income function levels off towards old working ages or takes the form of an inverse U-shape (as a result of approximating long work experience with age-squared in the functional form of the equation). This yields the following regression equation, where Y denotes labour income and ε the error term:[8]

$$Y = \alpha.Education + \beta_1.Age + \beta_2.Age * Age + \varepsilon$$

Labour income is defined as income *before* taxation (gross income) received by a person who is employed *full-time*.

[8] Earning functions are usually expressed in a log-linear functional form. Other functional forms are also considered, such as the log-log and the linear; see reviews by Lemieux (2003) and Polachek (2007). The debate on the functional form refers to interpretations of the coefficients. It is not relevant here as we apply the coefficients without reference to their interpretation.

Less than a dozen persons with extremely high incomes were considered outliers and excluded (limits: more than € 200,000 for persons with lower than tertiary education, and more than € 300,000 for persons with tertiary education). Figure 1 shows the income functions for the two sexes. The figures for the higher education graphs were estimated over the age span 23–63 because of the small number of cases outside this age interval, and the estimates were extrapolated to ages 20 and 65. An example: The values of the income functions at age 50 for men are € 25,000, € 35,000 and €58,000 for levels below junior secondary, upper secondary and tertiary education, respectively. For women, the corresponding figures are € 19,000, € 27,000 and € 40,000.

The mean values by age yielded by each of the income functions matched very well with the means directly estimated from the sample. Comparisons were made for 10-year age groups: 25–34, 35–44, 45–54 and 55–64, separately for males and females and for each education level. Only in 3 out of 24 cases was the mean of the income function outside the 95% confidence interval of the sample mean, namely for males aged 25–34 with secondary and tertiary education and for females aged 35–44 with tertiary education. In most of the other cases, the differences between the two means were smaller than 1%.

**Figure 1: Gross income functions of women (left) and men (right) by age and education level, Italy, 2007**

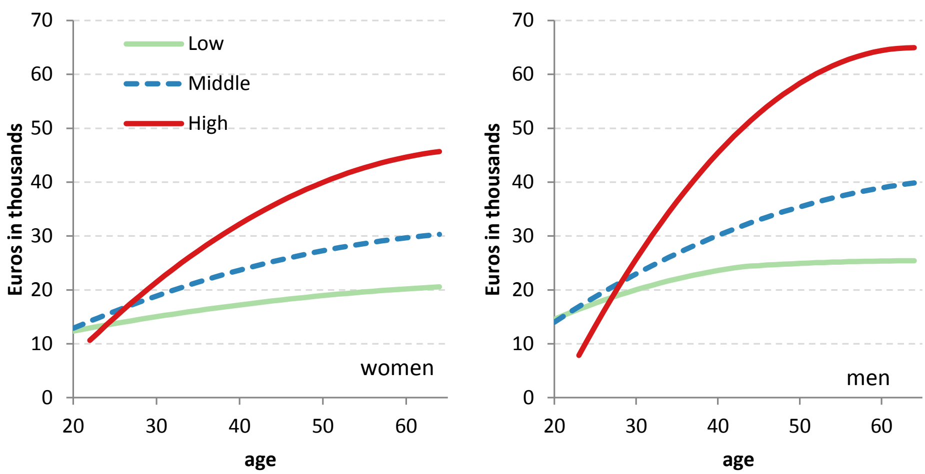


Figure 1 shows well-known characteristics of the distribution of income by age, gender and level of education: higher education leads to higher income, men earn more than women, levels of income flatten (but do not decrease) before retirement. We only mention these findings, as a detailed discussion would be beyond the scope of this article. It is important to note that while the income functions are differentiated by education in Figure 1, they also reflect accumulated human capital, because they depend on the length of working life. If the latter had not been considered, the curves would be straight lines running parallel to the horizontal axis and would not reflect real income by age accurately.

We applied the income functions to construct a human-capital and age-specific composition of the population aged 20–64. Consider as an example the values of the income functions at age 50 as outlined above. For men, the ratios are 1:1.42 for middle education and 1:2.34 for high education, relative to the income of a male with low education. Hence, if a man aged 50 with low education contributes 1 unit to the human-capital-specific age composition of the working-age population, a male aged 50 with middle education contributes 1.42 and a male aged 50 with high education contributes 2.34 units. Similar ratios can be computed for other ages, but they are incomparable across ages, because the income of a less-educated male differs by age. Similarly, the income of a female aged 50 is neither comparable to that of a male aged 50 nor to the income of individuals at other ages. In order to achieve comparability across ages and sexes, we pivoted all values to the lowest income, which is that of a female aged 20 having an education equal to or lower than junior secondary level. If she contributes 1 unit to the age composition, a man aged 50 contributes 2.2, 2.87 or 4.72 units, respectively, depending on his level of education.

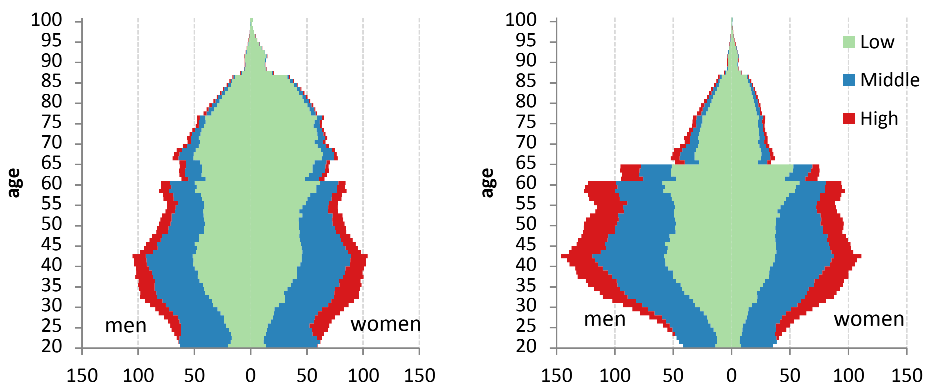
The human-capital composition of the population aged 65 and above is constructed differently. We assumed that this population was retired, so we examine its *retired* human capital. To this end, we made use of the median of education-specific gross public pensions over the whole age span 65 and above. The person-units assigned to a person aged 65 or older with a specific sex and education were once more related to the income of a female aged 20 having an education equal to or lower than secondary level. The median gross public pensions for both males and females and by each level of education were taken from the EU-SILC data (Table 1).

Our method of constructing a human-capital and age-sex composition of the working-age population combines individual-level estimates of income differentiated by human capital, age, and sex, with the *observed* working-age population distributed by the same three components. One may argue that estimates of the income functions derived for full-time employment are assigned to persons employed part-time or not employed at all. Our rationale is that, when assigned to the whole working-age population, these estimates present the full productive capacity, independent of employment and health/disability status. In case the distribution by employment status was introduced, we would have to assume that it would remain unchanged during the next several decades; the effect of similar assumptions on our results is discussed in the last section. Similar note is valid for the population aged above 65, where median human-capital and sex-specific pensions computed from survey data are assigned to the observed population differentiated by education and sex.

### 2.3 Human-capital-specific age pyramid

The human-capital-specific age pyramid shows an age and sex-specific population composition, in which each person's contribution of one person-unit is weighted with his/her level of human capital. The total number of weighted person-units depends on the selected pivot value and on survey information on gross income and public pensions and does not correspond to the actual population size, which, however, is insignificant for the purposes of the present study. Hence, the age composition can be standardised to a total population of say 10,000. Figure 2 shows the age compositions of the studied population broken down into three educational levels (left) and standardised for 10,000 person-units, and the human-capital-specific population (right) standardised for 10,000 human-capital-weighted (or human-capital-specific) person-units. Ages are considered from 20 upwards because our method of constructing human-capital-specific person-units is inapplicable for the population aged 0–19.

**Figure 2: Age composition of the studied population by sex and education (left pyramid), and of the sex and human-capital-specific population (right pyramid), Italy 2007, both weighted to 10,000 units**



Pyramids like the one in the left part of Figure 2 have been extensively studied by Lutz, Goujon, and Wils (2008), Lutz and KC (2011) and, specifically for Italy, by Goujon (2009). Results of population forecasts by levels of education are presented in this form. Pyramids like the one in the right part of Figure 2 have not been discussed in the literature. This is a pyramid of person-units specified by age, sex and human capital, in which the latter is weighted by the size of gross labour income and public pensions. Since income and pensions are of primary importance in the construction of a person-unit, the form of the pyramid is typically influenced by income dynamics: it is thickest around ages 40–50 when labour income is high, and it is very thin from age 65 onwards, when the pension size constitutes the basis for person-unit construction.

## 3. Ageing dynamics: The human-capital-specific old-age dependency ratio

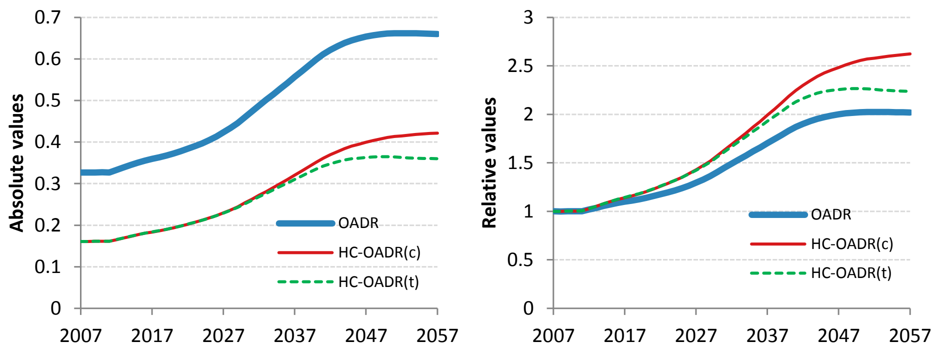
Demographers traditionally study ageing dynamics with the help of such indicators as median age, the share of the population aged 65+ and the old-age dependency ratio (OADR). Figure 2 shows that all of them can be estimated for a population disaggregated by the level of human capital. The analysis in this paper is based on the OADR in conjunction with the dynamics of changes in the population aged 65 and above.

In the conventional OADR, defined as the ratio of the population aged 65 and higher to the population aged 20–64 (the choice of 20 and 65 as cutting ages is insignificant in this paper), each person contributes exactly one unit to the denominator or numerator, irrespective of his/her level of human capital. Instead, we use the population composition disaggregated by human capital as explained above and presented in the right part of Figure 2. The OADR extended in this way thus includes the effect of accumulated human capital. It is a new rate, which we call HC-OADR. For the pyramid in the left part of Figure 2, the conventional old age dependency ratio is 33%, while the HC-OADR is 16% for the population shown in the right pyramid of Figure 2. The latter ratio is considerably lower, because public pensions are lower than gross labour income and hence a pensioner's contribution to a human-capital-specific person-unit is smaller.

We used projections by education till 2057 and constant assumptions thereafter up to 2107 to estimate the HC-OADR for each of the projection years and applied both the constant and the trend scenarios. The ratios of pensions and labour income by age and gender were kept constant at the level of the initial year, i.e., 2007. Figure 3 shows the HC-OADR over the 50 years till 2057 in absolute terms (left) and relative to 1 in the initial year (right).

Our analysis yielded the following results: First of all, the HC-OADR is two times lower than the conventional ratio (16% versus 33%). When measured in person-units based on income and pensions, population ageing seems to be less severe than when measured with the conventional ratio. However, this does not lower the economic burden: it is simply a more precise way of computation than the conventional demographic method. Second, both the conventional and the HC-OADR will grow in the forthcoming decades (see left graph in Figure 3). Education, whether it is kept constant at the initial year of projection or extrapolated to grow till 2057, does not turn around the ageing process, although the latter is attenuated after 2045 according to the trends of the HC-OADR(t) and the conventional OADR. Third, each of the HC-OADR grows *faster* than the conventional OADR (see graphs in the right part of Figure 3). Fourth, when education increases as depicted in the trend scenario, the HC-OADR grows at a slower pace after 2030 than the HC-OADR depicted in the constant education scenario. We also tested the robustness of the projection results by removing the education differentials for fertility, mortality, and migration (not shown here) and it did not affect significantly the relative measure of the HC-OADR compared to the conventional OADR.

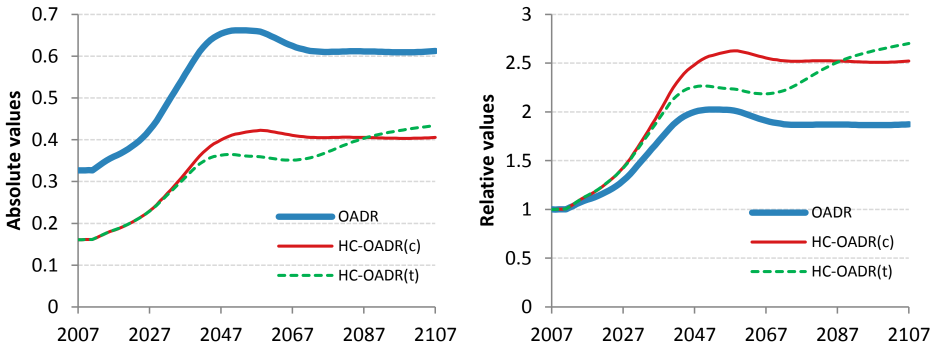
**Figure 3: Trends in the conventional OADR and the HC-OADR [constant (c) and trend scenario (t)], 2007-2057, absolute values (left) and relative to 1 in the initial year (right)**




The last two results outlined above are peculiar. According to contemporary literature, an increase in human capital is expected to decelerate the negative consequences of population ageing. However, at least for Italy and for the next 50 years, our results do not support this view.

Before explaining these findings, let us take a look at the long-term projection up to the point when population stability has been reached. After 2057, the two scenarios were continued for an additional 50 years, based on the assumption that the educational transition rates do not change. When keeping all components of population change constant, projections over a longer period showed that the values observed for 2107 are stabilised to the extent required for the needs of the discussion in this paper. Figure 4 shows the ratios over a period of 100 years.

**Figure 4: Conventional and HC-OADR [constant (c) and trend scenario (t)], 2007–2107, absolute values (left) and relative to 1 in the initial year (right)**



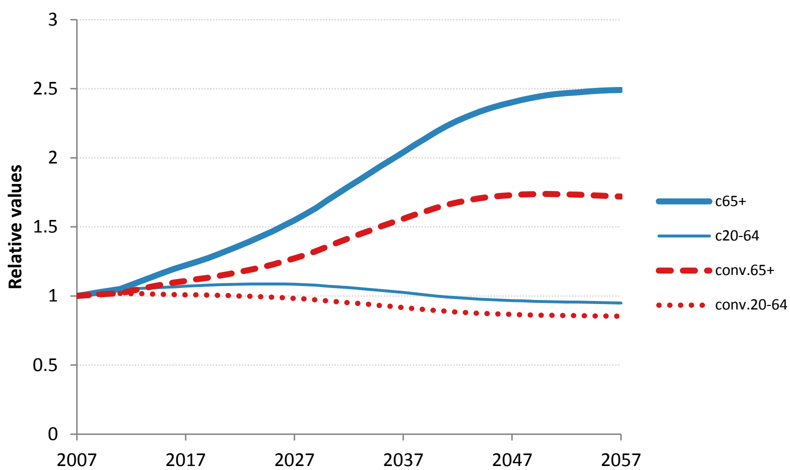

When population stability has been reached, the absolute values of the three indicators (left part) are 0.58 for the OADR and 0.37–0.39 for the HC-OADR. The conventional OADR remains higher than the HC-OADR. The relative dynamics of change are better depicted in the right part where the three indicators are weighted so that their value in 2007 equals 1. The corresponding values at the point of stability are 1.8 for the OADR, 2.3 for the HC-OADR(c) and 2.5 for the HC-OADR(t): i.e., while the conventional OADR is 1.8 times higher as compared to the observed value for 2007, the HC-OADR increases by 2.4 to 2.5 times.

The OADR-based results show that population ageing is faster when quantitative differences between levels of human capital are appropriately measured. What is the explanation for this unusual finding? We refer to the initial and projected composition of the population by education given in Tables 1 and 2. While the less-educated dominated among the old-age population in the initial year, their share declined drastically over a period of 50 years, i.e., the education level of the elderly population increased considerably.

Figure 5 shows how the populations aged 65 and above and the working-age populations change up to 2057 both in the conventional projection and in the constant HC-scenario (where person-units are weighted with their human capital), all relative to 1 in 2007, i.e., the initial year. The working-age populations do not change much during the 50-year period; their relative values fluctuate around 1. The elderly populations, however, increase considerably and the HC-weighted populations grow much faster. Hence, while the denominators of both the OARD and the HC-OADR do not change much, their numerators grow significantly, but those of the HC-OADR grow faster.

The faster growth of the HC-weighted aged population is due to the larger number of highly educated persons whose pensions are higher. Thus an earlier increase in human capital entails a higher demand for public pensions (provided the other conditions remain unchanged). From a demographic viewpoint, this link is sound and obvious. In real life, it is only one among numerous economic and social forces that should be taken into account to better control the overall effect that raising human capital has on the economic and social consequences of ageing. This has not yet been explicitly considered in contemporary research. Our analysis shows that the link can be significant and should not be neglected.

**Figure 5: Relative projected trends in numerators (age group 65+) and denominators (age group 20–64) of old-age ratios, conventional (conv.) and constant HC-scenarios (c)**



## 4. An alternative measurement: Education-specific OADR

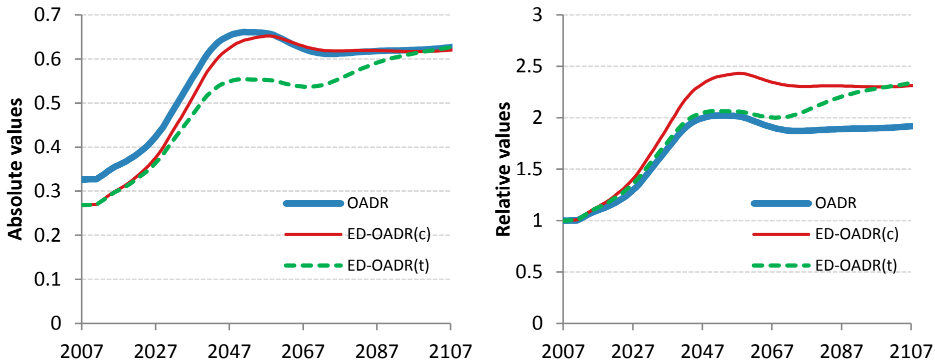
Human capital comprises at least three important components: education, work experience and health. The impact of the first two was taken into account when constructing the HC-OADR. As data on work experience and health are scarce, human capital is frequently equated with education. It is therefore interesting to examine how education affects the ageing dynamics of populations while disregarding the impact of other human-capital components.

Education can be measured in different ways, one being the number of years spent studying. When three levels of education are considered, they correspond to study lengths of around 8 years for students with a junior-secondary or less education, 12 years for those with an upper-secondary education and 16 years for the tertiary educated. This ratio of 1:1.5:2 can be assigned to persons of any age. A disadvantage of this approach is that an elderly person and a working-age person with the same education contribute the same amount of education-weighted person-units to their corresponding age group, while in the approach outlined above, elderly people contribute a lower number of person-units because pensions are lower than labour income. Hence, trends can differ.

The construction of an education-weighted population size for one specific age does not affect other ages because no pivot value is applied. This is a distinctive difference to the method outlined above. Yet the age composition will not be identical to the conventional one because the person-units contributed by individuals with a high education are doubled, and those of individuals with a middle education are increased by one half. Moreover, the proportion of individuals with a specific level of education differs across age groups over time. These differences are reflected in the ED-OADR, which is lower than the conventional OADR (Figure 6, left part) because the proportion of higher-educated people is lower among the elderly than among the younger cohorts and the weighted person-units increase more for the young than for the elderly population. When transition rates and components of change remain constant in the long run, the educational and age composition of the population stabilise and the OADR and the ED-OADR from the two scenarios equalise, which is not the case when using the HC-OADR.

Figure 6 (right part) describes the pace of changes noted for the three types of OADR. Relative to the conventional OADR, the dynamics of the ED-OADR differ from those of the HC-OADR (Figure 4, right part). It is interesting to note that an increase in education keeps the pace of increase in the ED-OADR(t) similar to that of the conventional ratio for some six decades, while the ED-OADR(c) in the scenario based on a constant level of education shows a steeper ageing curve. The population ages faster when human capital is measured in this way instead of using the conventional OADR, but slower than indicated by the ratio that also takes into account the length of work experience.

**Figure 6: Conventional and ED-OADR [constant (c) and trend scenario (t)], 2007–2107, absolute values (left) and relative to 1 in the initial year (right)**




## 5. Summary and discussion

Governments in developed countries make every effort to relieve the unsustainable pressure of growing population ageing. Raising the education level is frequently advocated as a solution because of its established positive impact on the productivity of the labour-force and economic growth. The aim of the article is not to cast doubt on the necessity of education and the many positive externalities associated with enlarged quality education at the individual and macro level, that range from better health to increased economic wealth to mention just a few. However, researchers rarely, if at all, tackle the fact that a better-educated labour force will require higher pensions once it has retired. This obvious consequence shows that raising the level of education is not a cure-all for easing the burden of population ageing. By integrating human capital into the calculation of the conventional population age composition and dependency ratio we show that an increase in education accelerates population ageing.[9]

[9] An anonymous reviewer put it neatly: "Can human capital solve the ageing crisis? Of course not, for the same reason that encouraging migration is no solution: migrants themselves become old. Today's highly qualified high earners become tomorrow's expensive pensioners."

We show these findings for Italy by elaborating the fundamental concept of a person-unit. In conventional calculations, each person contributes one person-unit to the age composition of a population. Instead, we weight person-units with human-capital-based weights. The human-capital-based age composition of the population can be used to compute the share of the population aged 65 and above as well as the human-capital-specific OADR. We found that the share of the weighted population aged 65 and above increases faster than that in the non-weighted equivalent. As a consequence, the HC-OADR increases faster than the conventional OADR.

Constructing weighted population age compositions is a new approach. Let us first consider the OADR. As a measure of population ageing it is subject to a range of assumptions, among them fixed cutting ages, and in particular the upper one. This assumption can be crucial when life expectancy beyond age 65 increases. It was relaxed by Sanderson and Scherbov (2005) who introduced the concept of prospective age based on a reverse measurement of ageing, i.e., not from the start of life but relative to its expected length. Their method of measuring ageing showed a much slower trend of ageing as compared to a measurement based on the OADR.

In a later article, Sanderson and Scherbov (2010) measured ageing based on the ability to work (ratio of persons with disabilities to persons without disabilities). They defined this measure with one cutting age at 30, formulating the ratio for persons aged 30 and above. This indicator of ageing relaxes other implicit assumptions in the conventional OADR, namely that all persons in the economically active age group (approximately 16 to 65) contribute to the economy independently of their health status, and that all persons aged 65 and above are considered to be consumers but not producers of wealth. In a related approach, the so-called Rostock index of ageing considers employed versus unemployed persons in the numerator and denominator of the OADR (Vaupel and Loichinger 2006). While relaxing assumptions of the conventional OADR, their extensions add new assumptions: for example, that the share of persons with abilities/disabilities, or employed/unemployed will remain constant during the projection periods. Nevertheless, they supply useful information and enrich the understanding of population ageing.

The HC-OADR does not incorporate these extensions of the conventional OADR while it relaxes another assumption, namely that each person contributes exactly one person-unit to either the denominator or the numerator (or in terms of earnings, each person receives one and the same income, independently of age, sex, education, work experience, and independently of whether it is labour income or pension). Instead, we differentiate individuals according to the level of their human capital; moreover, we distinguish between working and retired human capital.

Like the above extensions, our HC-OADR also depends on assumptions about such unchanging shares as those related to employment and ability. Its sensitivity to these assumptions does not differ significantly from that in the extensions described above. Consider, for example, the share of unemployed persons. Our assumption is that all people are fully employed. If we relax it and use the share of employment instead, but keep the latter unchanged during the period of projection, we get the same trend in the HC-OADR as the one depicted in the right parts of Figures 3 and 4. The absolute values of the HC-OADR shown in the left parts of these figures would be different and the corresponding trend would run parallel to the one depicted in the figures (presumably it would be even higher, as excluding the unemployed from the denominator would decrease it). Thus our conclusions remain fully valid, as they do not depend on the absolute values of the HC-OADR. Similarly, fixed age at retirement does not have any effect, whether it is set to the level of 63 or 67 or any other level that remains unchanged during the projection period. Relatedly a stepwise increase in retirement age that is enacted in a range of countries (including the Fornero reform in Italy, see appendix) does not eliminate the influence of the specific increase in human capital as discussed in this paper. We also assume constant returns to education.

We applied ratios of human-capital-specific gross income and pensions as they were observed around 2007 and kept them constant during the period of projection. Our findings do not rely on absolute values because their units of measurement depend on assumptions. Hence, we used relative values to restrict the effect of these assumptions.

The issue if the results are applicable to other countries remains open, and will be explored in future research. The Italian case, although atypical in some aspects is not an outlier in the European context. Similar relationship between the income and the pensions of high, medium and low educated people are observed in other countries of Europe. Preliminary analysis based on EU SILC data show that differences in education affect more markedly pensions, and less income in the same manner as in Italy in Spain, the Netherlands, Ireland, France and Finland. In some other countries, the pattern is even more pronounced, like in Portugal, Cyprus or Greece. For example the pensions of the high educated are about five-time higher than the pensions of the low educated in Portugal.

We once more emphasise that our findings are not based on forecasts. They rest on projections that are based on specific assumptions, as is the case with the extensions of the OADR outlined above. The use of projections permits us to analyse a selected force of population change while keeping a range of other relevant issues constant.

Besides the ‘no changes’ assumption, we did not consider additional important aspects such as health and social care for the elderly population. Although they are unrelated to education we can assume that persons with higher human capital are accustomed to a higher quality of life and request more quality in care. Hence, an increase in retired human capital may increase the demand for better quality care. Private pensions were not considered either. It can be argued that they also are proportional to human capital and the assumption about keeping them constant remains valid in the same way as the assumptions discussed above. Numerous other issues related to the increase in the human capital of the elderly population, such as changes in patterns of consumption, private savings and investment, travel, politics and voting etc., remain out of the scope of this paper although they might refer to consequences of population ageing.

Extending our findings towards relaxing some of the assumptions will stimulate the debate on the search for demographic and/or socio-economic solutions to the challenges posed by population ageing. Finally we share a word of caution. In the last section we discussed many assumptions that relate to the method used, mostly following on comments raised by colleagues and the reviewers. Most of these assumptions refer to turning a projection into a forecast, which is not the purpose of this paper. The long list of assumptions may leave the impression that our indicators are less parsimonious than preceding indicators. Such an impression is wrong because other indicators are also subject to many assumptions although they are not explicitly stated.

## 6. Acknowledgments

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## References

Becker, G. S. (1964). *Human capital*. New York: Columbia University Press.

Börsch-Supan, A. (2003). Labor market effects of population aging. *Labour* 17: 5–44. doi:10.1111/1467-9914.17.specialissue.2.

Chawla, M., Betcherman, G., and Banerji, A. (2007). *From red to gray: the "third transition" of aging populations in Eastern Europe and the former Soviet Union*. Washington DC: The World Bank. doi:10.1596/978-0-8213-7129-9.

Crespo Cuaresma, J., Lutz, W., and Sanderson, W.C. (2009). *The dynamics of age structured human capital and economic growth*. Paper presented at the New directions in the Economic analysis of Education. Milton Friedman Institute, University of Chicago, November 21.

Docquier, F., Lowell, B.L., and Marfouk, A. (2009). A gendered assessment of highly skilled emigration. *Population and Development Review* 35(2): 297–322. doi:10.1111/j.1728-4457.2009.00277.x.

European Commission (2010a). Europe 2020: A strategy for smart, sustainable and inclusive growth. Brussels: European Commission.

European Commission (2010b). Demography Report 2010, Commission staff working document. Brussels: European Commission.

Fougère, M. and Mérette, M. (1999). Population ageing and economic growth in seven OECD countries. *Economic Modelling* 16(3): 411-427. doi:10.1016/S0264-9993(99)00008-5.

Goujon, A. (2009). Report on changes in the educational composition of the population and the definition of education transition scenarios: The example of Italy and the Netherlands. Extended version of Deliverable D3 in Work Package 1 (Multistate Methods) of EU (6th Framework) funded project MicMac: Bridging the micro-macro gap in population forecasting.

ISTAT (2007). *Resident population by sex, age and level of education - Italy - Continuous Labour Force Survey – 2007*. Rome: ISTAT.

ISTAT (2008). *Previsioni demografiche 1° gennaio 2007-1° gennaio 2051*. Rome: ISTAT.

ISTAT (2011). *Il futuro demografico del Paese Previsioni demografiche al 2065: peggiora la dinamica naturale, sostenute ma in calo le migrazioni con l'estero, in aumento stranieri e anziani. Rome: ISTAT.*

KC, S., Barakat, B., Goujon, A., Skirbekk, V., Sanderson, W.C., and Lutz, W. (2010). Projection of populations by level of educational attainment, age, and sex for 120 countries for 2005-2050. *Demographic Research* 22(15): 383–472. doi.10.4054/DemRes.2010.22.15.

Kemnitz, A. and Wigger. B.U. (2000). Growth and social security: the role of human capital, *European Journal of Political Economy* 16(4): 673–683. doi:10.1016/S0176-2680(00)00020-3.

Lee R. and Mason, A. (2011). *Population Aging and the Generational Economy: A Global Perspective.* Northampton: Edward Elgar Publishing.

Lee, R. and Mason, A. (2010). Fertility, human capital, and economic growth over the demographic transition. *European Journal of Population* 26(2): 159–182. doi:10.1007/s10680-009-9186-x.

Lemieux, T. (2003). The “Mincer Equation” thirty years after Schooling, Experience, and Earnings. Berkeley: Center for Labor Economics, University of California (Working Paper 62).

Lucas, R.E. (1988). On the Mechanics of Economic Development. *Journal of Monetary Economics* 22(1): 3-42. doi:10.1016/0304-3932(88)90168-7.

Lutz W., Crespo Cuaresma, J., and Sanderson W.C. (2008). The demography of educational attainment and economic growth. *Science* 319(5866):1047–1048. doi:10.1126/science.1151753.

Lutz, W., Goujon, A., and Wils, A. (2008). The population dynamics of human capital accumulation. In Prskawetz A., Bloom, D., and Lutz, W. (eds.). *Population aging, human capital accumulation, and productivity growth*. New York: Population Council.

Lutz, W. and KC, S. (2011). Global human capital: integrating education and population. *Science* 333(6042): 587–592. doi:10.1126/science.1206964.

Lutz, W., Sanderson, W.C. and Scherbov, S. (2004). *The end of world population growth in the 21st century: New challenges for human capital formation and sustainable development*. London: Earthscan.

Mankiw, N.G., Romer, D., and Weil, D.N. (1992). A contribution to the empirics of economic growth. *The Quarterly Journal of Economics* 107(2): 407–437. doi:10.2307/2118477.

Mincer, J. (1974). S*chooling, experience, and earnings.* New York: NBER Press.

Polachek, S. (2007). Earnings over the lifecycle: the mincer earnings function and its applications. Bonn: Institute for the Study of Labor (IZA Discussion Paper 3181).

Romer, P.M. (1990). Endogenous technological change. *Journal of Political Economy* 98(5): 71–102.

Sanderson, W.C. and Scherbov, S. (2005). A new perspective on population ageing. Vienna: Vienna Institute of Demography of the Austrian Academy of Sciences (European Demographic Research Papers 3).

Sanderson, W.C. and Scherbov, S. (2010). Remeasuring aging. *Science* 329(5997): 1287–1288. doi:10.1126/science.1193647.

Schultz, T. (1961). Investment in human capital. *The American Economic Review* 51(1): 1– 17.

Skirbekk, V. (2008). Age and productivity potential: A new approach based on ability levels and industry-wide task demand. In Prskawetz A., Bloom, D., and Lutz, W. (eds.). *Population aging, human capital accumulation, and productivity growth.* New York: Population Council.

Striessnig, E. and Lutz, W. (2014). How does education change the relationship between fertility and age-dependency under environmental constraints? A long-term simulation exercise. *Demographic Research* 30(16): 465–492. doi:10.4054/DemRes.2014.30.16.

Vaupel, J.W. and Loichinger, E. (2006). Redistributing work in aging Europe. *Science* 312 (5782): 1911–1913. doi:10.1126/science.1127487.

## Appendix: The Italian context

We briefly outline the Italian context as our results are shaped by past reforms in the Italian education and pension systems.

Until 1859, compulsory education only comprised two years of elementary school, from 1877 onwards three and from 1907 four years. It took until 1962-63 before the norms proposed in the famous 1926 *Gentile reform* were implemented in the framework of a new reform and 8 years of schooling (lower secondary education) became mandatory in Italy. The reform covered all people born in or after 1949, i.e., those who turn 65 in 2014 or later. Our projection thus captures the massive increase in education of the cohorts born after 1949, which was, in fact, almost invisible among the elderly population before 2007. Differently to most other European countries, upper secondary but not tertiary education steadily increased for the generations born after 1960. Completion of tertiary education only prevailed among the generations born during and after the 1970s. The very dynamic and recent evolution of the education system in Italy makes this country particularly interesting for the topic of our research. We expect the impact of education on ageing dynamics to be quite different in countries with other education histories. More specifically, the evolution of the proposed ageing indicators in the analysed time span will be less dynamic in countries, in which high education was already widespread in the past decades.

Besides the change in the education system, the recent history of pension reforms in Italy is one other specificity of the Italian context which needs pointing out. Until 1992, the Italian pension system was based on an earnings-related scheme, in which the pension level depended on the income the retiree had earned during the last years before retirement and the pension usually amounted to at least 80% of the last pay. Thereafter, and especially from 1995 onwards, the Dini reform introduced a gradual transition from this earnings-related scheme to a contribution-based-system (planned to be completed after 2030), in which the pension depends on the amount the retiree contributed during his/her working life. As a result, the pension amounts to 50–60% of employees' last salary and even less for self-employed retirees. The fact that most of the people aged 65+ in 2007 (the base year for our projections) retired under the earnings-related system might explain why the median pension is comparatively high as compared to the income in the highest education group. First of all, the highly educated are only a very small fraction of the total population aged 65+. They may therefore have had jobs, which were much better paid in the past than nowadays. Secondly, the best-educated in the age group 20–64 include both very young people, whose earning capacity has not yet been exhausted, and highly-educated people, who are forced to accept poorly paid jobs due to difficulties on the labour market.

The new pension reform (known as the Fornero reform) became effective as of 1 January 2012. It incorporated all pensions into the contribution system, raised the pension age for both women and men to at least age 66 by 2018 and higher thereafter, indexed the pension age to changes in life expectancy and introduced strong disincentives for all those who want to retire before the given age limit even if they have already paid their contributions for the required minimum number of years (42 years + 1 month for men and one year less for women in 2012, more thereafter).