Part II

Conceptual Issues of Design and Implementation
Chapter 6

Demographic Uncertainty and Evaluation of Sustainability of Pension Systems

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Population aging in Europe is more complex than is generally recognized. The uncertainty in demographic projections is also larger than is usually assumed. This makes the assessment of long-term characteristics of pension systems challenging. Since different pension policy instruments react in different ways to demographic developments across cohorts and over time, the risk characteristics of the existing policies and proposed alternatives should be investigated and “crash-tested” under a wide range of realistic alternatives.

Because of the complexities of changing age structures, neither individuals nor firms nor administrators of pension systems can easily see what will happen to pensions and contributions if unlucky demographics materialize. Thus it is difficult for anyone to design and apply their risk strategies efficiently. “Crash testing” provides one way of addressing the problem. The broader conclusion is that for a pension strategy to be sustainable, it should explicitly state what actions are to be taken if the population and the economy do not evolve as expected. For example, while the notional defined contribution (NDC) system in Sweden provides an exceptional degree of transparency in this respect, the challenge of quantifying and communicating the risk characteristics of the system to the population at large remains.

This study combines stochastic population simulations with an overlapping generations (OLG) model that assumes perfect foresight from the agents. We view this as a first step toward a more comprehensive model, in which future uncertainty is handled in a more advanced manner. Yet even the current models provide novel insights. New questions can be formalized and new strategies entertained. We suggest areas for future research that are relevant for pension policy design.

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Uncertainty Caused by Lack of Sustainability

A well-known definition of the sustainability of fiscal policies is the view of the Organisation of Economic Co-operation and Development (OECD): “Sustainability is basically about good housekeeping. It is essentially about whether, based on the policy currently on books, a government is headed towards excessive debt accumulation.” More precisely: “Fiscal policy can be thought of as a set of rules, as well as an inherited level of debt. And a sustainable fiscal policy can be defined as a policy such that the ratio of debt to GNP eventually converges back to its initial level.” The forecasts for spending and transfers are taken as given. This is close in spirit to generational accounting.

In the case of pension systems, the OECD view requires that the current contribution rate suffice to finance benefits and that the possible fund stays at a reasonable level compared with the size of the system. However, other aspects merit attention. In particular, a contributor may consider a system sustainable even if rules are changed or pensioners suffer but the contribution rate does not change too much. A pensioner may consider the system sustainable as long as the pension is as expected, even if this requires changing the rules and the contributors suffer. In either case the risk is that, because of future developments, the system puts an unexpected strain on one party or another. If the likelihoods of the various risks were known, the agents could prepare for them in a rational manner. Reducing the scope of the unexpected seems to be a natural aspect of sustainability.

In game theory, a strategy is a set of rules, defined for the present and the future, stating what action will be taken under all states of the world. In the case of pensions, a sustainable policy strategy is a set of rules such that both the contributors and the pensioners know, beforehand, what will be done in any reasonable future circumstance, and they accept the future actions, or at least cannot force a change of the system.

The difference between a policy and a policy strategy is a very practical one. Considerations about sustainable pension policies are usually based on one set of base assumptions about key factors such as future demographics, productivity, and interest rates. In contrast, considerations about sustainable pension strategies must be based on a large number of possible states of the world that cover a realistic range of economic and demographic developments.

The whole Swedish NDC system may be thought of as a step toward implementing a strategy rather than merely being a set of policy instruments. It is “designed to be financially stable, that is, regardless of demographic or economic development it will be able to finance its obligations with a fixed contribution rate and fixed rules for calculating benefits.” Adjustment mechanisms have been defined; even a “brake” has been established, to be activated if things go badly. Whether the strategy is sustainable depends on its operating characteristics. Will the contributors and pensioners accept the outcomes that come of the new legislation, under different future circumstances? The time horizon may also be important. Valdés-Prieto (2000) suggests that long-term financial stability is irrelevant if the rules allow imbalances that continue long enough so that the political process is likely to intervene.

In practice, one cannot know with certainty how future workers and pensioners will react to the system. The designers of new policies tend to emphasize the most likely future developments, when they argue for the reform. Opponents try to imagine circumstances in which one or another aspect of the system would cause it to crash. Our proposal is to provide realistic descriptions of the future contingencies in a probabilistic fashion. Conventional “high” and “low” scenarios that have been used for this purpose have had little or no effect on policy recommendations. Without any probabilities attached to the alterna-
tives, their importance is suspect and the results are difficult to interpret. Analyses based on expected or “most likely” assumptions have dominated.

For an individual contributor or a pensioner, sustainability is related both to trustworthiness and predictability. Can the level of future contributions and future pensions be known with sufficient accuracy, so that a choice can effectively be made between supplementary savings or consumption (or leisure time)? To have operational counterparts, this study will approach “trust” by defining thresholds for a change in contribution rates and replacement rates. These thresholds form a politically viable region within which the rates can change without leading to system reform.7 “Predictability” requires a known or estimated distribution of outcomes in the viable region. In the Swedish case, for example, it would be desirable to produce estimates of the likelihood of having to use the “brake.”

What is said above concerning an individual can be said for a firm, as well. In decisions concerning which country to invest in, it helps if the firm has a realistic view about indirect labor costs in the future. Unrestricted pension contribution rates can be a major source of risk.

Aspects of Future Fertility and Mortality in Europe

Age Structure and Negative Growth

The total fertility rate of year \( t \) is defined as the expected number of children a newborn baby girl is expected to have, under the fertility and mortality regimes of year \( t \). About 105 boys are born for every 100 girls, so if all women would survive to the end of child-bearing ages, a total fertility rate of 2.05 would suffice for internal population renewal. Allowing for mortality, a somewhat higher value, about 2.07, is sufficient in Europe. In year 2000, Iceland had a total fertility of 2.07. The remaining European countries have below replacement fertility. Belgium, France, Luxembourg, the Netherlands, the Nordic countries, Portugal, and the United Kingdom had a total fertility in the range \([1.51, 1.89]\). Austria, Germany, Greece, Italy, Spain, Bulgaria, Hungary, Poland, and Romania form a low fertility group with fertility in the range \([1.24, 1.36]\). It is well known that these are exceptionally low values, in historical perspective. What has received less attention is the implication of fertility on the age distribution.

In Finland, the total fertility rate in 2000 was 1.7. If this level were to persist, the population would start to decline at the rate of about 0.63 percent per year. Figure 6.1 tries to put this into a perspective. The solid curve corresponds to the age distribution of a closed stationary population (in which births equal deaths) whose mortality equals that of the Finnish women of the late 1990s. The dashed curve is based on the same survival probabilities, but with births exceeding deaths by a constant ratio. The ratio has been chosen so that the resulting rate of increase \((= 0.0065)\) equals the average growth of the Finnish population during the 20th century. The dotted line has the corresponding age distribution when the rate of decline is negative \((= -0.0065)\). This happens to be almost exactly the asymptotic rate of decline implied by the current Finnish fertility. The declining stable population has a much older age distribution than the stationary one, let alone the growing population from which we derive our understanding of the world. This form of population aging derives from fertility alone, since we are keeping mortality fixed.

In general, convergence to stability might take over a century, so stable populations have not received much attention in past years. However, the solid line with squares in figure 6.1 gives the current age distribution of Finland. In about 10 to 15 years’ time, the Finnish age distribution will be quite close to the asymptotic stable age distribution that
would result from constant schedules of fertility and mortality. The conclusion is that baring large changes in fertility or migration, the Finnish population will resemble its stable equivalent quite soon. A similar conclusion probably holds for most European countries, but with variations in timing, and with due allowance for differential migration.

Although much of current aging discussion involves future prospects of mortality, the major determinant of population aging is fertility, both via the current low level that leads to negative growth, and via the large baby boom cohorts that will begin to retire soon. The decrease in mortality does have an important effect on the sustainability of the pension systems. Vaupel and Oeppen (2002) have presented evidence of the development of the “best practice life expectancy.” This is the life expectancy of the country that at any given time has the longest life expectancy. Vaupel and Oeppen show that for women the curve goes almost linearly from the value of 45 years, observed in Sweden in 1840, to 85 years, observed in Japan in 2000. Accordingly, the best practice life expectancy has improved by approximately 0.25 years annually for 160 years.

In individual countries the development has been quite erratic, however. In Finland, for example, female life expectancy increased by 24 years (81 years – 57 years) from 1930 to 2000, or by 0.34 years annually. During the first 40 years, the increase was 0.45 years annually. During the latter 30 years, the increase was 0.20 years annually. Finland is not alone in this respect. Female data from 19 industrialized countries (Austria, Australia, Belgium, Canada, Denmark, Finland, France, Iceland, Ireland, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, and the United States) from 1950 to 2000 show that Japan’s improvement is much higher than that of the other countries. During the first half of the 50-year period the average improvement of the remaining 18 countries was 0.23 years annually, but during the latter half it was 0.18 years annually, and in the 1990s it was only 0.15.

It is difficult to say how the development should be interpreted. One can argue that as the leading country demonstrates that the improvements are possible, this will lead to policy responses in other countries to catch up. However this may be, the example of Denmark shows that such a response may take a long time. Fifty years ago Denmark was

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Figure 6.1. Age Distribution: Actual and Three Scenarios

Source: Authors’ calculations.
almost at the best practice line, but now it is six years behind. Pessimistic forecasters would suggest that improvements in European mortality are becoming smaller. Even if this view agrees with the most recent data, we note that a diminishing returns hypothesis has been repeatedly advanced in the past, but in retrospect, it has been the major source of error in mortality forecasts.

A compromise between the optimistic and pessimistic views is to assume the continuation of past trends, but to quantify the variations about the declining trend. This can be particularly important for individuals making their career plans. Decisions about how much and how long to work may depend on how the level of pensions is viewed relative to the wages one might earn and the savings one might have. If, in addition, the pensions are lowered—assuming a fixed retirement age—as a response to improvements in life expectancy (as is the case in Finland), decisions about saving may become more important than before.

Quantifying Uncertainty

Past forecasts can be analyzed to assess how accurate they have been. The difficulty in doing this in practice is that the number of past forecasts is small for all European countries. Reliable estimates are hard to obtain. Statistical time-series models can also be used, but it is difficult to find a compromise between overfitting on the one hand, and ignoring substance knowledge on the other. An intermediate way of assessing the uncertainty of forecasting is to consider the so-called naive or baseline forecasts. There is evidence that forecasts in the United States for total fertility have essentially assumed the current value to persist indefinitely. This has later been observed in many other (post-demographic transition) countries, as well. If total fertility were a random walk (or more generally, a martingale), then such a forecast would be optimal. Indeed, the autocorrelations of first differences of the total fertility suggest that a random walk provides a rough approximation.

For countries with long data series available, one can determine how large errors such baseline forecasts would have had in the past, had they been systematically made every year (Alho 1990). In considering past errors, this study concentrated on the absolute value of the relative error and used the median to describe central value because this automatically eliminates the effects of outliers that were caused by wars or famines. Figure 6.2 (from Alho 2003) shows estimates from the Netherlands, Denmark, Norway, Finland, Iceland, and Sweden (here listed from the largest to the smallest in terms of forecast error). The differences between the countries are considerable, but the order of magnitude is similar. This is to be expected due to the high autocorrelation of the errors. To appreciate the order of magnitude, note that 0.10 in the log-scale corresponds to an expected median error of 10 percent. Under a normal (Gaussian) model of relative error, this corresponds to a standard deviation of 0.15, or 15 percent.

A similar analysis was carried out for mortality. Long data series from nine European countries (Austria, Denmark, France, Italy, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom), in ages 50–54, 55–59, . . . , 90–94, were analyzed much the same way as fertility data. The difference was that in this case, the baseline forecast assumed that the decline observed during the most recent 15 years would continue indefinitely. Such a forecast would be optimal, if the actual development would be a random walk with a drift, and 15 years worth of data were available. Lee and Carter (1992) have shown that models of this type have considerable empirical support. The data were aggregated over age groups for each country. Figure 6.3 shows the relative error. Comparing with figure 6.2, we find, surprisingly, that the relative error one can expect in age-specific mortality forecasts is almost equal to that of total fertility. We have no explanation for the close
agreement of the two estimates. One should note, however, that the probability of survival can be forecast much more accurately. If one makes a large relative error in forecasting a mortality rate that is of the order of 1 percent, then the relative error in the number of survivors is about one-hundredth of that.

Estimates such as those displayed in figures 6.2 and 6.3 can be coupled with point forecasts of age-specific demographic rates, and translated into statistical models that can be

**Figure 6.3. Median Relative Error of Mortality Forecast**

Source: Authors’ calculations.

Note: Relative error is forecast as a function of lead time for nine countries with long data series, and their smoothed average.
used in simulation. A number of additional parameters for correlations across age and over time are needed in this. In our practical work, we have used the program PEP (Program for Error Propagation) written at the University of Joensuu.

Demographic Uncertainty, Pensions, and Public Finances

In the past, the volatility of demographics has often been underestimated, and economic analyses have concentrated on other uncertainties that are essential in population aging research. Research results obtained thus far unequivocally show that demographic uncertainty must not be neglected. Its magnitude should make us humble when recommending policies to avoid bad and unsustainable outcomes caused by aging. However, this does not mean that inactivity in policies is recommended. Quite the contrary, uncertainty is an extra reason for activity. As Auerbach and Hassett (2001) point out, for a risk-averse population the cost of future outcomes worse than expected outweigh the benefits of outcomes better than expected. Wise aging policies should be especially robust against a worse demographic future than the expected one.

The discussion below presents examples of how stochastic population simulations have been used with economic models to analyze pensions in Europe. We look at projections of pension outcomes and the effects of single policy instruments. We hope to address explicit pension policy strategies, consisting of contingent use of several instruments, in future studies.

Although our main goal is to throw light on the sustainability of pension systems, it is useful to keep in mind that there are other social systems that compete for the same economic assets. The costs of health care, schools, and social services are financed essentially by pay-as-you-go (PAYG) systems that aggravate the fiscal burden of the economically active population, in addition to pensions, for some potential future population paths; for other paths, they may bring relief. This chapter will not discuss these aspects further.

Economic Calculations Subject to Exogenous Demographic Uncertainty

The following two tables summarize the effects of the current policy, and four alternative pension policies, to contribution rates in Lithuania. The study used an OLG model for Lithuania. The demographic population paths were generated as described in Alho (2001). They were treated as being exogenous to the economic system. The results have been obtained by simulating the population 100 times and solving the OLG model in each case. A number of technical issues had to be solved to be able to carry this out. For example, arranging the population paths in a suitable manner helped in achieving convergence faster. The results were stored so that their statistical characteristics can be examined using standard statistical programs.

The old-age pension system in Lithuania consists of the basic pension and the earnings-related supplementary component. The pension system is purely pay-as-you-go. Contributions are collected from the wage bill. The basic pension is almost flat, and it depends only to a minor extent on a person’s insurance period. The supplementary pension component depends on the number of years the insured person has worked according to social insurance records and income. Pension benefit is fully indexed to average wage income.

Table 6.1 presents statistical summaries of the predictive distribution of the social security contribution rate, under each of the four policies. In Lithuania, social security contributions consist of a 31 percent employer contribution on the wage bill, plus a 3 percent employee contribution on individual wages. These are used to finance pensions (old-age, disability, and survivorship), short-term benefits (sickness and maternity), as well as unemployment and health insurance partially. The contribution rate of 28 percent in 2000
is the employer rate where the health insurance is excluded. In the future the contribution rate is assumed to endogenously adjust so that the benefits are financed each period. Table 6.2 presents summaries of the predictive distribution of policy effects: that is, the difference between the contribution rate under an alternative policy and the current policy.

The width of the 80 percent predictive interval for the contribution rate is 4 percentage points in 2030 and 12 percentage points in 2050. Ranges of this sort are not atypical. As shown in the previous section, demographic uncertainty is of the same order of magnitude in different countries, and the closer a pension system is to a PAYG system the closer it replicates the underlying demographics. These estimates suggest what can be expected about the accuracy of our aging projections—and this is just the demographic component.

Tables 6.1 and 6.2 show that pension policies have effects on both the location of the distribution of outcomes and its scale. Indexation of benefits to total wages, instead of average earnings, cuts the expected contribution rate by 3.6 percentage points in 2050 and narrows its 80 percent predictive range from 12 to 6 percentage points. This instrument is analyzed more closely in the discussion below on wage-bill indexation. Longevity adjustment of future pension benefits was applied only partially, and has very small effects on outcomes, perhaps because of problems related to the quality of old-age mortality statis-

### Table 6.1. Distribution of the Social Security Contribution Rate in Lithuania (percent)

<table>
<thead>
<tr>
<th>Policy measure</th>
<th>2000 Median</th>
<th>2030 Median</th>
<th>2000 50%</th>
<th>2030 50%</th>
<th>2000 80%</th>
<th>2030 80%</th>
<th>2000 2050 Median</th>
<th>2030 2050 Median</th>
<th>2000 2050 80%</th>
<th>2030 2050 80%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current system</td>
<td>28</td>
<td>29.41</td>
<td>28.49</td>
<td>27.46</td>
<td>35.70</td>
<td>33.31</td>
<td>30.19</td>
<td>38.05</td>
<td>38.05</td>
<td>42.69</td>
</tr>
<tr>
<td>Wage-bill indexation</td>
<td>28</td>
<td>28.43</td>
<td>27.64</td>
<td>26.64</td>
<td>32.10</td>
<td>30.39</td>
<td>28.29</td>
<td>34.25</td>
<td>34.25</td>
<td>36.55</td>
</tr>
<tr>
<td>Longevity adjustment</td>
<td>28</td>
<td>29.16</td>
<td>28.34</td>
<td>27.42</td>
<td>34.84</td>
<td>32.90</td>
<td>29.96</td>
<td>37.17</td>
<td>37.17</td>
<td>42.01</td>
</tr>
<tr>
<td>Retirement age increase</td>
<td>28</td>
<td>25.05</td>
<td>24.20</td>
<td>23.31</td>
<td>29.83</td>
<td>28.06</td>
<td>25.24</td>
<td>31.77</td>
<td>31.77</td>
<td>35.51</td>
</tr>
</tbody>
</table>

**Source**: Authors’ calculations.

**Note**: The table shows the median and 50 percent and 80 percent predictive limits.

### Table 6.2. Distribution of Policy Effects on the Social Security Contribution Rate (percent)

<table>
<thead>
<tr>
<th>Policy measure</th>
<th>2030 Median</th>
<th>2030 50%</th>
<th>2030 80%</th>
<th>2050 Median</th>
<th>2050 50%</th>
<th>2050 80%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wage-bill indexation</td>
<td>−0.84</td>
<td>−0.38</td>
<td>0.22</td>
<td>−3.00</td>
<td>−1.74</td>
<td>−1.17</td>
</tr>
<tr>
<td>Longevity adjustment</td>
<td>−0.18</td>
<td>−0.12</td>
<td>−0.04</td>
<td>−0.47</td>
<td>−0.13</td>
<td>0.25</td>
</tr>
<tr>
<td>Retirement age increase</td>
<td>−4.38</td>
<td>−4.18</td>
<td>−4.07</td>
<td>−5.64</td>
<td>−5.22</td>
<td>−4.96</td>
</tr>
</tbody>
</table>

**Source**: Authors’ calculations.

**Note**: The table shows the median and 50 percent and 80 percent predictive limits.
tics in Lithuania. The next section considers the likely effects of the longevity adjustment in Finland. Increasing the retirement age also effects both the location and the scale of the predictive distribution of outcomes, but it is not directly linked to demographics, and this study will not discuss it in more detail.

**Predictive Distribution of Longevity Adjustment**

An increase in life expectancy can put a strain on the finances of a defined benefit pension system. In a PAYG system this means increasing the contribution levels of the current workers. In anticipation of future gains in life expectancy, a law was passed in Finland that automatically adjusts pensions if life expectancy changes. The aim is to preserve the expected present value of future pensions.

Define $p(x)$ as the conditional probability of surviving to age $62 + x$ given survival to age 62. Let $0.02$ be the discount rate. Suppose a pension is paid continuously, at the rate of one euro per year. Then the Finnish law stipulates that the expected net value of the pension that forms the basis of life expectancy adjustments is

$$
\xi = \int_0 \overline{p(x)} e^{-0.02x} \, dx.
$$

(6.1)

In practice, estimates of expected net values are computed based on past data. Consider the cohort of individuals who become 62 years old during a calendar year $t = 2009$. To calculate the expected present value for year $t$, denote it by $\overline{x}(t)$, mortality data from the five-year period $[t-6, t-2)$ is used to calculate $p(x)$. Thus there is no element of forecasting in the calculation, but the expected net value does not correspond to the actual cohorts of pensioners either. This aspect has been analyzed more closely in Lassila and Valkonen (2003), showing that the use of forecasts may mitigate the adjustment factor.

The life expectancy adjustment is then defined as $A(t) = \xi(2009)/\xi(t)$. Or, the pensions of those who became 62 years old in year $t$ are multiplied by $A(t)$. If mortality decreases from the year 2009 onward, $A(t) < 1$, so pensions would be cut.

Since the future level of mortality cannot be known with certainty, the values of $A(t)$ cannot be known accurately at the present time. However, in the interest of showing what one might expect, we can provide a probabilistic description of how the $A(t)$’s are likely to behave, since a predictive distribution of future mortality is available. Without going into details, we note that a number of technical issues must be resolved in any such calculation. For example, since a unique adjustment factor is used for males and females, a combined measure of mortality is used. This depends on the shares of women and men, in ages $x \geq 62$, in the future. Various approximations were used to obtain the results shown here.

The practical calculations were carried out via stochastic simulation using the program Minitab. The median, the first and third quartiles, and the first and ninth deciles, for the predictive distribution of the adjustment factors in 2030 and 2050, are as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>$d_1$</th>
<th>$Q_1$</th>
<th>$Md$</th>
<th>$Q_3$</th>
<th>$d_9$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2030</td>
<td>0.86</td>
<td>0.88</td>
<td>0.92</td>
<td>0.95</td>
<td>0.99</td>
</tr>
<tr>
<td>2050</td>
<td>0.78</td>
<td>0.81</td>
<td>0.87</td>
<td>0.92</td>
<td>0.98</td>
</tr>
</tbody>
</table>

We expect the adjustment factor to decline to about 0.87 in 2050, with an 80 percent prediction interval [0.78, 0.98]. These intervals are valid provided that the volatility of the
trends of mortality during the next 50 years does not exceed the volatility of mortality during 1900–94. In view of the discussion above, an optimist in mortality reduction who believes in a reversal of the recent slowdown might use the first decile (0.78 for year 2050) as a benchmark to consider how to adjust the predictive distribution to better match his or her beliefs.

**Wage-Bill Indexation**

Studies of the type presented in the previous two sections can be criticized because they do not incorporate the notion of sustainability or system reform in any way. The current (or alternative) rules are assumed to apply, irrespective of how the population or the economy develops. Addressing this issue in full generality is vastly beyond current analytical capabilities. Yet some aspects of a more realistic analysis can be easily introduced in the existing modeling framework via thresholds.

In Lithuania, the earnings-related pension benefit is fully indexed to average wage income. Alho et al. (2003) studied an alternative indexation, where the benefit follows the weighted average of the average wage income (with a weight 1 – $\alpha$) and the total wage bill in the economy (with a weight $\alpha$). The rationale of wage-bill indexation is that it would provide automatic relief to the working population should, as expected, the share of pensioners in the population increase.

In the spirit of the previous two sections, figure 6.4 shows how the situation would change by 2050, in the polar cases of $\alpha = 0.0$ (left-hand side) and $\alpha = 1.0$ (right-hand side). The scatter plots are based on 300 population paths, each producing a dot on the $(c, r)$ plane. First, we see that increasing $\alpha$ tilts the scatter cloud from a horizontal position downward. Second, with current indexation, there are some extremely high contribution rates by 2050. A high degree of wage-bill indexation effectively cuts down the most extreme contribution rates, but even at $\alpha = 1.0$ the contribution rate can reach values above 0.4 with nonnegligible probability. Third, the control of contribution rates is accomplished by accepting a lower replacement rate.

**Figure 6.4. Replacement Rates and Contribution Rates in Lithuania in 2050, with $\alpha = 0$ (left) and $\alpha = 1$ (right)**

Source: Alho et al. (2003).
As pointed out by Edward Palmer, a crucial assumption in these calculations is that the retirement age is kept fixed, even though life expectancies vary between population paths. Assuming, for example, a constant retirement/work ratio would certainly produce smaller declines in replacement rates, and further analysis should take this into account. At present this cannot be done properly because, as noted in connection with table 6.2, variation in longevity appeared modest, perhaps due to quality problems of old-age mortality data in Lithuania.

In an effort to address the sustainability issue, Alho et al. (2003) approximate the complex political process by postulating bounds for the contribution rate, \( c \), and the replacement rate, \( r \), that cannot be violated. They assume that there is an upper bound \( c^* > 0 \) such that values \( c > c^* \) would not be considered politically acceptable for the working population, and institutional arrangements would be changed instead. Similarly, they assume that there is a lower bound \( r^* > 0 \) such that replacement rates \( r < r^* \) would lead to a system reform. The set \( \{(c, r) \mid c \leq c^*, r \geq r^*\} \) is the viable region of the policy.

Neither \( c^* \) nor \( r^* \) can be known with certainty. Alho et al. (2003) consider a range of values for both bounds, in an effort to get a feeling of how likely it is that the indexation rule might survive in future political process. Using these bounds, they try to find a suitable degree of indexation. Table 6.3 replicates some of their results for one value of \( c^* \).

The limit \( c^* = 0.38 \) represents a 10 percentage point increase in the contribution rate. Many countries face the prospect of such increases in their payroll taxes, and it is exactly these projections that have led the experts and decision makers to pay attention to the aging problem and seek ways to avoid such increases.

The rightmost column of table 6.3 shows that the replacement rate is below 33 percent in all alternatives. The values in bold italics are maximum probabilities of staying in the viable region that can be achieved by choosing \( \alpha \) optimally, for the specific combinations of \( c^* \) and \( r^* \). For example, should one think that the replacement rate has to be at least 30 percent and the contribution rate must not rise more than 10 percentage points from the current level (or it stays at or below 38 percent), then it is best to stick with the current indexation system where \( \alpha = 0 \). With this policy, the probability of staying in the viable region is 63 percent. If one would accept a replacement rate as low as 29 percent, choosing \( \alpha = 0.2 \) would produce a probability of 68 percent of staying in this viable region, whereas sticking with the current policy (\( \alpha = 0 \)) would have lower probability of being sustainable, or 63 percent.

Table 6.3. Joint Probabilities of the Contribution Rate Being Lower Than \( c^* \) and the Replacement Rate Being Higher Than \( r^* \) in 2050

<table>
<thead>
<tr>
<th>( c^* = 0.38 )</th>
<th>( r^* = 0.20 )</th>
<th>0.25</th>
<th>0.26</th>
<th>0.27</th>
<th>0.28</th>
<th>0.29</th>
<th>0.30</th>
<th>0.33</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha )</td>
<td></td>
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<td></td>
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Source: Alho et al. (2003).

Note: The table is for \( c^* = 0.38 \) and selected values of \( r^* \) and for different values of the indexing parameter \( \alpha \).
Other measures for operationalizing sustainability can be developed based on the minimal $r$ and maximal $c$ over the forecast horizon (2001 to 2050), for example. Yet even the simple analysis that concentrates on year 2050 adds an aspect of realism to the study of sustainability that is absent from statistical summaries such as the expected values, variances, or fractiles.

**Fertility-Dependent Prefunding**

The following example is based on the partially funded defined benefit (DB) private sector pension system (TEL) in Finland. In this statutory system, funding does not affect pension benefits at all; it affects only the timing of contributions. This cohort-specific forced saving makes current workers partially pay their own future pensions. It is an open issue whether this increases total saving in the economy or whether people counter it by saving less privately. What it definitely does is to smooth the changes in pension contribution rate that are due to demographic developments. That is the main aim of funding in Finland; the issue is how efficiently this aim is fulfilled.

Lassila and Valkonen (2001) showed that to reduce the effect of the expected aging of the population on the contribution rate, increasing the level of prefunding is a sensible policy. Yet there is a clear danger of prefunding too much, in the sense that current workers pay unnecessarily high contributions and future workers will face lower contributions. Utilizing fertility data in setting the funding level is a promising approach to increase funding and avoid excesses. The discussion that follows elaborates on this idea.

Prefunding in a DB system reduces the risk caused by changing fertility on contribution rates. The risk reduction is obtained, in part, by introducing new risks through uncertain investment performance. Since the funding rate is far from full (no target is set for the funding rate in the Finnish system, but currently it is roughly one-quarter), the funding rules can potentially be improved by considering the future size of the working cohorts.

The current prefunding rule is as follows. Every year $t$, new pension rights accrue at a rate $k$ for each worker. A share $a$ of the present value of the accrued right, to workers aged $i = 23, \ldots, 54$, is put in the funds. The present value is calculated from age 65 to a maximum age, denoted here by $M$. Let $g(t,i)$ be the labor income of the individual in age $i$ during year $t$. For prefunding purposes, the magnitude of this right is evaluated ignoring all future changes due to wage or price developments. An interest rate $r$ is administratively set. Suppose the proportion $S(i,j,t)$ of those in age $i$ at $t$ is expected to be alive at age $j$. Then, the following amount is prefunded for the worker in age $i$ during period $t$,

\[
(6.2) \quad h(i,t) = a \sum_{j=65}^{M} kg(i,t)S(i,j,t)/(1+r)^{j-i}.
\]

We propose to amend the rule so that, for each funding cohort (those aged 23 to 54), the share funded also depends on the size of the cohort at birth $B(t)$ relative to the size of the later born cohorts. The idea is that we can estimate from the size of recently born cohorts the size of the work force in those future periods when the funding cohort is retired. Or we propose to multiply $h(i,t)$ by

\[
(6.3) \quad b(i,t) = B(t-i)/\sum_{j=0}^{i-1} w(j,i)B(t-j-1),
\]

where $w(j,i) \geq 0$ add up to 1 for each $i$. The weights are calculated so that they approximate the shares of the various cohorts in the working-age population, when the funding cohort
(those in age $i$ at $t$) has retired. This fertility effect on funding varies between cohorts, and for each cohort it varies in time. If the funding cohort is bigger than the younger cohorts are, $b$ exceeds unity and thus funding is increased. If fertility increases and younger cohorts are bigger, funding declines compared with current rules.

Under current pension rules the contribution rate is expected to stay close its current level of 21.5 percent over the next 10 years, and then rise to about 30 percent. Uncertainty increases with the time horizon, and in the 2060s the 80 percent predictive interval is 12 percentage points wide. These estimates were obtained by simulating the population 100 times, and solving the Finnish OLG model in each case. The demographic population paths were generated as described in Alho (2002).

A fertility-dependent funding rule would narrow the predictive intervals from the 2050s onward. The cost of this is that the intervals before the 2050s become slightly larger. Doubling the current funding degree would restrict the future variability sooner, but it would also increase the variability in the near future. Thus funding in general shifts demographic risks in time. Figure 6.5 shows this in the form of standard deviations, calculated each period from the contribution rates in each of the 100 population paths.

With a fertility-dependent funding rule, the median contribution would be first slightly higher and later somewhat lower than with current rules, but the distributions would be

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Source: Authors’ calculations.
markedly different. The 80 percent predictive interval in 2060–69 would be about 26 to 35 percent instead of 26 to 38 percent. The slight increase in variability in some earlier periods seems a price worth considering for reducing the third quintile value by 2 percentage points and 9th decile value by close to 4 points in 2060–69. Figure 6.6 compares the contribution rates under a fertility-dependent rule with those under the current rule in each of the 100 population paths.

Funding too little and funding too much are not symmetric cases. Increasing funding requires unpopular decisions of increasing contributions, and smaller increases are easier to accept. Thus in the future, looking back to the present time, we would probably be happier for not prefunding too much. This provides another tool for comparing different funding rules. The simulations suggest that excess funding has taken place if somewhere in the future the contribution rate declines significantly. Different threshold values for “significant” can be used. Table 6.5 shows the share of cases in the 100 population paths where excess funding was observed, with five different threshold values. The unit period in calculations is five years, so qualifying for “excess” requires that there is a pair of five-year periods, not necessarily successive but both within the total period of 2005–69, where the contribution rate in the earlier period exceeds the latter period’s contribution rate by at least the threshold value.

Table 6.5 shows that small decreases in the contribution rate have a probability of one-third with current pension and funding rules. With fertility-dependent funding, that probability will be slightly larger. But looking at decreases over 2 percentage points, or 3 or 5, note that with fertility-dependent rules, the probability of overshooting in funding would be reduced markedly compared with current rules.

A permanent increase in the funding degree does not seem a good choice because it does not adjust to demographics. The gains are there from 2050 onward, but they are partly in the form of very low contributions. The price to pay, higher contributions in the near future, is high. Excess funding would become much more likely.
Figure 6.6. Pension Contributions in the Finnish Private Sector TEL System

Source: Authors’ calculations.

Note: Each of the 100 dots represents one population path.
Future Directions

The need for sustainable financing strategies is not confined to pensions. Publicly financed health care and long-term care are another area where the tools described above can be used. These areas are correlated: demographic paths that are costly from the pension point of view are likely to be costly in terms of health care.

The pension examples above seem relevant also for NDC systems, although both Lithuania and Finland have DB pension systems. Longevity adjustment and wage-bill indexation are by nature NDC instruments, and funding, at least in buffer form, is required to keep contributions fixed and prevent the necessity of using brake-type arrangements continuously.

The Swedish NDC concept has strong strategy features, especially the aim of keeping contributions fixed in all states of the world. It seems like a major improvement compared to the many current PAYG defined benefit systems. Yet the system has not been crash-tested, and it is conceivable that it may not be sustainable in all realistic circumstances. There may also be other systems with comparable risk characteristics.

We view the combination of stochastic population simulations and a numerical OLG model as a first step toward a more comprehensive model. Stochastic population simulations for all EU countries and some other European countries are being produced in the European Union’s fifth framework research project, Uncertain Population of Europe (UPE). In another EU project, Demographic Uncertainty and the Sustainability of Social Welfare Systems (DEMWEL), several European research institutes are working together to create models where future uncertainty is handled in a more advanced manner. But even with current models many aspects of uncertainty in the economic consequences of population aging can be explored, and that is also the aim in DEMWEL.

In future work, it might be useful to extend the notions of sustainability and sustainable strategies into a probabilistic direction, complemented with a “viability” concept with soft or unknown limits of acceptability. A theoretical challenge is to achieve a better concordance of the demographic and economic models. Alternative descriptions of how uncertainty is taken into account in actual practice, when it is not clear what the relevant decision horizon might be, is one aspect of such work.

Creating pension strategies more sustainable than the current ones is important. As Disney (1999) argues, if the future paths turn out to be unsustainable, there are stark choices left: to adjust other public finances or to change the rules ex post. Stochastic simulations with models combining the economic and demographic ingredients of the pension system can be used to crash-test the current systems and reveal the circumstances where their potential weaknesses become crucial. Similarly, the simulations will help to design alter-

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Source: Authors’ calculations.

Note: Share of cases where the pension contribution rate decline, in some subperiod of 2005–69, exceeds the threshold value. Threshold expressed as percentage points.
native, and possibly very complicated, pension policy strategies, and test their consequences both at the system level and the individual level.

Notes

1. “Notional defined contribution” and “non-financial defined contribution” should be understood to have the same definition.
2. See Blanchard et al. (1990, p. 8).
3. See Blanchard et al. (1990, p. 11).
4. See, for example, Rasmusen (1989, p. 17).
7. For more on viability theory, see Aubin (1991).
8. See, for example, Lee (1974).
11. See Alho et al. (2002).

References


Discussion of “Demographic Uncertainty and Evaluation of Sustainability of Pension Systems”

Sergio Nisticò*

The chapter by Alho, Lassila, and Valkonen succeeds in showing how stochastic population simulations could assist the main agents (individuals, firms, policy makers) in dealing with the lack of reliable information about the strains demography is exerting on pension systems. More specifically, the aim of the chapter is to show that it is possible to enforce sustainability of defined benefit (DB) pay-as-you-go systems by providing all agents with a “sustainable policy strategy...[that is,] a set of rules such that both the contributors and the pensioners know, beforehand, what will be done in any reasonable future circumstance, and they accept the future actions.” The authors rightly emphasize the importance for agents to know “the likelihood of the various risks” because “without any probabilities attached to the alternatives, their importance is suspect and the results are difficult to interpret.” This is why stochastic demographic simulations in conjunction with appropriate economic models can certainly help policy makers evaluate the likely impact of alternative policy measures on the key parameters of those pension systems on which demography puts a strain.

Although in a pure DB scheme the burden of adjustment entirely falls on contribution rates—in that if benefits are defined there are no means to contain pension expenditure—in actual (spurious) DB schemes, all parameters can undergo possible revisions: accrual rates (through longevity adjustments), indexation of already awarded pensions, and retirement ages. Alho, Lassila, and Valkonen provide some very interesting stochastic exercises showing the comparative impact on contribution rates in Lithuania of continuing the current policy as opposed to the three alternative parametric reforms. They convincingly suggest that a widespread diffusion of this kind of information can help agents foresee what policy will actually be enforced in a context in which the “rules of the game” allow for various policy measures.

However, it should be added that NDC schemes are precisely designed to provide individuals with that set of rules the authors argue will stem from good demographic information. As discussed by Gronchi and Nisticò (2006), the NDC scheme is endowed with a sort of automatic pilot that intervenes promptly on expenditure, avoiding the usually protracted waiting period necessary before governments resign themselves to the necessity of sustaining the electoral cost of altering the award parameters and unions assume the responsibility of agreeing to such changes. The NDC’s intervention is not only prompt but also, more importantly, perfectly predictable. This contrasts with DB schemes, wherein the outcome of the political process leading to parametric reforms is not only delayed but also uncertain.

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Take as an example the argument the authors develop in the section of their chapter focusing on alternative possible adjustments of indexation for pensions already awarded. The authors rightly emphasize that the domain within which indexation will ultimately fall is “constrained” by the contribution rate, which cannot exceed a given ceiling, and the replacement rate, which cannot fall below a given floor. In this respect, the authors show that, within DB schemes, good forecasting of possible demographic scenarios becomes crucial for the identification of a sustainable indexation: that is, for an indexation compatible with admissible levels of contribution and replacement rates. Again, the NDC adjustment mechanisms solve this dilemma through an automatic, predictable, and fully transparent mechanism. Once the contribution rate is freely chosen, the policy maker has a “lever” to solve the trade-off between the first pension annuity (the replacement rate) and the indexation of future installments. The lever is the return on pensioners’ account balances that can be “prepaid” (“imputed,” in Swedish terminology): that is, devoted to increasing the first installment. Indexation of subsequent installments will, each year, equal the sustainable return minus the prepaid return. (This is why in chapter 19 the prepaid return is referred to as the “deviation rate” between the sustainable return and the indexation.) This “endogenous” indexation, which Italy has awkwardly failed to adopt, ensures the sustainability of the NDC scheme. The lower the prepaid return (the replacement rate), the better indexation will perform in adverse economic and demographic scenarios. This is why Sweden has probably prepaid an excessively high return (1.6 percent).

The difference between the DB and NDC adjustment mechanisms also has important consequences on the distribution of the burden of adjustment among generations. The authors argue that within a DB scheme “to reduce the effect of the expected aging of the population on the contribution rate, increasing the level of prefunding is a sensible policy.” Also on this respect, good demographic forecasting is essential to convince active generations not to shift the entire burden of adjustment on future generations and to pay a contribution rate that is above its equilibrium level. It is hard to ask current workers to fund the system on the basis of “weak” predictions: that is, when the risk of overshooting is not negligible. Funding is generally possible only in the face of good demography: that is, by keeping the contribution rate unaltered when it could be lowered. Again, the authors hit the target when they emphasize that information is essential for fine tuning the policy mix within a DB setting to guarantee, at the same time, both sustainability and fairness (in this case, intergenerational). On the other hand, it is common to misinterpret the ability of NDC systems to be self-sustainable for any given contribution rate, as if pensioners only were asked to bear the burden of balancing the system. According to this view, NDC schemes would suffer from an intergenerational unfairness, which is symmetric to that characterizing pure DB schemes, wherein active workers only bear the burden of adjustment. However, one should consider that the prompt intervention of the “automatic pilot” has the twofold form of slower indexation of old pensions and reduction of the contribution balances being formed (thus containing future pension awards), so that the sacrifice is imposed at the same time on pensioners and active workers.

Good demographic information is obviously also essential to NDC schemes, though not as a direct support to the provision of alternative policy measures, but rather to provide individuals with some important pieces of information needed to respond to demographic trends. The flexibility in retirement age is one of the most important features of NDC schemes. Postponing retirement age is the main instrument at individuals’ disposal to offset the effects of a bad demographic scenario. Good predictions about longevity, when collected, filtered, and synthesized by signals (such as the expected levels of the
annuitization divisors and of the sustainable return) that are easy to be perceived and interpreted by individuals will play a fundamental role in this respect.

The authors conclude by asserting that the NDC system “has not been crash-tested and it is conceivable that it may not be sustainable either in all realistic circumstances.” This is true, but no pension scheme can survive in any demographic scenario that is seriously negative. However, when something can be done for public pension schemes to survive, NDC does it in a prompt and fair way; and good demographic forecasting will help.

Reference
