Ageing Dynamics of a Human-Capital-Specific Population: The Case of Italy

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1. Background and main research topic

The conventional old age specific dependency ratio (OADR) is defined as the ratio of the population aged 65 and higher to the population aged 20 to 64 in completed years of age. The cut-off ages of 20 and 65 can be different depending on the specific interests of the analysts. The OADR thus defined is interpreted as the number of pensioners which will be supported by one working-age person. It has become a common statement today that one worker supports one elderly person and that this ratio will increase in the future.

The OADR as a measure of population ageing is subject to a range of assumptions that have rarely been subject of discussion. One assumption is that when the OADR is applied for the measurement of trends of population ageing the cutting ages and particularly the upper one are assumed fixed. This assumption can be crucial when life expectancy beyond age 65 increases. The assumption has been relaxed by Sanderson and Scherbov (2005) who introduced the concept of prospective age based on a reverse measurement of ageing: not from the start of life but relative to the expected length of life. Their method of measurement of ageing showed a much slower trend of ageing as compared with a measurement based on the OADR.

In a subsequent article Sanderson and Scherbov (2010) considered measurement of 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 another implicit assumption in the conventional OADR: that all persons in economically active age (approximately 16 to 65) contribute to the economy independently of the status of their health; analogously all persons aged 65 and above are considered to be consumers but not producers of wealth. A related approach is reflected in the so called “Rostocker” index of ageing where employed versus unemployed persons are considered in the numerator and the denominator of the OADR (Vaupel and Loichinger 2006).

At the basis of the OADR there is also the common assumption that each person of working age contributes one person-unit to the denominator of the ratio, and each elderly person contributes one person-unit to the numerator. This assumption does not reflect the heterogeneity of the population for some characteristics that are instead important for the evaluation of the ageing process in a population.

The age, cohort, and sex dimensions applied usually to economic models of ageing do not exhaust the broad potential of demography for the analyses of the heterogeneity of the population and its impact on population ageing. Instead, the composition of the population by human capital can play an important role for the evaluation of future development of the consequences of population ageing. Human capital is usually defined by the number of people, their educational attainment and acquired skills, and their health. Stocks of human capital can therefore increase when education increases, health improves, mortality declines, and fertility rises. Human capital and population are strongly linked, as emphasized by population and human capital forecasts where human capital is

approximated by levels of educational attainment (e.g. Lutz et al. 2008b; see also Lutz and K.C. 2011). A specific feature of these forecasts is that fertility, mortality, and migration are disaggregated by educational attainment, and multistate methods are used to account for consequential transitions to higher levels of education.

Research on the effect of rising human capital on the consequences of population ageing rarely, if at all, considers the fact that the elderly population has its own human capital composition achieved through earlier schooling, training and work practice. This composition defines a corresponding structure in public old-age pensions insofar as the size of pensions depends on past labour incomes which are proportional to human capital. Hence, for an elderly population of a fixed size and age-sex composition, the higher is its human capital, the higher is the total amount of public pensions to be paid. So although a rise in human capital of the working age population will most likely generate economic growth, it will also increase the economic burden of the elderly when this working age population reaches retirement age. Thus a positive economic effect of rising human capital may engineer a negative factor for economic growth.

This discussion indicates that there exists a population dynamics specified by human capital in addition to the conventional specification by population age-sex composition. This topic has not been considered in detail in contemporary research.

The main objective of this paper is to examine the existence of human capital-specific population dynamics and their impact on population ageing. We take as a starting point the outcome of multi-state population projections as discussed by Lutz et al. 2008b which gives a projected distribution of a specific population by age, sex, and levels of educational attainment. We further use a measurement unit to quantify the levels of human capital. This measurement unit, called thereafter person-unit[1], corresponds to the level of accumulated human capital for the population of each age and sex beyond age 20. Thus we achieve a specific population age-sex distribution which differs from a conventional one since one person contributes a number of person-units corresponding to his/her human capital[2]. Next we construct a human capital-specific old age dependency ratio and compare its future trends with those of the conventional demographic old age dependency ratio. We perform an explicit demographic analysis without direct reference to economic dependencies. We use data for Italy and evaluate the outcomes of our analyses for this country. We focus on Italy not only because in this country the ageing process of the population is already extremely pronounced, but also because the composition of the population by education is expected to undergo an important change in the next decades due to the education reform of the 1960s and the increasing participation in higher education.

2. Methods and data

We compare the projected trends of the conventional old-age dependency ratio, OADR, to a human capital-specific old age dependency ratio (HC-OADR). For the latter indicator, each person is represented by a number of units corresponding to this person's level of educational achievement and working experience. The construction is discussed in detail in the next section. Trends in the OADR and the HC-OADR are constructed with the use of multi-state models for projecting an education-specific population (Lutz et al. 1998, 2008b).

2.1 Multi-state projections

[1] The size of a conventional population measured at a moment of time is expressed in terms of number of persons. The size of a population subject to a certain event is measured in person-years. In this paper we use the concept of person-units which denote the contribution to a population specified by human capital measured in terms of income or pensions.

[2] In this paper human capital is measured with the level of education and working experience.

We based the multi-state population projections on the research produced by Goujon (2009) for the EU project MicMac[3], implementing the calculation of transition probabilities between four levels of education (ISCED 01, ISCED 2, ISCED 34, and ISCED 56) and translating those through multistate techniques into projections of the population by levels of educational attainment. For the purpose of this paper, although the population is still disaggregated in the four education categories we show the results according to the following three categories: junior-secondary and below (ISCED 2 and below), upper-secondary (ISCED 3-4) and tertiary (ISCED 5-6). Initial year of projection is 2007; projections are carried out until 2057 (first phase) and to 2107 (second phase) according to the main demographic assumptions detailed in Table 1.

Table 1: Fertility, mortality, and migration assumptions, Italy, 2007, 2057, and 2107

Variable	Total and by education	2007	2057	2107
TFR	*Total*	*1.4*	*1.6*	*1.6*
	ISCED 01	1.7	2	2
	ISCED 2	1.4	1.6	1.6
	ISCED 34	1.4	1.6	1.6
	ISCED 56	1.4	1.6	1.6
e_0 Male	*Total*	*78.6*	*85*	*85*
	ISCED 01	Na	Na	Na
	ISCED 2	Na	Na	Na
	ISCED 34	Na	Na	Na
	ISCED 56	Na	Na	Na
e_0 Female	*Total*	*84.1*	*90*	*90*
	ISCED 01	Na	Na	Na
	ISCED 2	Na	Na	Na
	ISCED 34	Na	Na	Na
	ISCED 56	Na	Na	Na
Net migration Male (in thousand)	*Total*	*196*	*97*	*84*
	ISCED 01	97	50	50
	ISCED 2	38	18	13
	ISCED 34	42	20	14
	ISCED 56	18	9	6
Net migration Female (in thousand)	*Total*	*237*	*94*	*79*
	ISCED 01	104	42	42
	ISCED 2	45	18	13
	ISCED 34	58	22	16
	ISCED 56	29	11	8

The evolution of the overall fertility is taken from the median variant of the ISTAT projections (ISTAT 2008), and is further disaggregated until 2050 by educational attainment according to estimates by K.C. et al. After 2050, fertility rates are kept constant. At present, mortality is not disaggregated by education; however, we will implement some differentials based on estimates for 2008 showing that male life expectancy at age 30 is 48 years for men with lower than secondary, 52.9 years for men

[3] 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, available here: www.nidi.nl/Content/NIDI/output/micmac/micmac-d3.pdf [May 15, 2012]

with secondary, and 53.1 years for men with higher than secondary education. For women the number of years is correspondingly 54, 56.6, and 56.7 (Demography Report 2010, page 41, Table I.3.7). I.e. a significant difference was observed between the first and the second levels; we comment below whether this is a caveat in the analyses. Figures for the net number of migrants follows the latest projections by ISTAT to 2065 (ISTAT 2011) and keeps the rate of decrease estimated by ISTAT for net-migration between 2064 and 2065 constant across the rest of the projection period (to 2107), meaning less migrants as the population declines. Migration is also disaggregated by education, according to Docquier et al. (2009) for population ages 25+. The distribution of migrant for ages up to 24 follows the distribution of the Italian population.

The projections follow two scenarios for the educational transition rates: A constant scenario and a trend scenario. The constant scenario assumes unchanging rates as observed during the last period of observation (2004-2007). The trend scenario is set by looking at the sum of transitions across three periods (1995-1999, 2000-2003, and 2004-2007) and prolonging it until the 2050s. Some targets are set along the line, where a maximum transition rate will be reached:

- Maximum value for transitions from ISCED 01 to 2 is 1.0
- Maximum value for transitions from ISCED 2 to 34 is 0.85 (as targeted by the EU in its Lisbon strategy)
- Maximum value for transitions from ISCED 34 to 56 is 0.45 (to arrive at levels comparable to that of the United States).

2.2 Data

We used EU-SILC data for Italy, data from 2007 (wave 2008). The EU's Statistics on Income and Living Conditions (EU-SILC), launched in 2003, is the first longitudinal micro-level data set to provide comprehensive data on incomes and a large number of other social and economic domains, across all 27 member states of the enlarged EU and a number of other countries. In our estimates we use information for respondents aged 20-64 who work full-time (16765 persons, out of about 24000 persons who work either full or part-time), or who are aged 65 and higher and receive a public pension (10464 persons). The selection of full-time respondents is done on the basis of the self-defined current economic status, and the income is the self-declared individual gross income from labour. As far as pensions are concerned, we computed the gross public pension received by the respondent as a sum of old-age benefits, survivor's benefits and disability benefits. Every form of private pension is excluded. As usual, also in the EU SILC data education is computed as the highest education level ever achieved, and we categorized it into ISCED 0-2 (lower than secondary), ISCED 3-4 (secondary), ISCED 5-6 (higher than secondary).

Table 2 gives the populations aged 20-64 and 65+ and their income/pension disaggregated by the three education levels. The population with education level equivalent or lower than junior secondary is the largest in each one of the age groups. However, education improvements are visible through the different cohorts. Notably the old-age population has relatively lower levels of education as compared with the younger cohorts. Specifically, 85% of the 65+ population have a below secondary education level, compared to 25 percent in the 20-24 age group in the same year (not shown in the table). In Italy, until the end of the seventies, most of the increase in educational enrolment happened at the level of lower secondary education. It was only at the beginning of the 1990s that the transition to an upper-secondary education became the norm for pupils. Income and pensions are very well differentiated by education level.

Table 2: Population 20+ and median value of income/pension by three levels of education, Italy, 2007

	Numbers (thousand)		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
ISCED 0-2	16,714	10,033	46%	85%	18,892	10,749
ISCED 3-4	13,140	712	41%	11%	22,259	19,495
ISCED 5-6	4,718	282	13%	4%	27,769	27,445

Source: ISTAT (2008) and LFS Italy (2007); for income and pensions: EUSILC 2008

Table 3 informs about the projection results in a 50-year period. The proportion of the lower-education aged population will decline considerably.

Table 3: Distribution of the population 20+ by three levels of education, Italy 2057

	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
ISCED 0-2	28.6%	36.9%	17.6	36.8
ISCED 3-4	52.8%	44.5%	21.1	42.9
ISCED 5-6	18.6%	18.5%	61.3	20.4

Source: Authors' calculations

The two scenarios give significant differences with respect to the educational composition of the working-age population: the trend scenario gives a considerably higher education.

2.3 Some notes about the Italian context: education and pension system reforms

Our results are strongly influenced by the past reforms in the education system in Italy. The compulsory level of education was only up to the second class of the elementary school until 1859, up to the third class of the elementary school from 1877 and up to the fifth elementary class from 1907. Only in 1962-63 the proposed norms of the famous 1926 "Gentile reform" were applied in the context of a new reform and the lower secondary education (or up to 8 years of schooling) became the mandatory level of education in Italy. The reform applied to all people born from 1949 onwards, which are becoming 65 years old from 2014 on. Therefore, our projection catches the massive increase in education of this population, which was in fact almost invisible before 2007. For the generations born after the 1950s we observe a steady increase of the upper secondary education but not of the tertiary one, differently from most of the other European countries. Completion of the tertiary education started to be more diffused only for the generations born after the 1970s.

Human capital information is based on the income and pension levels observed in 2007 for the populations aged 20-64 and 65+, respectively. The values of pensions at present strongly depend on the recent history of pension reforms in Italy. Until 1992 the Italian pension system was built on retributions, related to the income received in the last working years before retirement, and usually equal to at least 80% of the final retribution. Thereafter and especially from 1995 onwards, the "Dini" reform introduced a gradual transition from a retribution to a contribution based-system

where the pension depends on the amount of contributions in the working life. As a result, the amount of the pension could be about 50-60% of the last retribution for dependant workers, and much less for self-employed. Since most of the people aged 65+ in 2007, the base-year for our projections, retired with the retribution system, this could explain why the median pension is comparatively high with respect to the income in the highest education group. First, the tertiary educated people are only a very small fraction of the total population aged 65+ and therefore it is possible that they were in job positions which were much better paid in the past than the same positions nowadays. Second, among the best educated in the age group 20-64 we find both very young people, whose earning capacity is not yet at its top, and people who have a tertiary education but, due to difficulties in the job-market, have to perform not very well paid jobs.

3. The human capital-specific age-sex population composition

An important assumption impinged in the conventional OADR is that each person of working age contributes one person-unit to the denominator of the ratio, and each elderly person contributes one person-unit to the numerator. We challenge this assumption. Instead, we assign to each person a number of units corresponding to his/her level of accumulated human capital. To this end we constructed quantitative human capital-specific age profiles separately for the working-age and for the elderly population. On the basis of these profiles, we estimate the total number of person-units within an age group which depends both on the number of persons and on their accumulated human capital.

3.1 Income

An estimation of a person-unit of the working-age population can be done in at least two different ways. The first one is education-specific: one could consider the number of years in school and differentiate all persons according to the length of their schooling. This approach has one disadvantage: since length of schooling beyond age 30 does not change, the accumulated human capital per person will not change further in the remaining lifespan after education is completed. The approach is appropriate when education alone is of interest in the estimation of the human capital. This approach is anyway examined below for purposes of comparison.

Another approach advocated by Mincer (1974) is to consider the working experience, measured by income, in addition to the length of schooling. For this purpose we applied a simple form of Mincer's earning function for the three educational levels and separately for men and women; we use here the term "income function" as it is estimated with labour income before taxes. This function assumes that labour income depends on schooling (the longer the schooling, the higher the income) and on work experience. We approximate period in school with the achieved level of education. We also consider that work experience increases with age: the higher the age, the longer the work experience. However, when work experience is too long, knowledge becomes of old *vintage* and hence income marks a relative decline. Therefore, the income function will have the form of an inversed U-shape (achieved approximating long work experience with age-squared in the functional form of the equation). Thus the following regression equation is applied where E(.) stands for expectation:

$$E(\text{Labour income}) = \text{Education} + \text{Age} + \text{Age}*\text{Age}$$

Labour income was defined as income *before* taxation received by a person who is employed *full-time*. Hence persons with part-time occupation and persons with no labour income were excluded from the estimates. Thus we get an estimate of gross income which, when assigned to the whole working-age population, presents its full productive capacity independent of health and employment.

Less than a dozen persons with extremely high income were considered as outliers and were therefore excluded (more than 200 thousand Euros for persons with education below tertiary, and more than 300thousands for persons with tertiary education). Figure 1 gives the income functions for the two sexes. The graphs for the higher education were estimated over the age span from 23 to 63 years because of the small number of observations outside this age interval, and the estimates were extrapolated. As an example, the values of the income functions at age 50 for the men are 25, 35, and 58 thousand Euros for education levels below secondary, secondary, and above secondary. For women the corresponding numbers are 19, 27, and 40 thousand Euros.

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

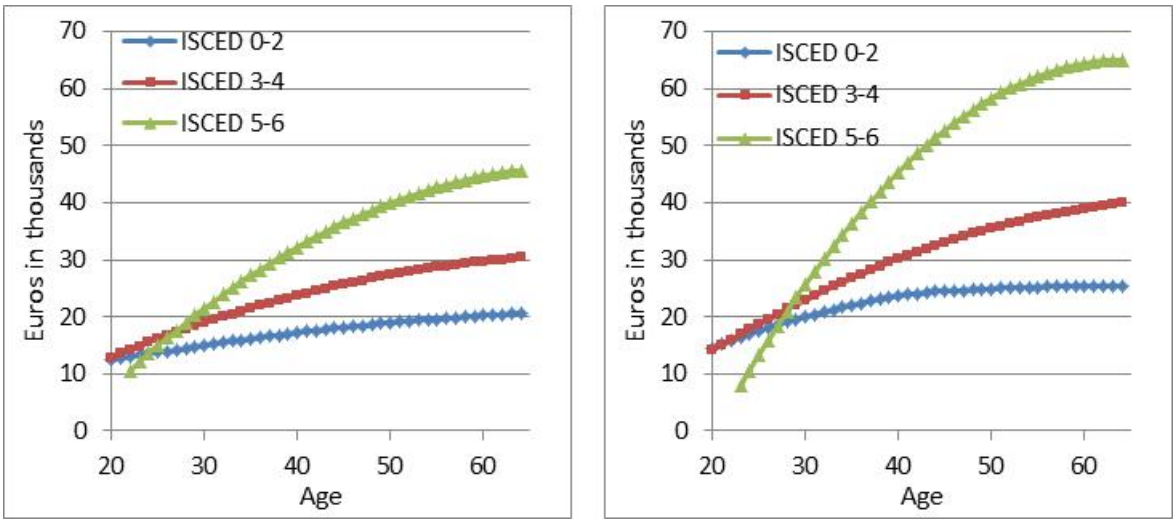


Figure 1: Gross income functions of women (left) and men (right) by age and education level, Italy, 2007.

The figure shows well known features of income by age: higher education brings higher income; men earn more than women; levels of income flatten before retirement but do not decrease. We only mark these observations whose detailed discussion is outside the scope of this article. We note that although the income functions are differentiated by education on the figure they reflect accumulated human capital because they are also dependent on the length of the working life (in case the latter were not considered the curves would have been straight lines running parallel to the horizontal axis).

The income functions can be used to create a human capital- and age-specific composition of the population aged 20 to 64 years. Consider as a starting point of discussion the values of the income functions at age 50 cited above. For men they relate as 1:1.42 for secondary education and 1:2.34 for higher education, relative to the income of a male with an education lower than secondary. Hence if a male aged 50 with lower secondary education contributes 1 unit to the age composition, a male aged 50 with a secondary education contributes 1.42 and a male aged 50 with education higher than secondary 2.34 units. Similar ratios result for other ages but they are incomparable in between as the income of a lower-educated male differ by age. Similarly the income of a female

aged 50 is not comparable to that of a male aged 50 as well as to income of females at other ages. In order to achieve comparability across ages and gender we pivot all values to the lowest income which is that of a female aged 20 with education lower than secondary. If she contributes 1 unit, then the income function estimates that the contributions to the age composition of a man aged 50 are 2.2, 2.87, and 4.72 units correspondingly to the three levels of education.

3.2 Pensions

The human capital- and age- composition at age 65 and beyond was achieved with the use of the median of education-specific gross public pensions over the whole age span 65 and over. The person units that are assigned to a person aged 65 or higher of a specific gender and specific education were related again to the income of a female aged 20 with education lower than secondary. The median gross public pensions for both males and females and by each level of education are provided by the EUSILC data.

In this way we achieve an age composition where the total number of units depends on how a unit is defined. The total number of units is not of significance for the purposes of the present study, so the age composition can be standardized to a total population of say 10000. Figure 2 below presents the age compositions of the observed population distributed by three educational levels (left) and the age composition of the population where the units correspond to units of human capital (depending on income/pension, right), both standardized to a size of 10000 person-units. Ages are considered as of 20 upwards because our method for the construction of person-units is inapplicable for the population aged 0 to 19 years.

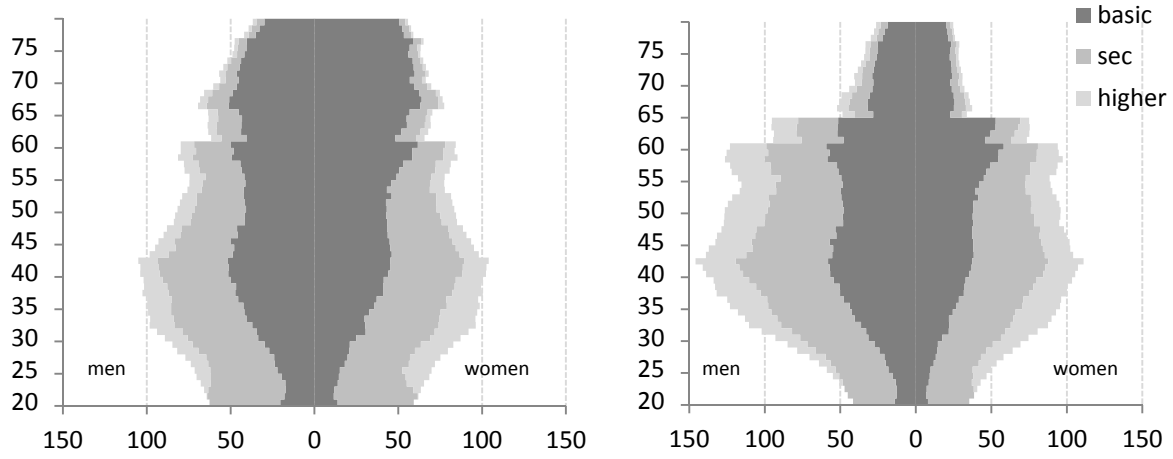


Figure 2: Age composition between ages 20 and 80 of the observed population distributed by sex, education (left pyramid) and the human capital-specific population (right pyramid), Italy 2007

Pyramids like the one on the left side in Figure 2 have been extensively investigated by Lutz et al. (2008b), Lutz and K.C. (2011) and specifically for Italy by Goujon (2009). Outcomes of population forecasts by levels of education are presented in this form. Pyramids like the one on the right side of figure 2 have not been discussed in the literature. This is a pyramid of person-units specified by age, sex, and education, and equalized by the size of labour income or pensions. Since income and pensions are of primary importance in the construction of a person-unit the pyramid has a form that is typically influenced by the income dynamics: it is thickest around ages 40-50 when labour income is high, and it is very thin as of age 65 when pension size is the basis for the construction of a person-unit.

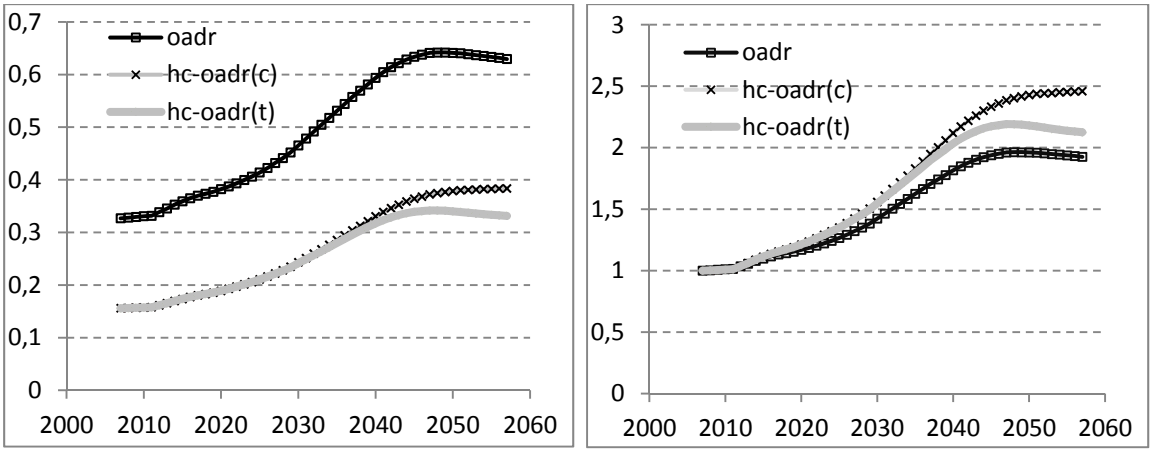
4. Definition and trends in the HC-OADR

As already discussed, the common assumption that each person of working age contributes one person-unit to the denominator of the ratio, and each elderly person contributes one person-unit to the numerator does not reflect the heterogeneity of the population for some characteristics that are instead important for the evaluation of the ageing process. Therefore, we assign to each person a number of units corresponding to his/her level of accumulated human capital, separately for the working-age and for the elderly population. We estimated the total number of person-units within an age group which depends both on the number of persons and on their accumulated human capital.

As shown in the previous section, this estimate was done so that person-units across age groups are compatible. The estimation of the HC-OADR is then straightforward: the number of person-units of the elderly above age 65 is divided by the number of person-units of the working-age population aged 20-64[4]. For the left-side pyramid of Figure 2 this conventional old age dependency ratio is equal to 33 per cent. For the population shown on the right pyramid of Figure 2 the ratio is 16 per cent. The second ratio is considerably lower because public pensions are in general considerably lower than gross labour income and hence their contribution to a person-unit is smaller.

Projections by education till 2057, and further on with constant assumptions till 2107, were used to estimate the HC-OADR for each one of the projection years. Both the constant and the trend scenarios were applied. In these estimates the ratios of pensions and labour income by age and gender were left constant at the level of the initial year 2007. Figure 3 exhibits the HC-OADR over the 50 years till 2057 in absolute terms (left) and relatively to one in the initial year (right).

The following straightforward observations are due. First, the HC-OADR is twice lower than the conventional one (16 versus 33 per cent). When population aging is measured using the definition of person-unit on the basis of income and pensions it is not as severe as it seems when measured with the conventional ratio. However this does not mean that the economic burden is lower. Second, as the left graph on figure 3 shows, both the conventional and the HC-OADR will grow during the forthcoming decades. Education, whether constant at the initial year of projection or extrapolated to grow till 2057, does not cause a turnaround in the process of aging. Third, as the graphs on the right panel show, the rate of growth of each one of the HC-OADR is *faster* than that of the conventional OADR. Still when education increases as in the trend scenario the increase in the HC-OADR is slower than that of the constant education scenario as of the 2030s.



[4] Our analyses do not depend as such on particular cut-off ages because we examine trends and not magnitudes but, once defined they should not change during the projection period.

Figure 3: Trends in the conventional OADR and the HC-OADR, 2007-2057, absolute values (left) and relative to one in the initial year (right). HC-OADR(c) is based on the constant scenario, and HC-OADR(t) on the trend scenario

The fourth observation is unexpected. As the contemporary literature discusses an increase in human capital would slow negative consequences of population ageing, yet our results do not support this view, at least for a period of 50 years.

Since the discussion of the issues is frequently theoretical it might refer to a steady state case with a stable population. Figure 4 shows the ratios over a period of 100 years when they are about stabilized. The extrapolation scenario was continued after 2057 under the assumption of no change in the educational transition rates.

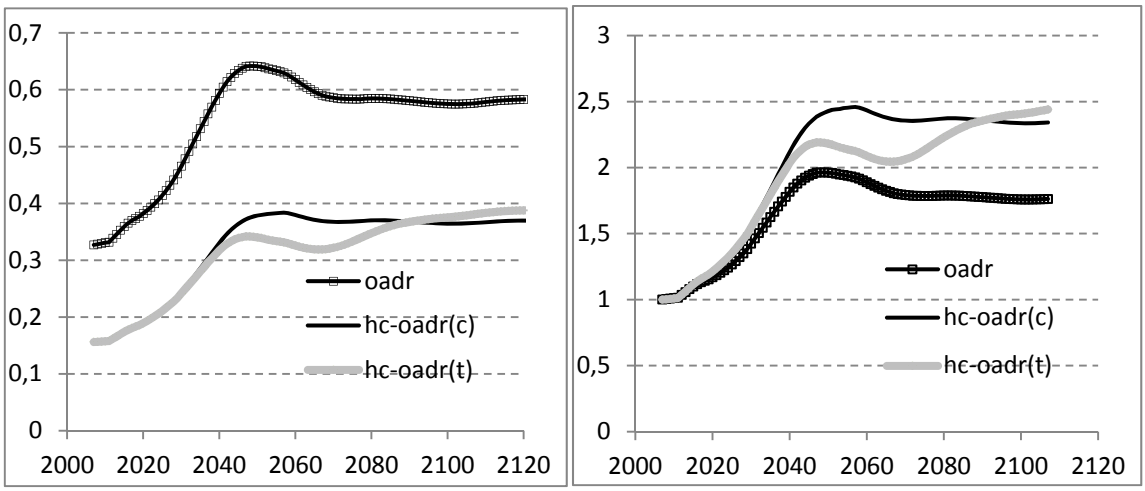


Figure 4: conventional and HC-OADR, 2007-2107. HC-OADR(c) denotes the constant projection scenario, and HC-OADR(t) refers to the extrapolation scenario

The absolute values of the three indicators under stability (left panel) are 0.59 for the OADR and 0.37-0.39 for the HC-OADR. The conventional OADR remains higher than the HC-OADR. Yet the conventional and the HC-OADR are measured in incomparable person-units, so this comparison does not bring to meaningful inferences.

In the long-term the trend of HC-OADR(t) approaches that of the HC-OADR(c) and both remain considerably lower than the conventional OADR. Similar inferences hold for the relative values equal to one in the initial year. The corresponding values at stability are 1.8 for the OADR, 2.4 for the HC-OADR(c) and 2.5 for the HC-OADR(t). That is, while under stability the conventional OADR is 1.8 times higher as compared with the observed 2007 value, the HC-OADR increases 2.4 – 2.5 times.

Thus our results show that population ageing is faster when measured more precisely with human capital-specific person-units. What is the explanation for this unexpected finding? We recall the initial and the projected composition of the population by education given in table 1 and 2. While the lower-educated dominated the old-age population at the initial year, their share declined drastically over a period of 50 years. As a result the education level of the elderly population increased considerably.

Figure 5 displays 50-year-long relative trends in the changes of the two population age groups which constitute the numerator and the denominator of the OADR and the constant HC-OADR. Only the "constant" HC-scenario is displayed as the "trend" HC-scenario gives results that can be interpreted

in a similar way. While the denominators of the two ratios (denoted on the figure with "conv20-64" for the conventional ratio and "c20-64" for the constant scenario) mark only moderate changes, the numerators mark a drastic increase which is considerably faster for the constant HC scenario.

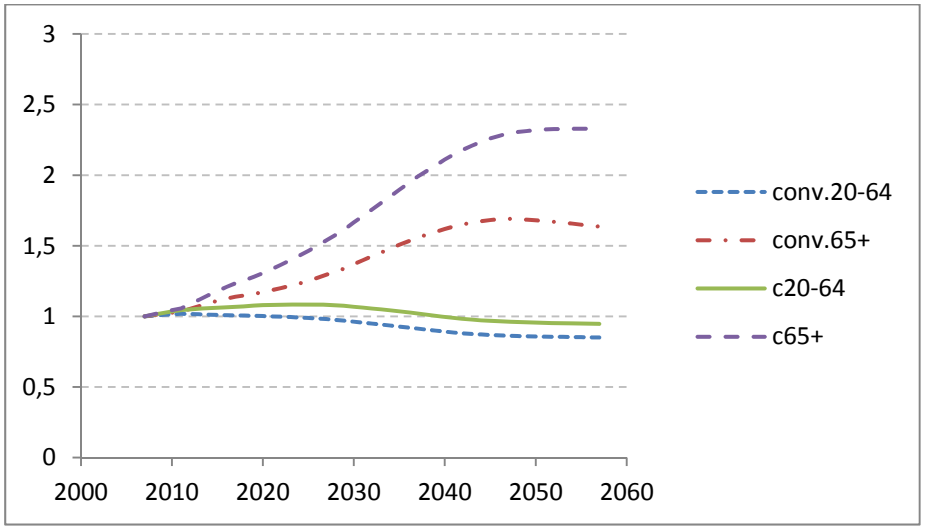


Figure 5: Relative projected trends in numerators (age group 65+) and denominators (age group 20-64) of the old-age ratios, conventional (conv.) and constant HC-scenarios (c).

The figure illustrates differences in population dynamics of a conventional and of a human capital-specific population age composition. Both show a process of relative increase in the aged population but aging in the latter is faster.

5. Sensitivity of assumptions

In this paragraph we test or comment the sensitivity of the results on our basic hypotheses. Each time we relax only one of the assumptions that are accepted in the conventional OADR and we examine what news it brings. We do not claim construction of forecasts. The latter require a synthesis of diverse interdependencies while we analyse only one specific component.

Our results rest on a number of assumptions. In most cases the assumptions are valid because we focus on comparing relative trends, and we do not claim a true absolute value of the new HC-OADR. This explanation validates assumptions like in the following cases:

- Age at retirement fixed at 65 for all education levels. Instead we can take 63 for lower educated and 67 for higher-educated. These changes do not influence trends.
- We designed the human capital functions to respond to the maximum productivity capacity of the working age population, i.e. everyone gets full-time gross earnings specified by education and age. We could have considered instead the labour-force population. In the latter case we must take additional assumptions that unemployment rates and labour-force participation rates remain fixed throughout the next decades.
- Same with old-age population: we consider gross pensions and we state that their median amount by education level applies to the aged population in total. Instead we could include in the model that some of the old age population will not get a public pensions. This approach requires again additional assumptions.

Moreover, as mentioned in a previous paragraph, it is possible to quantify the human capital-specific age structure in alternative ways, namely considering only the education level quantified in some

way. The literature discusses number of years in school. We have made alternative estimates under the assumption that length of education is 8 years for the lower educated, 12 years for the secondary education and 16 years for the higher educated, i.e. a ratio of 1:1.5:2. A disadvantage of this assumption is that one elderly person and one working-age person of the same education contribute the same amount of person-units to the corresponding age group while in our approach the elderly contributes considerably less because a pension is lower than labour income. Hence trends can differ.

Figure 6 below gives long-run trends in OADR in the case when human capital is restricted to length of schooling (ED-OADR). Ultimately all three OADR converge to the same value (left panel). This convergence suggests that the populations stabilize towards one and the same education- and age-specific composition. Additional research is necessary to assess this observation which was not observed when the human-capital composition by education and income was considered (figure 4, left panel).

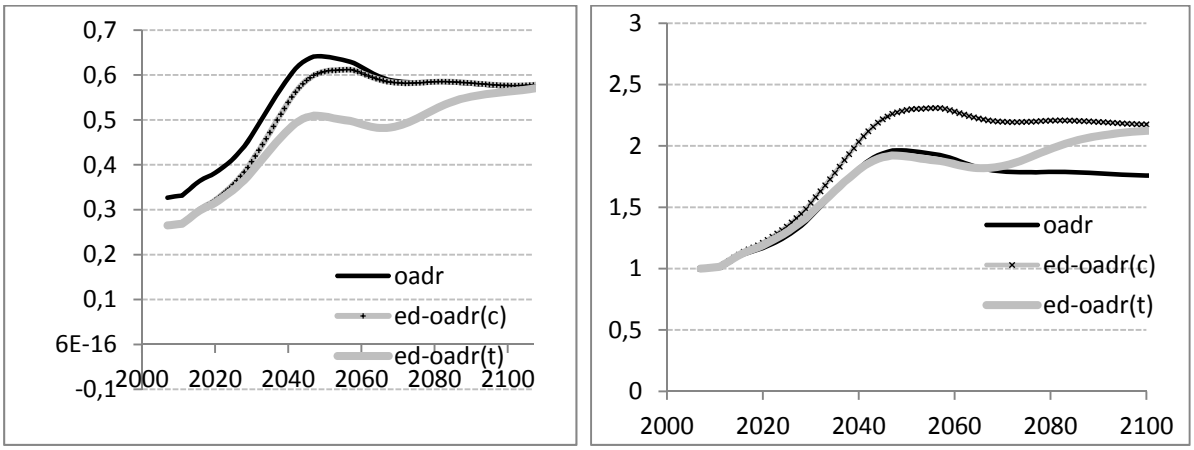


Figure 6: conventional and ED-OADR, 2007-2107. ED-OADR(c) denotes the constant projection scenario, and ED-OADR(t) refers to the extrapolation scenario

Important observations can be inferred from a comparison of the constant and the trend scenarios. In the trend scenario changes are introduced till 2057 and it turns constant after that year. As a consequence, the ratio starts to increase rapidly during the second half of the century and converges to the other two. This change is particularly visible in the relational values displayed on the right panel of the figure.

Noteworthy the trend scenario assures for a rate of ageing that is nearly the same as that measured with the conventional ratio until 2070 (right panel). A faster rate of increase in education would incur an even lower rate of aging; it is however unrealistic as it would bring to a near total dominance of higher education towards 2057.

6. Discussion (very preliminary)

For some years governments of developed countries face the emergency of the sharp increase in population ageing and struggle to find economic solutions to a situation that looks unsustainable. In the context of this debate, the increase in the education level of the population, and its positive consequences on labour force productivity and economic growth, is frequently advocated as a desired solution. Although the increase in education is positive for a number of reasons, researchers rarely, if at all, address the fact that a better educated labour force, will also require higher pensions once retired. This reflexion results in the fact that increased level of education in the population

surprisingly do not always ease the burden of population ageing. By integrating human capital in the calculations of OADR, we could show that increases in education lead to a faster increase in HC-OADR than the conventional ones.

We show these results for Italy, introducing a modified old age dependency ratio that is computed in units that correspond to the quantity of education and work experience (approximated by income/pensions) embedded in each person of the observed population. In this way we are able to show that the increase in education of the retired population in the next decades will indeed increase, and not decrease, the speed of the ageing process.

Although these results are not forecasts but rests on projections based on specific assumptions, they should stimulate the debate on the search of solutions, whether demographic or socio-economic, to the ageing problem.

In underlining the importance of an almost purely demographic approach, we deliberately excluded from our discussion some of the aspects connected to other aspects of population ageing that are, nonetheless, important mentioning. We did not consider additional important aspects such as health care and other care for the elderly. This is independent of education; yet when the number of elderly with higher education increases it can be expected that their demands about quality of services will increase.

We also did not include in the projection any trend in the measure of the human capital, in fact we evaluated the person units in the old age dependency ratio on the basis of the 2007 education and income/pension values. Instead, we could extend our analysis hypothesising a change in the income and pension levels by education as soon as the relative importance of the young and the old-age population changes.

The question if the outcome of our projections is due to the distinctive Italian situation or would be shown also in other contexts remains open. Therefore, we intend to replicate this study for several other European countries where data are available.

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