Islamic Republic of Iran
The Pension System in Iran: Challenges and Opportunities
(In Two Volumes) Volume II: Technical Appendix

September 2003

Middle East and North Africa
Social and Human Development Group (MNSHD)
CURRENCY EQUIVALENTS
Unit of Currency = Iranian Rhials (IR)
Average Exchange Rate (IR per US Dollar)
1 Dollar = 7,500 Rhials

BASIC INDICATORS 2001
GDP = IR 666,165 billion (USD 88.9 billion)
GDP per capita = IR 10.4 million (USD 1,396 million)
Population = 63.9 million
Labor Force = 17.1 million

ACRONYMS AND ABBREVIATIONS
CS Contractual Savings
CSRO Civil Servants Retirement Organization
DB Defined Benefit
DC Defined Contributions
FF Fully Funded
FFYP First Five-Year Plan
GDP Gross Domestic Product
IA Individual Accounts
MPO Management and Planning Organization
MENA Middle East and North Africa Region
MNSHD Middle East and North Africa Human Development
NDC Notional Defined Contributions
NPF National Pension Fund
OECD Organization for Economic Cooperation and Development
PAYG Pay-As-You-Go
SSIC Social Security Investment Company
SSO Social Security Organization
USD United States Dollars

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<tr>
<th>Vice President:</th>
<th>Jean Louis Sarbib</th>
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<td>Country Director:</td>
<td>Joseph Saba</td>
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<td>Sector Director:</td>
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Acknowledgements

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Technical Appendix

A.1. Methodology of Financial Projections

The financial projections presented in this report have been conducted using the Pension Reform Options Simulation Toolkit (PROST) model. This section describes the main features of the model and summarizes the set of assumptions used in the implementation of the simulations. The appendix is organized in five sections. Section A.1.1 provides a short introduction to PROST. Section A.1.2 discusses demographic assumptions that apply to the financial projections of both CSRO and SSO. Section A.1.3 is concerned with macroeconomic assumptions. Sections A.1.4 and A.1.5 describe the data and assumptions used to model CSRO and SSO base case (“no-reform”) scenarios respectively.

A.1.1. Introduction to PROST

PROST is a computer-based pension model developed by the Social Protection Unit of the World Bank. The model is designed to simulate the behavior of pension systems and can assess their financial sustainability under different sets of assumptions over a long time frame. It allows to model different pension reform options – from “parametric” reforms of PAYG-defined benefit schemes to systemic reforms, such as introduction of fully funded defined contribution and/or notional defined contribution schemes. The program can be adapted to a wide range of country circumstances and can handle simulations up to 100 years and more. PROST is programmed in visual basic, with input and output in Excel.

The user provides country specific data on demographic, economic, and pension system related parameters and assumptions about their behavior in the future. This information is entered in the input file with six embedded worksheets:

- **General**: Economic variables (GDP and wage growth, inflation, interest rate), non-age-specific pension system parameters (pension fund balance and benefit expenditures in the base year, retirement age, contribution rate, pension indexation rules, etc.) and some demographic variables.

- **Population**: Base year population by age and gender along with age-specific fertility and mortality rates and immigration information.

- **Labor**: Age-specific and gender-specific labor force participation and unemployment rates as well as distribution of wages and old age pensions across age and gender cohorts.

- **Pension**: Age-specific and gender-specific information about pension system contributors, beneficiaries, coverage and retirement rates,
average years of service at retirement, and replacement rates for new beneficiaries.

**Profiles**
Information on representative individuals, such as gender, career path, individual wages, life expectancy, etc.

**Reform**
Parameters relevant to systemic reforms to be simulated (any combination of conventional PAYG, fully funded DC and notional DC pillars), including switching pattern, how the acquired rights will be paid, contribution rates, rules for annuitization and pension payout under DC schemes and replacement rates/benefit formula in a PAYG pillar, indexation, etc.

In the most simplified way the general calculation scheme can be presented as follows:

**Figure 1. General Calculation Scheme**

PROST follows single age/gender cohorts over time and generates population projections, which, combined with labor market assumptions, are used to forecast future numbers of contributors and beneficiaries. These in turn generate flows of revenues and expenditures. The model then projects fiscal balances and calculates the implicit pension debt. The required contribution rates and affordable replacement rates for zero pension fund balance in each year of the simulation period are also calculated. Finally, PROST produces outputs related to individuals – what an individual would contribute to the system and what he/she would get out of it under PAYG DB and multipillar schemes. This allows both intra- and inter-generational analysis.

Depending on the characteristics of the pension system and data availability, the user can choose the method for calculation of some of the variables. In particular, the number of contributors and beneficiaries can be computed in either “Stock” or “Flow” method. With the “Stock” method, for each year the stocks of contributors/beneficiaries
are calculated first and then inflows (new contributors/beneficiaries) are derived as the changes of the stocks:

\[ \text{Inflow}(a,t,g) = stock(a,t,g) - stock(a-1,t-1,g) + outflow(a,t,g) \]

With the “Flow” method, inflows are calculated first and then stocks are derived as previous year’s stocks in each age/gender cohort adjusted for the net inflow (inflow-outflow):

\[ \text{Stock}(a,t,g) = stock(a-1,t-1,g) - outflow(a,t,g) + inflow(a,t,g) \]

where \( a = \text{age} \), \( t = \text{year} \), \( g = \text{gender} \)

As PROST keeps track of contribution years of service accrued by each cohort, the calculated number of new retirees – whatever method is used – is then adjusted so that the total length of service accrued by the cohort is equal to the total length of service claimed by the cohort at the time of retirement. After the number of new retirees is adjusted, the stock is recalculated using the “Flow” method.

The user can also choose how the benefit of new beneficiaries is specified - via benefit formula or via age- and gender-specific replacement rates.

Output produced by PROST is organized in five output modules. Each of the modules contains a number of Excel worksheets and a graphical summary on key output indicators:

- **Population Projection**: Population projections and pyramids, life tables, life expectancy changes, population dependency rates, etc.
- **Demographic Structure**: Labor force and employment projections, projections of contributors and beneficiaries, demographic structure of the pension system, and system dependency rates.
- **Finances of Monopillar**: Macroeconomic trends, wage projections, pension benefit
- **PAYG**: projections for the existing and new pensioners, revenue and expenditures of the pension system, required adjustments to contribution rates and replacement rates for zero current balance, and the implicit pension debt.
- **Finances of Multipillar**: Pension benefit projections for new and existing pensioners System under each of the three pillars (conventional PAYG, notional PAYG, and funded DC), revenues and expenditures of both PAYG and funded pillars, implicit pension debt of the PAYG system after the reform, and results of the reform (compares benefit projections and financial standing under the monopillar PAYG and multipillar scenarios).
Individual accounts

Lifetime contributions and benefits and individual related summary statistics for up to six different individuals specified in the “Profiles” input sheet under PAYG system (statutory, with adjusted contribution rates and with adjusted benefits) and multipillar system (for those who switched to the multipillar system and those who remained in the PAYG system).

A.1.2. Demographic Assumptions

All data required by PROST for population projections are obtained from the World Bank Population projections database:

- Population by age and gender in 2000 as a base year population
- Projections of fertility rates from 2000 to 2070 by age and period
- Projections of survivorship probabilities from 2000 to 2070 by age, gender, and period (used for deriving age- and gender-specific mortality rates).

As migration flows in Iran are negligibly small compared to the size of the population, net immigration is assumed to be zero in the base case scenario.

In accordance with the above mentioned World Bank population projections for Iran, total fertility rate in the base case scenario is assumed to decline from 250 percent in 2001 (base year) to 212 percent over the next 10 years and then further decline – at a lower rate – to 207 percent by the end of the simulation period (2070). Assumptions regarding changes in age-specific fertility rates are presented in Figure 2:

Figure 2. Changes in Fertility Rates

Source: PROST input file for SSO,
Similar to the worldwide trends and based on the World Bank projections, mortality rates are assumed to be lower for females as compared to males, decreasing over time for both genders (Figure 3).

**Figure 3. Changes in Mortality Rates**

![Graph showing changes in mortality rates over time for males and females](image)

*Source: PROST input file for SSO.*

Based on the above assumptions, PROST demographic projections for Iran show increasing life expectancy at birth: by about 10 years for men and 20 years for women over the next 70 years. As a result, the difference between male and female life expectancies increases over time from 2 to 13 years which is close to what is now normally observed around the world. For more details see Table 1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Male</th>
<th>Female</th>
<th>Both genders</th>
</tr>
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<tbody>
<tr>
<td>2001</td>
<td>68.4</td>
<td>70.8</td>
<td>69.5</td>
</tr>
<tr>
<td>2020</td>
<td>72.5</td>
<td>76.9</td>
<td>74.5</td>
</tr>
<tr>
<td>2040</td>
<td>74.7</td>
<td>81.1</td>
<td>77.5</td>
</tr>
<tr>
<td>2060</td>
<td>77.4</td>
<td>88.0</td>
<td>81.7</td>
</tr>
<tr>
<td>2070</td>
<td>78.6</td>
<td>91.8</td>
<td>83.8</td>
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*Source: PROST output file for SSO.*

Due to the combined effect of decreasing fertility and mortality rates, the Iranian population - which can currently be classified as “young” - is projected to age pretty fast. Given the assumptions, PROST projects a steep rise in the old age dependency rate (population over retirement age divided by population in age 15 to retirement age; retirement age = 55/60): from estimated 13 percent at the beginning to about 60 percent by the end of the simulation period. Population pyramids (Figure 4) illustrate the aging trend.
A.1.3. Economic Assumptions

Assumptions with regard to the key macroeconomic input variables for SSO and CSRO base case scenarios can be summarized as follows:

- In accordance with the Country Economic Memorandum 2002 prepared by the World Bank Iran Country Office, real GDP growth rate is fixed at 6 percent during the first 10 years of the simulation period; then it is assumed to gradually go down to a new steady-state of 3 percent by 2025 and remain constant thereafter.

- Wage growth projections are based on the assumption that over the next 40 years the labor share of GDP will grow from the current low level of 25 percent to about 45-47 percent. To ensure that, labor productivity is assumed to grow at 4 percent (in real terms) during the first 10 years; over the next 15 years its growth rate decreases to 2.5 percent.
- Analysis of all money values is done in real terms so inflation rate is assumed to be zero.

- Real interest rate is fixed at 5 percent throughout the whole simulation period.

A more pessimistic short- to medium-term economic scenario is also examined for both CSRO and SSO pension schemes:

1. Real GDP grows at 4 percent during the first 10 years (which is in–line with the current growth trends in the Iranian economy), drops to 3 percent by 2025 and remains constant throughout the rest of the simulation period.

2. Accordingly – to sustain the dynamics of the labor share in GDP similar to the base case scenario – productivity growth rate is set at 3 percent in the first 10 years, decreases to 2.5 percent by 2025.

Age-specific and gender-specific labor force participation rates in the base year are derived from the 1996 census data on population and economically active population by five-year age groups and by gender (Iran Statistical Yearbook, 2000). In the future, it is assumed that male activity rates – which are already high, even compared to current OECD levels – will remain the same, at about 60 percent on average. As for female activity rates, the assumption is that in the long run the average labor force participation rate converges towards OECD levels: from a current low of 10-12 percent to about 35 percent by 2035 – and will remain stable thereafter. Figure 5 presents the current distribution of the labor force participation rates by age and gender as well as the assumptions about their future changes.

**Figure 5. Labor Force Participation Rates by Age and Gender**
The total unemployment rate in Iran is currently 15 percent (see MPO, 2000). Future changes in unemployment are estimated using a “Cobb-Douglas” production function to ensure consistency.

\[ Q_t = A_t L_t^a K_t^{1-a} \]

where \( Q \) is total output, \( A \) is total factor productivity, \( L \) is employed labor, and \( K \) is capital. Under the assumption that the average capital per worker is constant, the growth rate of employed labor is given by:

\[ L_t = \frac{(Q_t - \dot{A}_t)}{(1 + \dot{A}_t)} \]

where a dot over a variable denotes its growth rate.

Total factor productivity is assumed to grow at 2.4 percent in the first 10 years in accordance with the Country Economic Memorandum 2002; it is further assumed that its growth rate gradually slows down to about 1 percent. The estimated total employment growth rates together with the assumptions on labor force participation rates and demographic projections are then used to calculate total unemployment rates for each year of the simulation horizon. Total unemployment rates estimated for the base case and pessimistic scenarios (“low case”) are presented on Figure 6.

Figure 6. Total Unemployment Rates

Age-specific and gender-specific unemployment rates for each year are then computed using the estimated total unemployment rates and the initial distribution of the unemployment rates by age and gender. The latter is derived from the 1996 census data on economically active population and unemployed by five-year age groups and by gender (Iran Statistical Yearbook, 2000) and assumed to remain invariable in the future.
Unemployment rates by age and gender and their changes over time in the base case scenario are shown in Figure 7.

Figure 7. Unemployment Rates by Age and Gender

Source: PROST output file for SSO.

A.1.4. Assumptions for Modeling CSRO Pension System

The main source of information on the current status of the CSRO pension system is the CSRO database kindly provided by CSRO technical staff. The following general assumptions are made to model the system:

- In the base case scenario, the total number of contributors in the CSRO pension scheme is assumed to remain constant over the first seven years and to increase by half of the population growth rate each year thereafter. Also, a scenario of closing the system to new entrants (no new entrants allowed to join the system) is modeled.

- Only the pension-related components of the overall budget of the pension fund are examined: (a) contributions to the pension system paid by employers and employees — on the revenue side; and (b) payments to old age pensioners, disabled and survivors, health insurance premiums for retirees, and administrative costs — on the expenditure side.
Contributors

According to CSRO, currently there are about 1.6 million civil servants covered by the system. Information about the number of contributors by age and gender in a sample set of CSRO organizations is also available. The number of contributors in the sample is pretty high—about 63 percent of the CSRO total—so the sample data are used as a basis for estimating the initial distribution of contributors by age and gender (Figure 8).

Figure 8. Contributors by Age and Gender in 2001 (Thousand Persons)

Changes in the number of contributors by age and gender over time are modeled using the “Flow” method (see Section 1 for details). Since no data on the initial age and gender distribution of new contributors are available, the shape of this distribution was assumed to be similar to the one for the SSO pension system. However, the total share of women is set to be much higher for CSRO than for SSO—at about 40 percent (compared to about 15 percent for SSO). It is further assumed that in the future this distribution remains invariable. Figure 9 presents the assumed distribution by age and gender of new contributors joining the system.

Based on these assumptions, PROST projects the total number of contributors in CSRO to increase from the current 1.6 million to about 2.1 million persons by the end of the simulation period. However, coverage rate in terms of the country labor force is projected to decline over the next 35 to 40 years and then stabilize at about 4 percent as shown on Figure 10.

Assumptions regarding the distribution of wages across age and gender is derived from the CSRO data on the average wages by age and gender for the above mentioned sample of contributors. Once again, it is assumed that the earning profile in the system as a whole is similar to the one in the sample. The sample data have been smoothed, and it is
further assumed that the age and gender distribution of wages does not change over time. See Figure 11 for the assumed earning profile for men and women.

**Figure 9. Distribution of New Contributors by Age and Gender**

![Graph showing distribution of new contributors by age and gender for men and women.]

*Source: PROST input file for CSRO.*

**Figure 10. Projected Total Number of Contributors (As Percent of the Labor Force)**

![Graph showing the projected total number of contributors as a percent of the labor force over years.]

*Source: Mission calculations based on PROST projections for CSRO.*
Figure 11. Wage Distribution by Age and Gender  
(Percentage of 20 Year Old Male’s Wage)

Source: PROST input file for CSRO.

**Beneficiaries**

Three categories of beneficiaries – the main ones in the CSRO pension system - are modeled: (1) old age pensioners, (2) disabled, and (3) survivors and orphans lumped together and counted as the number of families receiving survivorship pensions. The total number of the old age pensioners and disabled in the base year (419.1 and 10.4 thousand persons respectively) and their initial distribution by age and gender (Figures 12 and 13) as well as the total number of the survivors families (125.3 thousand) are obtained from the CSRO database.

Similar to contributors, future changes in the number of old age pensioners and disabled are modeled using the “Flow” method – via setting the number of new retirees by age and gender as percentage of previous year’s contributors. Initial retirement probabilities for both categories are derived from the CSRO data on the number of new old age pensioners and new disabled by age and gender and the assumed age and gender distribution of contributors. Adjustments are made to simulate actual fluctuations in the absolute number of new old age pensioners in the first two years. Starting in 2003, it is assumed that the retirement pattern stabilizes and by the year 2015 there is no new retirement after age 70. Figures 14 and 15 show the assumed future retirement probabilities for old age retirees and disabled.
Figure 12. Old Age Pensioners by Age and Gender in 2001

Source: CSRO database.

Figure 13. Disabled by Age and Gender in 2001

Source: CSRO database.
As mentioned in Section 1, future numbers of new old age retirees calculated by PROST are also affected by length of service accrued by each cohort in each year of the simulation period. For these calculations PROST uses input data and assumptions on the age- and gender-specific length of service at the moment of retirement. The required input data for the base year are derived using the data on entry pensions received by new old age retirees in 2001 contained in the CSRO database and the annual accrual rate of 3.3 percent set by law. It is further assumed that the base year distributions gradually
change as presented on Figures 16 (for men) and 17 (for women) by the year 2035 and remain invariable thereafter.

![Figure 16. Length of Service at Retirement, Men](image)

![Figure 17. Length of Service at Retirement, Women](image)

*Source: PROST input file for CSRO.*

The third beneficiary category — survivors — is modeled by assuming that the share of the total number of families receiving survivorship pension in the total number of CSRO contributors and beneficiaries remains constant throughout the simulation period (at about six percent).

Based on the above assumptions, in the base case scenario PROST projects changes in the number of beneficiaries as shown on Figure 18.

![Figure 18. Projected Number of Beneficiaries](image)

*Source: PROST output file for CSRO.*
The initial distribution of pensions across old age pensioners and disabled of different age and gender is obtained by smoothing the CSRO data on age- and gender-specific average pensions received by current old age pensioners and disabled. As pensions are indexed to inflation, the older pensioners have lower pensions than the younger ones (Figures 19 and 20).

PROST calculates further changes in the level of benefits for each age and gender cohort using the indexation rules and the level of pensions received by new retirees. As set by law, in the base case scenario pensions are assumed to be fully indexed to inflation. The size of the entry benefit for newly retired – both old age pensioners and disabled – is modeled by setting directly the replacement rates in terms of the current covered average wage.

**Figure 19. Old Age Pensions**

**Figure 20. Disability Pensions**

Distributed by Age and Gender (Percent of 50 Year Old OAP's Benefit)

Source: PROST input file for CSRO.

Initial replacement rates for old age pensioners and disabled are derived by smoothing CSRO actual data on average entry pensions received by new retirees of different age and gender in 2001. Future replacement rates for new old age retirees are calculated based on the assumptions about changes in the length of service at retirement and annual accrual rate (constant at 3.3 percent in the base case scenario) – to ensure consistency among these input variables. Output data on average wages and wages by age and gender are then used to recalculate replacement rates in terms of average wage. Figures 21 and 22 present the replacement rates for new old age retirees at the beginning and at the end of the simulation period. For new disabled, age- and gender-specific replacement rates are assumed to remain the same throughout the simulation period (Figure 23). The average survivorship benefit is also assumed to be constant in terms of the average covered wage (57 percent per family).
A.1.5. Assumptions for Modeling SSO Pension System

Data on the current status of the SSO pension system were kindly provided by SSO technical staff. Apart from the old age, disability and survivorship benefits, the SSO pension fund is heavily engaged in a number of non-pension-related programs, e.g. social assistance and health. For modeling purposes, only expenditures and revenues related to the "long-term" payments (those made to beneficiaries on a long-term basis) are examined:

- On the expenditure side – (a) payments to the old age pensioners, disabled, and survivors; (b) child and family allowances, and (c) some miscellaneous payments.
Non-pension expenditures constitute about 20 percent of the “long-term” expenditures and are assumed to remain at that level over the whole simulation period. Administrative costs are ignored as they are related to the whole fund.

- On the revenue side – only contributions earmarked for these type of expenditures (18 percent contribution rate out of the total 33 percent paid to the SSO fund by employers and employees).

Similar to CSRO, the SSO pension system is simulated under the scenarios of (1) keeping it open to new entrants throughout the simulation period, and (2) closing it to new contributors from the beginning of the simulation period.

**Contributors**

According to SSO, about 6.1 million people are currently contributing to the system. SSO also provided data on the composition of the stock of contributors by age (but not by gender). The initial distribution of contributors by age and gender (Figure 24) is derived from the available information and the assumption that women constitute around 15 percent of the total number of contributors. This assumption is based on the recent trends in the female employment in Iran (Iran Statistical Yearbook, 2000).

**Figure 24. Contributors by Age and Gender in 2001 (Thousand Persons)**

![Figure 24](image)

Source: PROST input file for SSO.
Total number of SSO contributors and its age and gender distribution are modeled using the “Stock” method (see section 1 for details) with coverage rates linked to employment. The initial age-specific coverage rates are based on the estimated initial age distribution of contributors as well as demographic and labor market assumptions described in Sections 2 and 3.

Future changes in coverage rates are based on the assumption that in the long run the total coverage rate for all contributory pension systems in Iran will converge towards prevailing international patterns in terms of the relationship between coverage and per capita income (see Palacios and Pallares, 2000). Under the base case assumptions on GDP per capita growth (taking into account purchasing power parity) and assuming that the share of SSO in the total coverage does not change, the number of SSO contributors as a proportion of the labor force will remain stagnant at the current level of about 35 percent over the next decade and then will gradually increase to about 48-50 percent by the end of the simulation horizon as shown on Figure 25.

**Figure 25. Projected Total Number of Contributors (Percent of Labor Force)**

![Graph showing the projected total number of contributors as a percent of labor force from 2001 to 2028.](source)

Driven by the above assumptions, age-specific coverage rates remain constant during the first 10 years and then gradually increase by about 20 percent over the next 60 years. The age profile of coverage is assumed to keep its current shape throughout the whole simulation period (Figure 26).
Figure 26. Coverage Rates by Age (Percent of Employed)

Source: PROST input file for SSO.

Figure 27. Wage Distribution by Age and Gender
(Percent of 20 Year Old Male’s Wage)

Source: PROST input file for SSO.

Information on the age- and gender-specific wages of the SSO contributors is not available, and it is assumed that for the young and middle age groups SSO earning profile is similar to the one for CSRO. However, for older age groups (50 and above) the decline is less steep compared to the CSRO curve (Figure 11). Similar to modeling the CSRO pension system, the SSO earning profile is assumed to remain invariable over time for both genders. Figure 27 presents the assumed age distribution of wages for men and women in terms of a 20 year old male.
Beneficiaries

The same three categories of beneficiaries as in the case of CSRO are simulated for SSO: (1) old age pensioners, (2) disabled, and (3) families receiving survivorship pensions. Traditionally, old age pensioners are modeled by tracking the beneficiaries over time from the moment of retirement until the pensioner dies. However, the disabled – differently from the CSRO simulations – are modeled by specifying directly the total number in each year of the simulation period, same as the total number of survivors families. In the base year – according to SSO – there were 419.1 thousand old age pensioners, 69 thousand disabled, and 286.7 thousand families receiving survivorship benefits. The initial age and gender distribution of the stock of old age pensioners was obtained by slightly smoothing the SSO actual data (Figure 28).

Figure 28. Old Age Pensioners by Age and Gender in 2001

The “Flow” method is used to compute further changes in the number of old age pensioners. In the input file retirement rates are specified as the flow of new old age retirees by age and gender relative to the previous year’s contributors. Initial retirement probabilities are based on the SSO data which were smoothed and slightly adjusted to ensure that projected rates of growth of the number of old age pensioners and pension expenditures are consistent with the past trends. In the base case scenario retirement rates are assumed to remain invariable over time (see Figure 29 for the assumed retirement rates for men and women).
The current average length of service at retirement in SSO is roughly estimated to be about 20 years. As no information is available about its age and gender profile, in the base year it is set at a flat level of 21.5 years for everybody retiring at legal retirement age or above (60+ for men, 55+ for women). This flat level was calibrated to simulate reasonable level of old age pensions in the first few years of the simulation period. For those retiring before the legal retirement age, length of service is assumed to be the following:

1. Men – 20 years for ages under 50, 25 years for ages 50-59
2. Women – 20 years for ages under 45, 25 years for ages 45-54.

These assumptions are based on the current regulations allowing early retirement with minimum 30 years of contribution or 20 years continuously. In the future – with no changes in early retirement arrangements in the base case scenario – length of service for ages under 60 for men and 55 for women is assumed to remain unchanged. However, for ages 60+/55+ length of service is assumed to increase gradually to 25 years over the next 20 years to reflect a recent change in legislation according to which the minimum number of contribution years is being increased from 10 to 20 years by 0.5 year every year (see Table 5 in Section 3.3 of the Report).

The total number of beneficiaries under the other two categories – disabled and survivors – is modeled as a constant share of the total number of contributors and beneficiaries in each year of the simulation period: about 1 percent for disabled and 4.2 percent for survivors. PROST projections of the future growth of the number of beneficiaries in each of the three categories are presented on Figure 30.
Age-specific and gender-specific pensions are modeled only for the old age pensioners category. Benefits for disabled and survivors are specified as an average replacement rate across the whole stock of beneficiaries under the respective category in each year. In the base case scenario average replacement rates for disabled and survivors (per family) do not change over time, remaining at 57 percent and 62 percent respectively (in terms of the covered average wage).

Age-specific and gender-specific benefits for old age pensioners are projected using the initial pensioner profile, indexation rules and replacement rates for new old age retirees. The initial pensioner profile (Figure 31) for the existing old age pensioners is based on the SSO data about average pensions received by beneficiaries in each age and gender cohort in 2001. Benefits are assumed to be fully indexed to inflation, as currently set by law. No data on initial distribution of entry pensions by age and gender is available. Similar to CSRO, replacement rates for new old age retirees are derived using the input data/assumptions about the length of service at retirement and annual accrual rate (3.3 percent in the base case scenario) as well as PROST projections of individual and average wages. The assumed replacement rates for newly retired in the first and ending year for men and women are shown on Figures 32 and 33.
Figure 31. Old Age Pensions Distribution by Age and Gender (Percent of 50 Year Old OAP’s Benefit)

Source: PROST input file for SSO.

Figure 32. Replacement Rates for New Old Age Retirees (Percent of Average Wage)

Men

Women

Source: PROST input file for SSO.
A2. Sustainable Rate of Return on Contributions Paid by a Pay-As-You-Go System

Consider the case of an overlapping generations model where each generation lives two periods, contributing to a pay-as-you-go system when young and receiving pensions when old.

For each generation the rate of return on contributions is given by:

\[ r_t = \frac{\alpha_t w_0 (1 + g)^t}{cw_0 (1 + g)^{t-1}} - 1, \]  

where \( w_0 \) is the wage at time 0, \( g \) is the growth rate of wages, \( c \) is the contribution rate (assumed to be constant), and \( \alpha_t \) is the equilibrium replacement rate assumed to adjust over time to guarantee financial equilibrium. The equilibrium replacement rate can be derived from the equilibrium condition in a pay-as-you-system:

\[ L_t cw_0 (1 + g)^t = \alpha_t L_{t-1} (1 + g)^{t-1}, \]

where \( L_t \) is the number of workers in generation \( t \) (our proxy for the labor force). This condition states that the contributions of generations \( t \) should be equal to the pensions of generation \( t-1 \). Therefore we can write:

\[ \alpha_t = (1 + l)c, \]

where \( l \) is the growth rate of the labor force.

The sustainable rate of return of the system can thus be written as:

\[ r_t = (1 + l)(1 + g) - 1 = g + l + lg \quad \text{for all } t, \]

which is exactly the growth rate of the wage bill \( W = L^*w \).
A3. Replacement Rates in the Notional Defined Contribution System

A worker joining the NDC system at time 0, facing an average growth rate of its wage of $g\times100$ percent per year and contribution $c\times100$ percent to the NDC system, receiving a rate of return equal to $r\times100$ percent, and retiring at time $R$, will have accumulated a capital given by:

$$K_R = \sum_{t=0}^{R} cw_0 (1 + g_w)^t (1 + g_s)^{R-t} = cw_0 (1 + r)^R \left( \frac{1 - a^{R+1}}{1 - a} \right),$$  \hspace{1cm} (7)

where $a = \frac{(1 + g_w)^t}{(1 + g_s)^t}$.

This capital needs to be sufficient to pay a pension $p$ to the individual until his death. This pension therefore needs to verify:

$$K_R = \sum_{t=1}^{D-R} p \theta^t,$$  \hspace{1cm} (8)

where $\theta = 1/(1+r)$ is the discount factor.

This implies that the pension is given by:

$$p = K_R \cdot \frac{1 - \theta}{1 - \theta^{D-R+1}},$$  \hspace{1cm} (9)

Hence the replacement rate is given by:

$$p/w_R = c \left( \frac{1 - a^{R+1}}{1 - a} \right) \left( \frac{1 - \theta}{1 - \theta^{D-R+1}} \right),$$  \hspace{1cm} (10)

The replacement rate increases when the contribution rate ($c$) increases, when the rate of return on savings ($g_s$) increases, and the growth rate of wages ($g_w$) decreases, when the discount factor for pension benefits ($r$) decreases, when the retirement age ($R$) increases, and when life expectancy ($D$) decreases.