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Overview on Heterogeneity in Longevity and Pension Schemes

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ABSTRACT

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Differences in life expectancy between high and low socioeconomic groups are often large and have widened in recent decades. In the United States, the differences may now be as large as 10 to 14 years. These longevity gaps strongly affect the actuarial fairness and progressivity of many public pension systems, raising the question of possible policy reforms to address this issue. This paper reviews the empirical literature on the longevity differences across socioeconomic groups and their impacts on lifetime benefits, considers how these impacts depend on four different pay-as-you-go pension structures (calibrated on the US case), and discusses some policy options.

KEYWORDS: Life Expectancy Heterogeneity, Socioeconomic Indicators, Pension Systems, Implicit Tax/Subsidy

JEL CODES: H55, D58, H23, J26

Abbreviations and Acronyms

DB	Defined Benefit
DC	Defined Contribution
HRS	Health and Retirement Survey
NASEM	National Academies of Sciences, Engineering, and Medicine
NDC	Nonfinancial Defined Contribution
NRA	Normal Retirement Age
NTA	National Transfer Accounts
OECD	Organisation for Economic Co-operation and Development
PAYG	Pay-As-You-Go
SES	Socioeconomic Status

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1. Introduction

Health and longevity are among the most basic dimensions of human welfare. Unfortunately, in many countries in Europe, Latin America, and North America, individuals with higher socioeconomic status (SES) have been found to live longer and in better health than those with lower status, whether SES is measured by income, education, or occupation. Differences between high- and low-status groups are sometimes as great as 10 to 14 years of life expectancy. Furthermore, these differences have widened in recent decades.

These widening differences are the most urgent matter for policy intervention. However, they also have secondary consequences in terms of the actuarial fairness and progressivity/regressivity of public pensions, and private sector financial products like annuities and life insurance. This paper reviews the empirical literature on these longevity differences, considers their impact on lifetime pension benefits, discusses some broader economic implications, and considers some policy responses.

2. Conceptual background

Life expectancy summarizes the average mortality experience in a population, but individual experiences vary considerably. Because this uncertain outcome has important implications for economic planning and well-being, both the private and public sector have developed programs and financial products to reduce the risk of living longer than expected. Public programs include annuitized pensions, publicly provided health care, and publicly provided long-term care, among others. Private programs include annuities, life insurance, health insurance, and long-term care insurance.¹

Differences in longevity ex ante and ex post are conceptually different. Ex ante differences arise from differences in the probability of death. Ex post differences in longevity reflect the

¹Health and long-term care insurance primarily deal with uncertainty about the relevant costs, but individuals also face the risk of outliving their savings and these unexpected costs greatly raise this risk – the total risk is an interaction of the two.

random component of death outcomes, given the probabilities. Ex ante differences in longevity can lead to issues of fairness in government programs or private financial programs.

Ex post differences in age at death may result in large differences in benefits received but do not lead to issues of fairness and equity because pooling such risks is the purpose of insurance (National Academies of Sciences, Engineering, and Medicine 2015, 65-71; henceforth NASEM 2015).

Ex ante differences in mortality challenge our concepts of fairness, since risk sharing may on average involve a transfer either from those with shorter lives to those with longer (as in the case of annuities and annuitized pensions) or from those with longer lives to those with shorter (as in the case of life insurance). When ex ante differences in longevity grow larger, these transfers become larger. Additionally, if a public pension program has a redistributive goal, the shorter lives of low-income people can thwart the redistributive intent as has happened in the United States, for example (NASEM 2015).

Focusing on ex ante longevity differences in the public sector, NASEM (2015, 65) states:

“...policy makers would not worry about people with a lower life expectancy receiving lower lifetime benefits from national defense or clean air because there is no obvious time dimension: in any given year, people who are alive pay taxes and receive benefits. But for programs with a strong or explicit time and age dimension, where the ages at which taxes are paid and benefits are received differ significantly, the principle of equal treatment requires consideration of such differences.”

Public pensions and long-term care are obvious examples of programs for which taxes or contributions are paid much earlier than the benefits are received. Because health care costs rise so strongly with age, they also fall in this category (Table 2.1).

Table 2.1: The average ages over the lifecycle of paying federal taxes and receiving federal benefits in the United States based on 2011 NTA data and US life table age distribution for that year

	Age
Total taxes	51.6
Total benefits	60.1
Selected benefits:	
Social Security	72.5
Medicare	74.7
Medicaid, paid to nursing home	79.8

Source: Calculated by the authors from National Transfer Accounts (NTA) data for the US which is accessible at ntaccounts.org.

Note: The NTA age profiles used here estimate all federal tax payments and all federal benefits received based on administrative data and survey data. NTA adjusts these age profiles so that when combined with population age distributions the implied total taxes and costs of benefits are consistent with totals in National Income and Product Accounts. While benefits can be unambiguously assigned to a particular program, it is not possible to say which taxes are used to fund which program. The average age of taxes is calculated for the actual mix of kinds of taxes, including income tax, payroll tax, corporate taxes, and excise taxes, but excluding property taxes which in the United States are levied at the local level, but not the federal. The numbers are the average benefits received at each age weighted by the probability of surviving from age 20 to that age.

Social Security retirement benefits are received 21 years after taxes are paid (72.5–51.6). For Medicare, the difference is 23 years. For long-term care (nursing home care), the difference is 28 years. Of course, these are just the midpoints of broad distributions.² The concept of ex ante longevity depends on the kind and amount of information that is used to estimate the systematic component of longevity variation. For starters, demographers typically estimate mortality differences and remaining life expectancy by age and sex. They might, in addition, estimate mortality by geographic location of residence or of birth, and perhaps by race or ethnicity, or for the foreign-born by country of origin and duration since arrival in destination country. Aside from age, each of these dimensions of variation could indeed lead to questions of fairness and equity. But the focus of interest in recent years has been

² This issue of fairness of public programs has a mirror image, illustrated by public education. Public education is received in childhood and paid for many years later through taxes. Those with ex ante high mortality are less likely to survive to pay the taxes that fund it. To complain about the resulting inequity would require a hard heart indeed.

different, with an emphasis on SES measured by educational attainment, by occupation, or by income, wealth, or labor earnings.³

It is well known that income distributions are becoming more unequal in many countries. As discussed below, in many but not all countries, mortality and longevity differences have also been widening. While widening income distributions seem an obvious explanation for widening mortality differentials by SES, most empirical studies cannot shed light on this matter, because they measure income or education by quantiles, which do not reflect widening or narrowing of distributions.⁴ This paper focuses on mortality/longevity differences by lifetime labor income, the measure used in NASEM (2015), Bosworth, Burtless, and Zhang (2016), and Waldron (2007), for example. It also sometimes considers mortality differentials by educational attainment, which are also widely used in the literature. The focus is on a particular kind of government program: public pensions. Many of the issues that arise, however, would apply equally to some kinds of private pensions or to other kinds of government programs, as suggested by Table 2.1.

3. Empirical evidence on mortality differences by socioeconomic status

3.1. Methodological issues

Reverse causality. Since ill health reduces the ability to work it causes a reduction in labor income. The estimated association of mortality and contemporaneous labor income reflects causality running in both directions, biasing upwards the apparent negative effect of income on mortality. Various methods for at least partially avoiding this problem have

³ One might go further and consider variation in self-assessed health, disability status, health biomarkers, and the individual genome. These possibilities are not entirely fanciful, since a recent OECD (2016) report raises the possibility of using this sort of information to set retirement age or replacement rate. This paper focuses mainly on the more traditional dimensions of SES.

⁴ It might also seem obvious that if socioeconomic differences in longevity have been widening, then variation in longevity must also be increasing. In fact, this is not the case, and in some populations the variation in longevity (conditional on surviving childhood) has declined in recent decades, even as SES differentials widened (see Tuljapurkar 2011, here and for the rest of the paragraph). This happens because the component of variance arising from differences in longevity between SES groups has indeed been growing, but at the same time the component arising from variance within SES groups has been falling. The first might be loosely referred to as *ante* variation (between groups identified by observable characteristics) and the second as *ex post* variation (within groups).

been proposed, and the recent approach of choice for the United States has been to use a multiyear average of income at midlife in relation to mortality at older ages (Waldron 2007; Bosworth and Burke 2014; NASEM 2015; Bosworth, Burtless, and Zhang 2016). Multiyear averages also avoid the problem that income in any particular year may not represent the normal circumstances of the individual. Another approach is to use educational attainment as the measure of SES (Manchester and Topoleski 2008; Olshansky et al. 2012); since education is typically completed in one's 20s, it is not affected by mortality in later life, and it is highly correlated with life expectancy and income. Chronic ill health dating back to childhood could affect both educational attainment and later adult mortality, so this does not solve the problem completely. After controlling for several factors, educational attainment is found to explain about 30 percent of the total difference in mortality by SES in the United States (Hummer and Hernandez 2013).

Households versus individuals. Many individuals live as couples in households, and presumably pool their income in some way. Bosworth and Burke (2014) sum the average midlife earnings of the individuals in a couple and divide by the square root of two, to allow roughly for returns to scale in household consumption.

Changing meaning of absolute measures over time. When considering mortality differences over long periods in which the general level of per capita income or educational attainment changes greatly (Goldring, Lange, and Richards-Shubik 2016), it does not seem advisable to use the absolute levels of these measures for individuals at different times in the same equation. The different absolute levels correspond to very different positions in their distributions at different dates. The literature on income and mortality typically uses income quantiles for each year in the analysis, e.g., quintiles, deciles, or top and bottom halves of the income distribution (Waldron 2007). Similarly, high school graduation rates rose from under 10 percent in 1900 to close to 80 percent by 1970 (Bound et al. 2015). Again, one way to partially address the problem is by using quantiles of the educational distribution rather than absolute levels attained, as done by Bound et al. (2015).

Quantile measures are not a panacea. Unfortunately, the use of quantiles for income or education answers different questions than those initially asked here. The quantile distribution does not change when the income distribution gets more or less unequal – the top quintile is always separated by the same distance from the bottom quintile, by construction. Whether the widening income distribution accounts for the widening mortality distribution, for example, can no longer be asked. Similarly, whether the relationship of mortality to the quantile distribution of income or education is linear is a different question than whether the level of income or education is linearly related to mortality.

3.2. Data

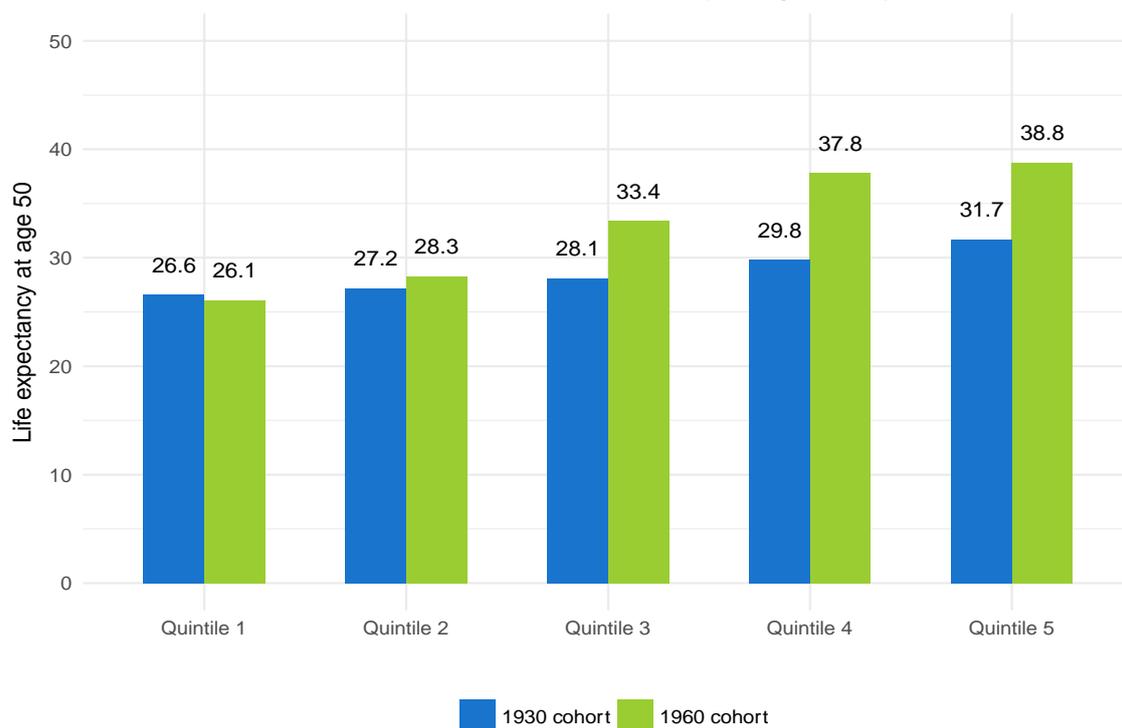
While data availability and limitations differ by country, some common cross-cutting issues are worth discussing. First, the public pension program may provide administrative data on earnings histories and deaths that are sufficient to analyze the relation of mortality to labor earnings averaged over a number of years at midlife, as was done for the United States in the seminal study by Waldron (2007). But such data will be less meaningful in maturing systems that have been expanding the coverage of workers. In those cases, earnings histories will be incomplete for many people and it may not be known whether zeros and gaps are spells of nonwork or spells of uncovered work. Data from HRS (Health and Retirement Survey) or SHARE- (Survey of Health, Ageing and Retirement in Europe) type surveys, which are often linked to public pension data on earnings histories, may greatly enrich the demographic, economic, and health information, but all the problems mentioned for the public pension earnings histories remain. In addition, the sample sizes are rather small, and the historical depth is severely limited by the timespan of survey cycles. Bosworth and Burke (2014) and Bosworth, Burtless, and Zhang (2016) are excellent examples of studies based on the HRS.

3.3. Research findings

A great deal of research has been done on the United States, using both educational attainment and income, and for both longitudinal (cohort) mortality and the more common

cross-sectional (period) mortality measures (Waldron 2007, 2013; Bosworth and Burke 2014; Bosworth, Burtless, and Zhang 2015, 2016; Meara et al. 2010; Hummer and Lariscy 2011; Dowd and Hamoudi 2014; Bound et al. 2015; NASEM 2015; Chetty et al. 2016; Bosley, Morris, and Glenn 2018). This research leads to two main robust conclusions. First, lower SES groups have substantially higher mortality than higher SES groups. Second, the mortality–SES gradient has gotten steeper in recent decades. For example, Rostron, Boies, and Arias (2010) find educational differences in period life expectancy at age 25 of 10 to 12 years for women and 11 to 16 for men, with differences at age 65 of 5 to 8 years (for less than secondary school completion compared to more than university degree). (However, Bosley, Morris, and Glenn [2018] find little or no increase in disparities from 1995 to 2015 at ages 62–64 and above.) Results found in the NASEM (2015) using the HRS and average reported labor income at ages 40–49 are shown in Figure 3.1.

Figure 3.1: US male life expectancy at age 50 by midcareer average labor income quintile for birth cohorts of 1930 and 1960 (extrapolated)



Source: As estimated by NASEM 2015, p.52.

Note: Birth cohorts survive past age 100, but for the 1930 cohort, death rates are observed only from age 62 in 1992 to 78 in 2008, and e50 is estimated by extrapolation of the trends in the fitted model. For the 1960 cohort, the entire estimate is by extrapolation since this cohort did not turn 50 until 2010, outside the sample range. Results are similar for Bosworth, Burtless, and Zhang (2016), who use HRS through 2012 and also use SIPP (Survey of Income and Program Participation).

For the 1930 cohort, life expectancy at 50 (e_{50}) for the top quintile is 5.1 (= 31.7-26.6) years greater than for the bottom quintile. For the 1960 cohort the gap has grown from 5.1 to 12.7 years (= 38.8-26.1). The implications for the US pension system are considered a bit later.

As discussed, education and income are both commonly used as measures of SES. Bosworth, Burtless, and Zhang (2016, 81-82) find that education and income do equally well individually in accounting for mortality differences, and whichever is used they find evidence of strong increases in the high–low gap. They also find that when both are included in the regression, both remain highly significantly associated with mortality, so evidently neither one is sufficient to capture all the covariation of mortality with SES. This finding has implications for how policy might take SES into account.

For Europe and other Organisation for Economic Co-operation and Development (OECD) countries, the OECD (2016) report gives differences in life expectancy at 65 (e_{65}) between highly educated and least educated men and women of between 1 and 7 years, with a median of 3 years for men and less for women. These differences are much less dramatic than for the United States, but they are not strictly comparable. The report also gives differences in e_{65} by high- versus low-income category for men and women in five countries, ranging from a low of 2 years in Chile to 5 years in Australia. Again, these are far less dramatic than the differences estimated for the United States. Methodological details are not given in the OECD report, so it is not clear how the methods may differ. The OECD report also finds that mortality differences by education have been widening, and for the one country with data this was also true for differences by income.

Some studies for Latin American countries report mortality differentials by SES. However, in Costa Rica the mortality gradient by SES is very much flatter than it is in the United States, in part because higher SES individuals also have more unhealthy behaviors (Rosero-Bixby and Dow 2016).

Measuring the SES gradient to inform pension policy. To measure some sort of pure or net association (causal or not) of income or education with mortality, or to understand the pathways through which SES affects mortality, one would include other covariates

such as marital status, geographic region of residence, disability status, biomarkers, health status, and so on. By doing so it is possible to greatly reduce the partial association of SES and mortality, because some of these variables are pathways through which mortality is affected. But for purposes of pension policy it does not matter how or why the SES–mortality association occurs, nor does the direction of causality matter (NASEM 2015; Pestieau and Ponthiere 2016). For policy purposes what matters is the strength and slope of association with income or perhaps education or occupation with controls only for age and sex. For this reason, many of the studies in the literature are not really relevant for policy purposes. Put differently, variables that are not candidates for inclusion in pension rules should not be included in the regression.

Is the relationship linear? Research for the United States has found a nonlinear relationship of mortality to educational attainment in recent decades. Until completion of secondary school, mortality declines slowly with educational attainment, then drops substantially for those who complete secondary school, and thereafter declines more rapidly with increasing education (Hummer and Lariscy 2011; Montez, Hummer, and Hayward 2012). For midcareer average income deciles in the United States, Waldron (2013, 25) shows that the slope remains negative all the way through the deciles – albeit less steep. It can be concluded that in the United States at least, the negative relationship between mortality and SES at older ages persists through the entire income and educational distribution, with some variation in slope. One implication emphasized by Waldron (2013) is that pension policies should not address differences in mortality by using some income threshold above which income variations are irrelevant. The relationship is continuous.

4. How the growing gap in life expectancy affects lifetime benefits in the United States

The US Social Security system is a mandatory, contributory defined benefit (DB) program. Retirement benefits are calculated based on the best 35 years of earnings. The payroll tax rate is constant up to an upper limit of US\$128,400 earnings (in 2018), while the benefit formula is progressive. Individuals with low lifetime earnings have a marginal replacement rate of 90 percent; middle lifetime earnings of 32 percent; and high lifetime earnings of 15

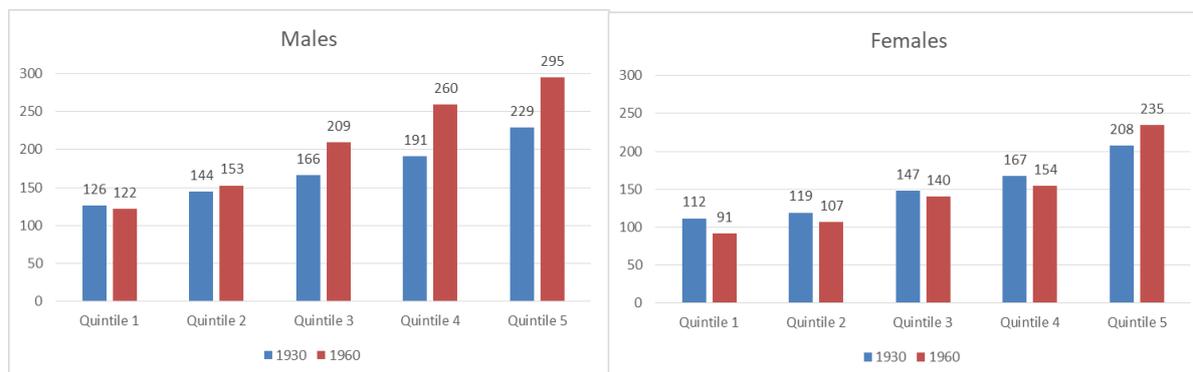
percent. When a person retires before or after the normal retirement age (NRA), the monthly benefits are reduced or credited to keep the system actuarially fair.

The US system is designed to redistribute from higher-income groups to lower-income groups. This is very different from nonfinancial defined contribution (NDC) systems, which are designed to provide benefits proportional to contributions, without redistribution on average. Yet the growing gap in life expectancy by SES poses challenges for both kinds of systems. NDC systems seek to treat all participants in an actuarially fair manner, but with ex ante differences in life expectancy and the use of a single life table to annuitize the contribution account for all individuals, the result is bound to be unfair. In the case of Social Security, higher-income participants with ex ante longer life receive benefits for more years than lower-income participants, undoing some or all of the intended progressivity of benefits on a lifetime basis.

This section reviews the NASEM 2015 study, which analyzed the effect on lifetime public pension benefits of the widening gap between longevity of those with higher and lower long-term labor income (Figure 3.1). The design held constant all aspects of the lifecycles across two simulations, varying only the mortality and survival according to the experience (actual and projected) of the 1930 and 1960 birth cohorts.⁵ The results are shown in Figure 4.1, where present values are calculated with a discount rate of 3 percent (real). The difference between the high and low quintiles for men is US\$103,000 for 1930 cohort mortality, rising to US\$173,000 for 1960 cohort mortality. The high–low gap grows US\$70,000 wider due solely to steepening of the mortality gradient. For women a similar calculation finds that the gap grows by US\$48,000. While Figure 4.1 shows only the effect on lifetime benefits, the effect on labor earnings is quite small because mortality during working years is low (see below for net total benefit results).

⁵ In addition to mortality, health was permitted to vary across the simulations in a way consistent with the mortality differences. This matters very little for this simulation of retirement benefits, but is quite important for the case of public health and disability insurance (NASEM 2015).

Figure 4.1: Present value of US lifetime pension benefits by income quintile under mortality regimes of the 1930 and 1960 birth cohorts (000's of US\$)



Source: Data taken from NASEM 2015, pp.80 and 82.

Note: Discount rate = 3%. In these simulations, everything including earnings histories is held constant except for the mortality regime and health.

The NASEM report also estimated the impact of mortality change on “total” lifetime public benefits for the elderly, which included pensions (OAI), elder health care (Medicare), health care for low income person, including nursing home care (Medicaid), disability insurance (DI), and Supplemental Security Income (SSI).

Including all five of these programs raises the high–low gap even more, by US\$132,000 for men and by US\$152,000 for women. The changes in the net benefits (net of tax payments after age 50) are US\$126,000 and US\$154,000, respectively. These are very large effects.

The report also considers how certain policy changes would affect benefits. Perhaps of greatest interest here is a policy of raising the so-called NRA from 67 to 70, while leaving the Early Retirement Age unchanged. Raising the retirement age is, of course, a form of benefit cut, and because the highest income quintile receives higher benefits as a reflection of its higher lifetime contributions, it also suffers a larger benefit cut in dollars if the retirement age is raised. For this reason, this policy change would reduce the pension benefit gap rather than increase it when measured in dollar terms.

However, the size of the benefit cut relative to initial benefits is greater for the lowest income quintile than for the top quintile. Evaluated under 1960 cohort mortality, the cut is 24.4

percent for the bottom quintile of men versus 19.2 percent for the top quintile, and 16.6 percent versus 13.8 percent for women.⁶

5. General equilibrium issues

To better understand the impact of the increasing gap in longevity on lifetime pension benefits, it is convenient to compare the effects under four different pay-as-you-go (PAYG) pension systems. To take into account the behavioral responses of the different socioeconomic groups, this paper develops a model in which individuals face an uncertain lifetime and decide about the number of years of schooling, the time devoted to work, and their retirement age. The information used in the model is based on the HRS and the NASEM (2015) report, from which cohort-specific life tables by income quintile are derived for the US cohorts of 1930 and 1960 (Figure 3.1). Moreover, the model is constructed to replicate the average lifetime Social Security benefits at age 50 (see Figure 4.1), the average years of schooling, and the average retirement age by income quintile for men born in the United States in 1930.

The four different PAYG pension systems result from combining the following two characteristics. The first characteristic is whether (i) contributions are set a priori, known as defined contribution (DC), which implies that benefits will be adjusted to guarantee the sustainability of the pension system; or (ii) on the contrary, the benefit formula is defined a priori, known as DB, which implies that contributions are adjusted to guarantee the sustainability of the system. The second characteristic is whether the pension system (i) “ex ante” redistributes resources from high-income earners to low-income earners, herein called “progressive”; or (ii) links the contributions paid during the working life to pension benefits in a one-to-one relationship by assuming a constant replacement rate, herein named “flat.”

⁶ Other useful calculations are provided in the literature. For example, in the OECD (2016, 198) report, the ratio of years in retirement to contribution years is 0.38 for the bottom income quartile in the United States in 2011 but is 0.46 for the top quartile. In France, this same ratio varies from 0.41 for manual workers versus 0.49 for higher managerial and professional workers. To maintain the same ratio in 2011 as held in 1979 in the United States, the lowest income quartile would have to work 2.7 years longer, but the highest quartile would have to work 5.4 years longer, twice as great an increase. The necessary changes for France from 1987 to 2011 for the highest and lowest occupational groups are very similar to these figures for the United States.

The model results are based on the following five assumptions:

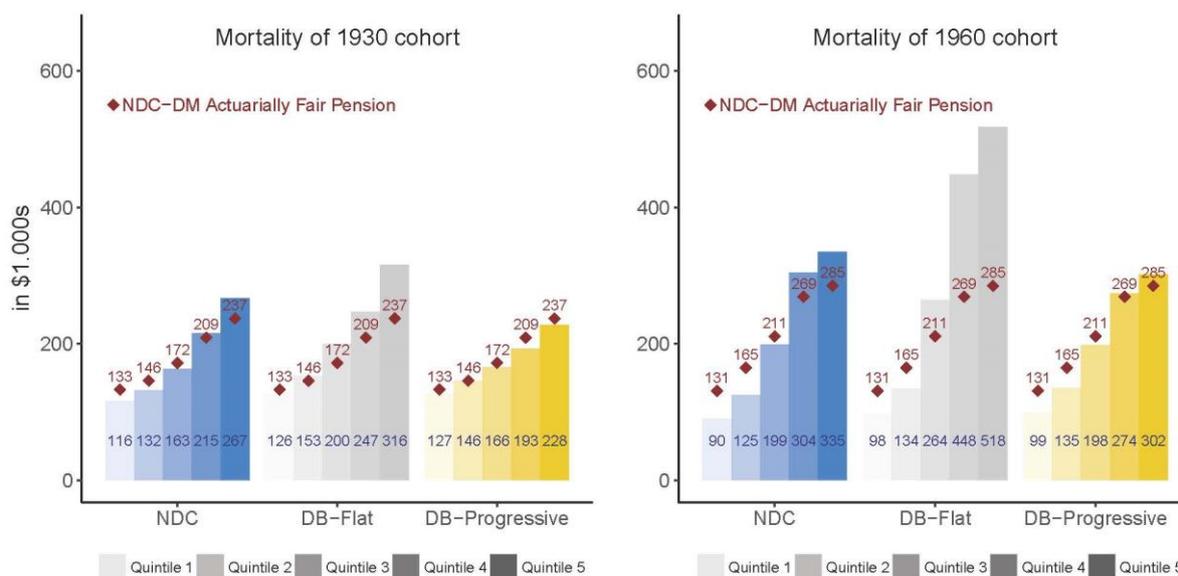
- The model assumes a risk-free discount rate of 3 percent, similar to the one used in NASEM (2015), a stable population growth rate of 0.5 percent, and a growth rate of labor productivity of 1.5 percent per year. The implicit rate of return of the unfunded pension system is 2 percent, which is lower than the market discount factor.
- Individuals choose the number of years of schooling taking into account the existence of monetary and nonmonetary costs of attending school (Sánchez-Romero, d’Albis, and Fürnkranz-Prskawetz 2016).
- Individuals can retire at any time in the NDC systems and between 62 and 70 in the DB systems, similar to the US pension system.
- Workers take into consideration that working is increasingly costly as the retirement period is squeezed. The marginal cost of continued working is proxied by the mortality rate (similar to Bloom Canning, and Moore 2014) of the 1930 birth cohort.
- All individuals are assumed to understand that higher contributions today imply higher future benefits.⁷

In a defined contribution (DC) system, the total number of pension points before retirement is equal to the pension wealth, while in a DB system the total number of pension points at retirement is used to calculate the “average indexed yearly earnings.” To calculate the pension benefit of a retiree in a DC system, the government transforms the pension wealth into an annuity using the average cohort-specific life table. The results from this simulation are labeled as NDC. For comparison, the model also simulates the case in which the government has the cohort-specific life table for each income-quintile, which is labeled as

⁷ The mechanism works as follows. By contributing to the pension system, individuals gain pension points that entitle them to receive a pension benefit upon retirement. Pension points are capitalized (or indexed) by the population growth rate plus the productivity growth rate. The amount of pension points earned each period depends on whether the system is DC or DB. In a DC system, the pension points earned each period are equal to the contribution paid, whereas in a DB system the pension points are equal to the yearly pension benefit accrual.

NDC-DM. This pension system is the benchmark against which all other pension systems can be assessed, since the NDC-DM corrects for differences in life expectancy across income quintiles. In the DB system, the government multiplies the average indexed yearly earnings by a replacement rate and then applies an adjustment factor for early or late retirement to determine the pension benefit of the retiree. The replacement rate can be constant (labeled DB-Flat) or it can increase as the average indexed yearly earnings declines (labeled DB-Progressive). The last simulation corresponds to the US Social Security system.⁸ Finally, to consider actuarial fairness, the model implements for the DB system the penalties/rewards for early/late retirement established in the US pension system for each birth cohort.

Figure 5.1: Present value of lifetime pension benefits by income quintile and PAYG pension system under mortality regimes of the 1930 and 1960 US birth cohorts for men (000's of US\$)



Note: Risk-free market discount rate = 3%. Results for cohort 1960 are detrended by labor productivity growth. Pay-as-you-go pension systems: DC system using the average cohort-specific life table (NDC); DC system using the cohort-specific life table by income quintile (NDC-DM); DB system with a constant replacement rate (DB-Flat); and DB system with an “ex ante” progressive replacement rate (DB-Progressive).

⁸ Retirement benefits are calculated based on the best 35 years of earnings, which are indexed to increases in the average national wage, divided by 420 to obtain the “average indexed monthly earnings” (AIME). Applying a progressive benefit formula with three segments with marginal rates of 0.90, 0.35, and 0.15, AIME is transformed into the “primary insurance amount” (PIA). PIA is the benefit a person would receive if she/he retires at the NRA. The average replacement rate for the average income earner is 41.67 percent.

For the sake of comparison with the NASEM (2015) report, the analysis first calculates the present value of lifetime pension benefits at age 50 by income quintile and four different PAYG pension systems for the 1930 and 1960 birth cohorts (Figure 5.1). The blue bars depict the model results under an NDC system.⁹ Grey bars represent the results of implementing a DB system with a flat replacement rate (DB-Flat) of 41.7 percent, which is the average replacement rate of the US pension system. Yellow bars represent the results for the US pension system (labeled DB-Progressive). Last, red diamonds show the results of the benchmark pension, which is an NDC that applies the cohort-specific life table for each income quintile (NDC-DM). The exact height of each bar in the NDC, DB-Flat, and DB-Progressive is given at the bottom (see blue numbers), while the exact height of each diamond in the NDC-DM system is reported above the symbol (see red numbers).

Figure 5.1 shows that for the 1930 birth cohort, the US pension system (DB-Progressive) generates the lowest difference in lifetime pension benefits across income quintiles among the four pension systems analyzed. The difference between the top and bottom income quintiles is US\$101,000 (=US\$228,000–127,000) in the DB-Progressive and US\$104,000 (=US\$237,000–133,000) in the NDC-DM. Therefore, the DB-Progressive is the pension system with the greatest degree of progressivity. The highest discrepancy is obtained with DB-Flat, followed by the NDC. Specifically, workers in the lowest quintile could expect to receive US\$190,000 (=US\$316,000–126,000) and US\$151,000 (=US\$267,000–116,000) less than workers in the highest quintile in the DB-Flat and NDC, respectively.

Using the mortality rates for the 1960 birth cohort, the difference in lifetime pension benefits across income quintiles widens for all pension systems due to the further increase in the longevity gap. The difference in lifetime pension benefits between the top and bottom income quintiles doubles in the DB systems compared to the 1930 birth cohort, while this difference increases around 50 percent in the NDC systems. In addition, the model shows that once the longevity gap across income quintiles becomes excessively high, the US pension

⁹ The social contribution rates are 11.2 percent and 11.9 percent when assuming the mortality of the 1930 and 1960 birth cohorts, respectively. For the sake of comparison across pension systems, the two NDC systems assume the same social contribution rate obtained for the US pension system (DB-Progressive).

system (DB-Progressive) does not redistribute income from top-income earners to low-income earners as well as the NDC-DM system, even though the US pension system is designed to be “ex ante” progressive. Indeed, in the DB-Progressive system workers in the lowest income quintile receive US\$203,000 (=US\$302,000-99,000) less than workers in the top income quintile, whereas this difference is US\$154,000 (=US\$285,000-131,000) in the NDC-DM system.

Table 5.1 shows the redistributive effects of each pension system in terms of rate of return. Remember that in a mature PAYG pension system with a stable population, the implicit rate of return equals the rate of growth of the population plus the rate of growth of productivity for all income quintiles, or in this case 2 percent per year (Samuelson 1958).

Table 5.1: Internal rate of return by income quintile and PAYG pension system, under mortality regimes of the 1930 and 1960 US birth cohorts for men (%)

Pension system	NDC		NDC-DM		DB-Flat		DB-Progressive	
	1930	1960	1930	1960	1930	1960	1930	1960
Quintile 1	1.5	0.7	2.0	2.0	1.4	-0.3	1.8	1.0
Quintile 2	1.7	1.0	2.0	2.0	1.5	0.3	2.0	1.3
Quintile 3	1.8	1.8	2.0	2.0	1.8	1.6	2.1	2.0
Quintile 4	2.1	2.4	2.0	2.0	2.1	2.5	2.0	2.2
Quintile 5	2.4	2.5	2.0	2.0	2.6	2.8	2.1	2.4

Note: Pay-as-you-go pension systems: DC system using the average cohort-specific life table (NDC); DC system using the cohort-specific life table by income quintile (NDC-DM); DB system with a constant replacement rate (DB-Flat); and DB system with an “ex ante” progressive replacement rate (DB-Progressive).

This rate of return is achieved by all income groups and mortality regimes under NDC-DM in which the pension system calculates the annuity using the mortality rate of each income group. However, in the NDC, DB-Flat, and DB-Progressive cases, lower income quintiles have an internal rate of return lower than 2 percent, while higher income quintiles have an internal rate of return greater than 2 percent. As a consequence, the redistribution goes from poor to

rich. Moreover, this redistribution becomes more regressive when using more unequal mortality rates, such as those of the 1960 cohort. For the DB-Progressive case, which was designed to be redistributive from rich to poor, the system fails to reach this goal due to the differential mortality by income quintile. Indeed, the expected return of a dollar contributed to the pension system by an individual born in 1960 who belongs to the bottom income quintile is 1.4 (=2.4-1.0) percentage points lower than the return received by an individual at the top income quintile.

Public pension systems also distort decisions about labor, education, and consumption, which may cause further inequality. This distortionary effect can be measured as the difference between the value of the extra pension points and the social contribution paid from an additional hour of work (Auerbach and Kotlikoff 1987; Sanchez-Romero and Fürnkranz-Prskawetz 2017; Sanchez-Romero, Lee, and Fürnkranz-Prskawetz 2018). If the value of the extra pension points generated from an additional hour of work is less than the social contribution paid, workers view their contribution as an implicit tax on labor income, which leads to a reduction in labor supply and hence to a fall in consumption. Of course, the opposite effects occur when the value given to the extra pension points from an additional hour of work is greater than the social contribution rate paid.

Table 5.2 shows the implicit tax rate (negative number) or implicit subsidy rate (positive number) by income quintile and PAYG pension system for US male cohorts born in 1930 and 1960. A worker born in 1930 with an income that belongs to quintile 3 faces an implicit tax of 6.1 percent from his contribution to the DB-Progressive system.^{10,11} The implicit tax of a worker born in 1930 with an income that belongs to quintile 3 is 2.6 percent in the NDC, 2.1 percent in the NDC-DM, and 3.1 in the DB-Flat system. Table 5.2 provides three important results. First, given that the assumed market discount factor is higher than the implicit rate of

¹⁰ Alternatively, given that the social contribution rate faced by the 1930 birth cohort is 11.2 percent, a worker belonging to this cohort considers that 46 (= (11.2 percent – 6.1 percent)/11.2 percent) percent of each dollar contributed at age 50 is invested in a savings account (saving share), while 54 (=6.1 percent/11.2 percent) percent is taxed (tax share). Similar interpretations can be given to all other numbers.

¹¹ The implicit tax in the DB-Progressive case is higher than in all other pension systems because the replacement rate decreases as the average indexed yearly earnings increases.

return of the PAYG system, all the numbers are negative. As a consequence, individuals view their contributions as an implicit tax (Auerbach and Kotlikoff 1987; Börsch-Supan 2006). Second, in the NDC and DB-Flat cases, the system penalizes short-lived and poor workers more than long-lived and rich workers. Third, the NDC-DM system produces very equal tax rates across all five quintiles, because the distortion is due solely to the differences in the retirement age. This last result suggests the value of introducing reforms in the direction of applying cohort-specific life tables for different socioeconomic groups, as proposed by Ayuso, Bravo, and Holzmann (2017).

Table 5.2: Implicit tax rate (negative number) and implicit subsidy rate (positive number) on labor by income quintile and PAYG pension system under mortality regimes of the 1930 and 1960 US birth cohorts for men (%)

Pension system Birth cohort	NDC		NDC-DM		DB-Flat		DB-Progressive	
	1930	1960	1930	1960	1930	1960	1930	1960
Quintile 1	-3.2	-5.1	-2.1	-2.1	-4.1	-8.7	-5.0	-6.9
Quintile 2	-2.9	-4.5	-2.1	-2.3	-3.9	-7.8	-4.5	-6.2
Quintile 3	-2.6	-3.1	-2.1	-2.5	-3.1	-4.9	-6.1	-6.6
Quintile 4	-2.0	-1.7	-2.2	-2.7	-2.3	-1.9	-7.6	-7.6
Quintile 5	-1.3	-1.4	-2.4	-2.8	-1.0	-0.8	-7.2	-7.3

Note: - signals a tax and + signals a subsidy. Values calculated at age 50. Pay-as-you-go pension systems: DC system using the average cohort-specific life table (NDC); DC system using the cohort-specific life table by income quintile (NDC-DM); DB system with a constant replacement rate (DB-Flat); and DB system with an “ex ante” progressive replacement rate (DB-Progressive).

6. Policy options

This section considers some policy options for addressing the negative effects of the increasing gap in life expectancy by SES on PAYG pension systems. An important result already shown is the necessity of accounting for the mortality differential by SES. Indeed, with an increasing longevity gap by SES, the pension system that does not account for the differential mortality will become “ex post” highly regressive. Here, the pros and cons of different reforms

are analyzed along three dimensions: (i) benefits, (ii) contributions, and (iii) the socioeconomic variable(s) to be used for differentiating across groups.

6.1. Benefits

Redesigning the benefit formula to cope with different “ex ante” life expectancies can be done through adjusting the annual benefit or through modifying the retirement age for each socioeconomic group (which amounts to the same thing).

In the presence of ex ante differences in life expectancy, an actuarial adjustment of the pension benefit – based on the average cohort life table – penalizes those with low life expectancy and favors those with long life expectancy.

In this context, it is desirable that the actuarial adjustment should be specific for each socioeconomic group. If this policy is not feasible, another approach would be to apply the actuarial adjustment of the most disadvantaged group for retirement before the NRA, and after the NRA the actuarial adjustment of those with the highest life expectancy.

An alternative option in a DB system for reducing the polarization of the present value of lifetime benefits is to change the replacement rate (Figure 5.1). In a DB-Flat system, moving to a replacement rate that varies by SES (DB-Progressive) would be desirable. For example, the annual benefit rate could be adjusted when mortality changes or differs so as to keep constant the ratio of present value of lifetime benefits to present value of contributions, or the implicit rate of return. In an NDC system, equity would be improved by applying the life table specific for each socioeconomic group or using a different effective interest rate for each socioeconomic group.¹²

¹² The first option is a priori better since it clearly accounts for differences in life expectancy. But if differences in life expectancy are correlated with other characteristics, such as the number of offspring, which influences the intrinsic return of the PAYG system, using a different effective interest rate by socioeconomic group could also be used to reduce the difference in the present value of lifetime benefits across socioeconomic groups. Indeed, policies that link pension entitlements to the quantity, and quality, of offspring have been proposed several times in the literature (Demery 1987; Sinn 2004; Fenge and Meier 2005).

6.2. Contributions

Some of the negative consequences of the increasing gap in life expectancy by SES are strengthened at the contribution side. Low socioeconomic groups enter earlier in the labor market and face a greater unemployment risk, especially late in their working lives, than high socioeconomic groups. Hence, when the pension benefit formula gives a greater weight to contributions late in the working life, the pension system tends to polarize even more the present value of lifetime benefits across socioeconomic groups. To avoid this polarization, pension systems should calculate the pension benefits using both all the years contributed and the total amount contributed to the system. Similarly, pension systems that index past contributions less than the growth of the labor force in real efficient units (known as the Aaron-Samuelson condition) also give more weight to late contributions.¹³ Therefore, PAYG pension systems should also use the implicit rate of return of a PAYG system as the indexation, or capitalization, factor for past pension contributions.

It is also increasingly debated whether pension benefits should be financed not only through contributions but also through taxes. This strategy has three major drawbacks. First, any tax will have a negative effect on labor income and thus on the implicit tax/subsidy (Sanchez-Romero, Sambt, and Frnkranz-Prskawetz 2013). Hence, the implicit tax may also rise rather than decrease. Second, if the marginal tax paid by long-lived and wealthy workers is lower than the marginal tax paid by short-lived and poor workers, then shifting the finance toward taxes will generate a higher distortion. Third, it will become more difficult for workers to link their contributions to their pensions. At the same time, it is recognized that for some countries in special circumstances (such as a very large informal sector and highly unequal distribution of income), other considerations may dominate.

¹³ An indexing factor lower than the growth of the labor force in real efficient units raises the implicit tax for young workers at the expense of producing an implicit subsidy for old workers. For example, consider a worker who earns exactly the average labor income and contributes to a pension system with a flat replacement rate of 50 percent and an indexation factor of zero percent (in constant terms). If the implicit rate of return of the PAYG system is 2 percent, the contribution paid at age 30 will increase less rapidly than the total wage bill of the economy. As a consequence, when the individual retires at age 65, the additional pension benefit entitled from the contribution at age 30 will be close to 25 ($= 0.5 \exp\{(0 - 0.02)(65 - 30)\}$) percent of the average income of a worker rather than 50 percent.

6.3. Socioeconomic variables

To implement some of the recommended policies, it is key to construct cohort-life tables by SES. In this regard, Ayuso, Bravo, and Holzmann (2016) provide an overview of the suitability of different socioeconomic indicators for capturing the difference in life expectancy. In addition, OECD (2016, 2017) reports data for many countries on differences in mortality rates by education, occupation, and lifetime earnings. In principle, the choice of a socioeconomic indicator should be based on two major criteria: (i) it should capture the strength of the increase in the life expectancy gap; and, conveniently, (ii) it should not change over time. For instance, the occupational group is an indicator that captures the increasing gap in longevity, as has been found in several countries (Burström, Johannesson, and Diderichsen 2005; Luy, Di Giulio, and Caselli 2011; Luy et al. 2015). However, the use of the occupation group as an indicator is more controversial than education and income level, since individuals can have several occupations over their working life and it can produce an adverse selection effect (Pestieau and Racionero 2016).¹⁴

Sex is an indicator that does not change over time. However, looking at age-profiles of consumption and labor income estimated for the NTA/AGENTA¹⁵ project, small differences in consumption and large differences in labor income by gender are observed, which suggests a significant pooling of resources among household members (Istenič et al. 2016). Under such a circumstance, it is then logical to use a unisex life table to pool the risk of the household, rather than at the individual level. Nevertheless, the increasing relative

¹⁴ An alternative is the use of health indicators as instruments for measuring the gap in life expectancy by SES. Some of these health indicators are smoking and drinking habits, body weight index, grip strength, disability status, and genome, among others. However, to avoid adverse selection, one might exclude smoking and drinking habits and, to some extent, body weight. The genome qualifies as a suitable indicator, but only 25–30 percent of the mortality gradient is due to exogenous factors such as genetic background (Christensen, Johnson, and Vaupel 2006). Hence, additional indicators are necessary.

¹⁵ The EU-funded AGENTA project (www.agenta-project.eu; AGENTA = Ageing Europe -An Application of National Transfer Accounts for Explaining and Projecting Trends in Public Finances), which relies on the National Transfer Accounts (NTA) methodology (see www.ntaccounts.org), measures how the difference between consumption and labor income of each age group is financed through the ownership of assets, public transfer, and private transfers. The data explorer (wittgensteincentre.org/ntadata) contains monetary and nonmonetary age profiles by age and sex for 25 European countries.

importance of different household types and individualistic lifestyles creates a need for finding new solutions and raises very difficult questions about gender-specific mortality differences. Education is also somehow problematic since pensions may have a positive impact on education (Sanchez-Romero and Fürnkranz-Prskawetz 2017) and education has a positive impact on life expectancy (Lleras-Muney 2005). Therefore, before a pension reform in which the use of cohort-life tables by SES is introduced, to avoid unexpected adverse selection effects, it is necessary to account for the impact that the pension system may have on the socioeconomic indicator.

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