

## Summary of Social Security Administration Projections of the OASDI System

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### Abstract

The projection methods used by the Social Security Administration's (SSA's) Office of the Chief Actuary (OCACT) are important. The resulting projections are cited regularly by policy-makers, academics and others interested in the long-term financial solvency of the OASDI system. However, a complete description of this projection methodology that is vital for serious policy discussions is not available to the general public.

This summary was constructed in connection with the Social Security Advisory Board's 1999 Technical Panel on Methods and Assumptions. A goal of the Methods and Modeling working group of the Technical Panel was to "work to ensure that the projection methods used by the Office of the Chief Actuary become more public." A technical summary can promote fruitful discussion of SSA projections. Construction of these notes illustrates this point by providing an initial version of this type of summary. Further, these notes provide a basis for future iterations of this summary.

Summarizing the projection methods is difficult because the SSA OCACT is constantly improving, and thus changing, their methodology. Nonetheless, documentation is important for informed policy discussions; the OCACT must acquire the resources to produce this documentation. Prior advisory panels have also made this recommendation. Below are two quotes from SSA history underscoring this point.

Quote by the subcommittee for Actuarial Cost Estimates of the 1958 Advisory Council. The quote appears in Myers (1959), "Methodology Involved in Developing Long-Range Cost Estimates for the OASDI System" (Actuarial Study Number 49).

"We also recommend that the Actuary adopt the practice of assembling in a single report a detailed description of the technique used in making cost estimates, the actuarial formulas and factors used and their bases or derivation and the actual calculations. Such report would be a public document available to any one for reference or study purposes. It would simplify the work of future Advisory Councils."

Quote by the Technical Panel to the 1991 Advisory Council on Social Security (page 41).

"The panel concludes that: ...The ability of staff to document the continually changing projection process and to engage in basic research that could enhance the process is severely constrained by lack of staff and limited computer resources."

# 1. Introduction

## Purposes of the projection system

The primary purpose of the projection methodology is to provide cost estimates of the current benefit system, both current and future costs. Long-range projections of costs are used for calibrating the design of the system, that is, structuring the amount and timing of benefits and contributions, so that the system is self-supporting. Short-range projections are also used to calibrate the design as well as to provide budget forecasts for OASDI that are required by all components of the Federal government.

Increasingly, the projection system is used to value the cost of benefit systems, with alternative benefit and contribution structures, proposed by policymakers.

The projection system is not directed towards making statements about the adequacy of benefits to different socioeconomic groups.

## How the projection system works

The system is split into three main input components; demographic, short-range (ten or fewer years) and long-range (up to seventy-five years). Although they follow the same actuarial principles, the details of the short and long-range projections differ substantially. Short-range projections are done quarterly whereas the long-range projections are done on annual basis. On the one hand, the short-range projections explicitly account for factors such as the timing of tax collections, the investment (maturity) structure of the Trust Funds and relative growth of sectors of the Gross Domestic Product that are not as relevant for long-range projections. On the other hand, the long-range projections have more explicit models of trends that are less critical for short-range projections.

Short-range and long-range projection systems differ, in part, because of the relative knowledge of the near future compared to the distant future. Further, several other government agencies make short-range projections, both of their own budgets as well OASDI obligations. The budget planning process for the entire Federal government requires detailed estimates by all components of government. Thus, it is critical for SSA forecasts to be in congruence with these alternatives.

The demographic component is common to both the short and long-range projections. The short and long-range components include economic and programmatic variables. Programmatic variables are those elements that are directly related to the benefit system whereas the economic (and demographic) variables are directly related to the population and economy as a whole.

The projection system disaggregates the population into homogeneous demographic cells, stratified based on age and sex and sometimes additional breakdowns such as marital status or cause of mortality.

The system is deterministic; projection uncertainty is portrayed by examining changes in system output based on small changes in inputs. Table 1 summarizes the key assumption variables that are inputs into the projections. Table 1 also lists assumption variables where the method of projection varies by alternative.

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**Table 1. Key Assumption Variables**

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*Demographic*

Total Fertility Rate

*Macroeconomics*

Productivity Growth Rate (GDP per Hour)

Mortality Decline Rate	Inflation Rate (CPI)
Net Flow of Immigration	GDP Price Deflator
<i>Labor Economics</i>	Nominal Investment Rate
Unemployment Rate	<i>Disability</i>
Wage-Share Growth Rate	Incidence Rate
Real Wage Growth Rate	Recovery Rate
Hours Worked Growth Rate	

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**Methods that Vary by Alternative**

Marriage  
Divorce

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**Some alternative SSA projection systems**

Because the system is geared primarily to handle demographic and not economic cohorts, it has little to say about the adequacy of benefits to different social groups. The SSA is developing alternative models, including the “MINT,” the “CORSIM” and the “Cohorts” models; these models address the adequacy of benefits under the current and alternative proposals. They are “micro-simulation” models; as such, they have little to say directly about fiscal implications.

**Purpose of these notes**

The projection model of the OASDI system is complex and understood by only a few experts outside of SSA OCACT.

1. Serious policy discussions are hampered by the fact that so few people understand the methodology.
2. Because they do not understand SSA methods, other agencies/groups try to grow alternative models without the benefit of SSA’s 65 years of experience. Both SSA and these other groups spend substantial amounts of time comparing and contrasting these competing models.
3. Even well informed consumers do not understand SSA methods. Thus, SSA upper management spends substantial amounts of time defending their projections to these individuals.
4. Because of the model’s complexity, there are many places where the development of the system appears to be uneven.

This summary was constructed in connection with the Social Security Advisory Board’s 1999 Technical Panel on Methods and Assumptions. This summary does not attempt to suggest alternatives to projection system currently in place. A goal of the Methods and Modeling working group of the Technical Panel was to “work to ensure that the projection methods used by the Office of the Chief Actuary become more public.” Additional documentation on the projection methods will be useful for external groups, as described above. Further, it should also be useful for SSA internal constituencies. In particular, consider:

1. New hires, who would like an overview of the system.
2. Seasoned veterans, who would like a broad perspective on areas outside of their main area of interest.

3. Technical panels. To provide useful advice to the SSA OCACT, a technical panel needs to have a good grasp on the projection methodology. A technical summary would be an invaluable addition to the resources of future technical panels.

### Outline of the Description

This article summarizes a technical projection system; the exposition is directed towards an audience that is comfortable with technical expressions. Technical expressions are compact and readily understood by readers who are actuaries, demographers or economists, the primary audiences of these notes. In particular, recursive equations are used throughout. Although users will not be able to replicate the work of the SSA OCACT with this summary (even with access to the confidential data used in the projections), there is a substantial level of detail involved.

This summary is meant to provide an overview of the projection system. *Many additional details can be found in Actuarial Studies published by the SSA OCACT.* These additional sources are described, by section, following the main body of the text. Also following the main body of the text is a list of SSA experts; these individuals provided the information about the projection system that is not available in public documents.

The summary is organized as follows. We start with the big picture – a description of the inflows and outgoes from the Trust Fund. This description distinguishes between short and long-range projections. Then, we present demographic and population projections. These feed into the short-range projections of revenues and expenditures. Finally, we consider long-range projections of revenues and expenditures.

### Detailed Outline

Section Description	Section
<b>1 Introduction</b>	<b>6 Short-Range Benefit Projections</b>
<b>2 Trust Fund Projections</b>	6.1 Insured Population
2.1 Introduction	6.2 Disability Beneficiaries
2.2 Income	6.3 Old-Age and Survivor Beneficiaries
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<b>3 Population Projections</b>	<b>7 Long-Range Revenue Projections</b>
3.1 Motivation	7.1 Employment
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3.3 Projection of Demographic Components	7.3 Earnings
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5.1 Calendar Year Taxable Wages, by Sector	8.4 Benefit Projections
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5.3 Taxable Self-Employment Earnings	<b>Sources</b>
5.4 OASDI Tax Collections	<b>Acknowledgements</b>

## 2. Trust Fund Projections

### 2.1 Introduction

Overall fiscal soundness of the OASDI system may be understood by examining an initial level of the trust fund, denoted by *Trust Fund*(0), as well as future income and expenditures. Specifically, the initial level of the trust fund is the end of the year preceding the first projection year. The index  $z$  represents years in the future with respect to year 0. We will consider  $z = 1, \dots, 75$  years when projecting OASDI. For each year, the income minus expenditures, denoted by *Income*( $z$ ) – *Outgo*( $z$ ), represents the net contributions to the trust fund in year  $z$ . Thus, the fund is incremented by the expression

$$\text{Trust Fund}(z) = \text{Trust Fund}(z-1) + \text{Income}(z) - \text{Outgo}(z), \quad z = 1, \dots, 75. \quad (2.1)$$

The income and outgo are defined below in Sections 2.2 and 2.3, respectively.

Projections are not made directly based on the system's income and expenditures for several reasons.

1. Both are subject to changes in law. As such, these interventions are controllable and are not readily amenable to forecasting.
2. They do not directly reflect the changing underlying demographic trends.
3. They only indirectly reflect the changing economic scene.

Broadly speaking, the projection system is decomposed into separate modules. These are (i) the demographic projections, (ii) the economic and revenue projections and (iii) the benefit projections. The demographic projections are the most fundamental and feed into the other two modules. The economic projections are part of the second module yet are also used in the third module.

Although they largely follow the same actuarial principles, the details of the short and long-range projections differ substantially. Income and outgo for short-range projections are done quarterly whereas the long-range projections are done on annual basis.

The focus of the short-range status is the *Trust Fund Ratio*, defined to be the trust fund assets at the beginning of the year divided by the anticipated outgo during the year. That is,

$$\text{Trust Fund Ratio}(z) = \frac{\text{Trust Fund}(z-1)}{\text{Outgo}(z)}. \quad (2.2)$$

The focus of the long-range status is the *Actuarial Balance*, defined to be the initial trust fund plus present value of net contributions minus the present value of the *Target Trust Fund*, as a percentage of the present value of future payroll. That is,

*Actuarial Balance*

$$= \frac{\text{Trust Fund}(0) + \sum_{z=1}^{75} \{ \text{PV}(\text{Revenue}(z)) - \text{PV}(\text{Outgo}(z)) \} - \text{PV}(\text{Target Trust Fund})}{\sum_{z=1}^{75} \text{PV}(\text{Effective Taxable Payroll}(z))}. \quad (2.3)$$

The *Target Trust Fund*, which is 100 percent of annual expenditures in the 76<sup>th</sup> year, is considered to be an adequate reserve for unforeseen contingencies. Sections 2.2 and 2.3

describe revenue and outgoes in each year. Present values (PV) are done by discounting using forecasts of the nominal interest rates that appear in Section 2.2.4. Sections 5.4 and 7.4 discuss forecasts of effective taxable payroll.

This balance is often decomposed into income and outgo portions. Thus, we define the

$$\text{Summarized Income Rate} = \frac{\text{Trust Fund}(0) + \sum_{z=1}^{75} \text{PV}(\text{Revenue}(z))}{\sum_{z=1}^{75} \text{PV}(\text{Effective Taxable Payroll}(z))}$$

and the

$$\text{Summarized Cost Rate} = \frac{\sum_{z=1}^{75} \text{PV}(\text{Outgo}(z)) + \text{PV}(\text{Target Trust Fund})}{\sum_{z=1}^{75} \text{PV}(\text{Effective Taxable Payroll}(z))}$$

This yields an alternative expression:

$$\text{Actuarial Balance} = (\text{Summarized Income Rate}) - (\text{Summarized Cost Rate}).$$

## 2.2. Income

Income can be classified non-interest income, which we call revenue for brevity, and interest income. Non-interest income consists of: (1) contributions (payroll taxes and self-employment taxes), (2) income from taxation of benefits and (3) reimbursements from the general fund of the Treasury. Thus, we define

$$\text{Income}(z) = \text{Revenue}(z) + \text{Trust Fund Interest Earnings}(z) \quad (2.4a)$$

and

$$\text{Revenue}(z) = \text{Contributions}(z) + \text{Taxes on Benefits}(z) + \text{Treasury Reimbursements}(z). \quad (2.4b)$$

Each component is discussed in turn.

### 2.2.1. Contributions

The contributions account for about 95% of income. The inputs are the payroll tax rate and taxable payroll. We may think of contributions as:

$$\begin{aligned} \text{Contributions}(z) = & \text{Employee Taxable Wages}(z) \times \text{Employee Payroll Tax Rate}(z) \\ & + \text{Employer Taxable Wages}(z) \times \text{Employer Payroll Tax Rate}(z) \\ & + \text{Self-Employment Taxable Earnings}(z) \times \text{Self-Employed Tax Rate}(z). \end{aligned} \quad (2.5)$$

For 1999 current and anticipated future tax schedules, the employee equals the employer tax rate and this is one half of the self-employed tax rate. Thus, we define the  $\text{Tax Rate}(z)$  to be simply the self-employed tax rate in year  $z$ . With this definition, we may think of the contributions as:

$$\text{Contributions}(z) = \text{ETP}(z) \times \text{Tax Rate}(z)$$

where we define the Effective Taxable Payroll (ETP) as

$$\text{ETP}(z) = \frac{1}{2} \text{Employee Taxable Wages}(z) + \frac{1}{2} \text{Employer Taxable Wages}(z)$$

$$+ \textit{Self-Employment Taxable Earnings}(z) .$$

This structure is used for the short-range projections, which are done on a quarterly basis. In addition, adjustments are made to account for the differences in wages on which tax liabilities are based (“incurred”) and those on which taxes are collected (“cash”). These adjustments are outlined in Section 5.

For the long-range projections, we include a specific allowance for military wage credits. (For short-range projections, military wages are treated in the same fashion as other wages.) Thus, we have:

$$\begin{aligned} ETP(z) = & \frac{1}{2} \textit{Employee Taxable Wages}(z) + \frac{1}{2} \textit{Employer Taxable Wages}(z) \\ & + \textit{Self-Employment Taxable Earnings}(z) + \textit{Military Wage Credit}(z) \end{aligned}$$

and use

$$\begin{aligned} \textit{Contributions}(z) = & \textit{Lag Factor} \times ETP(z-1) \times \textit{Tax Rate}(z-1) \\ & + (1-\textit{Lag Factor}) \times ETP(z) \times \textit{Tax Rate}(z) \end{aligned}$$

where

$$\textit{Lag Factor} = \frac{\textit{Tax Rate}(10) \times ETP(10) - \textit{Contributions}(10)}{\textit{Tax Rate}(10) \times ETP(10) - \textit{Tax Rate}(9) \times ETP(9)} .$$

The purpose of the *Lag Factor* is to convert taxable payroll from an incurred basis to a cash basis. Essentially, for long-range projections, tax liabilities are forecast directly and then converted to a collection, or cash, basis.

Because future tax rate schedules are known, an important goal of Sections 5 and 7 will be to provide forecasts of taxable earnings for short and long-range projections, respectively.

### 2.2.2. Taxes on Benefits

Beginning in 1994, up to 85% of Social Security benefits are subject to income tax. The OASI and DI Trust Funds receive this tax from Treasury (IRS), up to the first 50%. (The remainder of the taxes are credited to the HI Trust Fund.)

Historical data on income taxation of benefits comes from the Office of Tax Analysis in the Department of Treasury. These data allow one to project the percentage of benefits taxable. This percentage, together with projected benefit payments (that will be described in Sections 6 and 8), yields projected taxes on benefits. That is, from the Office of Tax Analysis, we get % *Benefits Taxable*(z). This yields

$$\begin{aligned} \textit{Taxes on Benefits}(z) \\ = & \textit{Annuity Benefits}(z) \times \% \textit{Benefits Taxable}(z) \times \textit{Average Marginal Tax Rate}. \quad (2.6) \end{aligned}$$

For the short-range projections, additional adjustments are made for taxes on benefits paid to non-resident aliens. These adjustments are described in Barrick and Zayatz (1996, Section IV.C, page 180).

### 2.2.3. Treasury Reimbursements

Reimbursements from Treasury to the Trust Funds are made for military service transfers and for benefits to uninsured persons.

Annual payments are made from the general fund of the Treasury to the Trust Fund for military service payments; payments representing employee and employer contributions for military service credit. For years after 1956, the basic pay of the military personnel is covered under OASDI. In addition, credits are granted to recognize that military personnel receive wages in kind (such as food and shelter) in addition to cash payments. In years after 1977, noncontributory wage credits of \$100 are granted for each \$300 of military wages, up to a maximum credit of \$1,200 per calendar year. For the short-range projections, these are part of contributions. As we have seen in Section 2.2.1, the long-range projections make a specific allowance for military wage credits.

Additional adjustments are made for service credits prior to 1957. The short-range projections project future transfers for 2000 that fall under this category. Further discussion of this may be found in Barrick and Zayatz (1996), Section IV.B, page 179. The long-range projections do not include this special category

The other type of special transfer from Treasury to the Trust Funds is for benefits to uninsured persons. The law provides for special monthly cash payments to certain uninsured persons who attained age 72 before 1968 or who have 3 quarters of coverage for each year after 1966 and before the year of attaining age 72. The number of such persons is based on extrapolation of historical survival rates. The average benefit is increased by the same percentage as regular OASDI benefits; see Sections 6.4.3 and 8.4.2.

### 2.2.4. Trust Fund Interest Earnings

For the short-range projections, the SSA OCACT uses a complex "simulation" model that tracks starting period assets of trust funds by amount, coupon rate and due date. It specifies monthly new issue rates, monthly payments and float factors. This model provides a detailed picture of the monthly performance of Treasury invested funds.

For the long-range projections, we may consider Trust Fund interest earnings to be composed of (i) interest received on investments, (ii) interest on interfund borrowings, (iii) amortization of premium or discount on bonds, (iv) interest on advance tax transfers and (v) miscellaneous interest items. For the long-range projections, we use:

$$\begin{aligned} \text{Trust Fund Interest Earnings}(z) = & \text{Trust Fund}(z-1) \times \text{nominal interest rate}(z) \\ & + \left( \frac{6.3}{12} \times \text{Contributions}(z) + \frac{1}{2} \times \text{Taxes on Benefits}(z) - \frac{1}{2} \times \text{Benefits}(z) \right. \\ & \left. - \frac{1}{2} \times \text{Expenses}(z) - \frac{7}{12} \times \text{RRR}(z) \right) \times \text{nominal interest rate}(z). \end{aligned} \quad (2.7)$$

Each coefficient in equation (2.7) represents the SSA OCACT's estimate of the midpoint of the annual flow of the associated variable. To illustrate, for the *Expenses* variable, Trust Fund expenses are assumed to occur uniformly throughout the year. Thus, approximately ½ year of interest is lost in the total amount of monies paid out due to expenses. Forecasts of contributions and taxes on benefits were given in equations (2.5)



and (2.6), respectively. Forecasts of the outgo, including benefits, expenses and Railroad Retirement Interchange (RRI) are outlined in Section 2.3.

Assets of OASDI Trust Funds are invested in special non-negotiable US government securities.

For the intermediate assumption of the 1999 Trustees report, the 1999 nominal interest rate is 4.7% and reaches its ultimate value of 6.3% in 2008. The ultimate low-cost is 6.0% and high-cost is 6.5%. Thus, the ultimate real interest rates are 3.0% for intermediate, 3.7% for low-cost and 2.2% for high-cost. The ultimate values are based on the opinions of the Trustees. Near term results from the simulation model are modified, based on the judgement of the SSA OCACT, to approach the ultimate values smoothly.

### 2.3 Outgo

Outgo from the OASI and DI Trust Funds can be classified into miscellaneous expenditures and (annuity) benefit payments. The annuity benefit payments are periodic benefits paid to qualified disabled and retired workers and their auxiliaries and account for about 98% of outgo. Thus, we consider

$$Outgo(z) = Misc\ Outgo(z) + Living\ Benefits(z) . \quad (2.8)$$

Sections 6 and 8 provide details on forecasts of annuity benefits for short and long-range projections, respectively.

The miscellaneous benefits and expenses consist of (1) lump-sum death benefits, (2) transfers to the Railroad Retirement program, (3) administrative expenses, and (4) other miscellaneous expenses. Thus, we have

$$Misc\ Outgo(z) = Death\ Benefits(z) + RRI(z) + Expenses(z) + Other\ Misc\ Expenses(z) . \quad (2.9)$$

#### 2.3.1. Death Benefits

We compute death benefits as \$255 times the projected number of insured deaths. The projected number of insured deaths is computed as follows:

1. Section 3 describes projections of the population and number of deaths by age, sex, marital status,  $z$ ) and  $D(age, sex, marital\ status, z)$ , respectively. Section 8.1.1 describes projections of the fully insured population; we will denote this as  $P_{FI}(age, sex, marital\ status, z)$ . Thus, form a preliminary estimate of the number of insured deaths:

$$Deaths_0(z) = \sum_{age, sex} \sum_{ms=married, widow(er)} \frac{D(age, sex, marital\ status, z)}{P(age, sex, marital\ status, z)} P_{FI}(age, sex, marital\ status, z) .$$

Here, the second sum is over marital status = married and widowed.

2. Using historical data, we may compute a preliminary estimate of the death benefit payments as  $Deaths_0(z) \times 255$ . An adjustment *Factor* is computed as the ratio of actual death benefit payments to this preliminary estimate for historical values. The final projected death benefit is:

$$Death\ Benefits(z) = \$255 \times Deaths_0(z) \times Factor . \quad (2.10)$$

### 2.3.2. Railroad Retirement Interchange

An annual exchange of funds between OASDI and the Railroad Retirement program. It is designed to place each trust fund in the same position in which it would have been if railroad employment had always been covered under Social Security.

This is evaluated on the basis of trends similar to those used above. The inputs consist of data from the Railroad Retirement Board, average wage index, average benefits for the Old-Age Insurance beneficiaries. The resulting effect is a long-range loss to the OASDI program of about 0.05 percent of taxable payroll.

### 2.3.3. Administrative Expenses

For the short-range projections, expenses are projected by a time series regression model, taking account of historical experience the expected growth in average wages in the economy. Further, estimates for the first two years reflect the latest available estimates prepared by SSA Office of Budget.

For the long-range, the projection is based on assumed increases in average wages and the levels of expenses and wages in prior years. After a ten-year period, the increase is augmented by increases in numbers of beneficiaries. The inputs consist of starting administrative expenses, total beneficiary population, average wage index, assumed increase in productivity. The long-range projected expenses are:

$$\begin{aligned} \text{Expenses}(z) &= \text{Expenses}(z-1) \times (1 + \% \text{Wage increase}(z-1)), & z = 1, \dots, 10 \\ \text{Expenses}(z) &= \text{Expenses}(z-1) \times (1 + \% \text{Wage increase}(z-1)), & z > 10 \\ & \times (1 + \% \text{increase in the Number of Beneficiaries}(z-1)). \end{aligned}$$

### 2.3.4. Other Miscellaneous Expenses

There are two other sources of miscellaneous expenses that are itemized in the short-range, although not the long-range, projections. These are vocational rehabilitation expenses and unnegotiated check reimbursements.

Vocational rehabilitation expenses are for services designed to contribute to the successful rehabilitation of disabled persons receiving cash benefits because of their disabilities. These costs are paid from the DI Trust Fund.

The OASI and DI Trust Funds are debited the amount of a benefit check at the time the check is issued. Treasury checks issued in October, 1989 or later are negotiable for 1 year; if uncashed after such time, action to reimburse the trust funds is instituted.

Barrick and Zayatz (1996) documents these expenses sources in greater detail; see Sections IV.E and IV.F.

### 3. Population Projections

#### 3.1 Motivation

The contributions depend on the projected number of workers. The benefits depend on the future population through age, sex and marital status.

Population projections begin with the initial population, by age, sex and marital status. They are updated through birth, death, marriage, divorce, widowing and net immigration.

Input data include: National Center for Health Statistics (NCHS) birth rates, number of marriages and divorces, number of deaths, Medicare deaths and population, Census population and INS immigration.

The key assumption variables are total fertility rate, mortality decline rates and net flow of immigration. These are given as low, intermediate and high cost alternatives. Further, certain methods also vary by alternative. These include marriage and divorce.

#### 3.2 Update procedure

Use  $P$  to denote the population as a function of age, sex, marital status and valuation date. That is,  $P(\text{age}, \text{sex}, \text{marital status}, \text{valuation date})$ .

The population is updated through:

Function Name	Description	Level of Detail
B	Births	sex
D	Deaths	age, sex, marital status
C	Marriages	age, sex and prior marital status
S	Divorce	age and sex
W	Widowings	age and sex
I	Net immigrants	age, sex and marital status.

We use the notation  $x$  for the age of a male last birthday,  $y$  for the age of a female

last birthday and  $ms$  for marital status, where  $ms = \begin{cases} 1 & \text{single} \\ 2 & \text{married} \\ 3 & \text{widowed} \\ 4 & \text{divorced} \end{cases}$ . The valuation date is

denoted by  $z$  and taken at July 1,  $z; z = 0, 1, \dots, 75$ . With this notation, projected populations are updated through:

$$\begin{aligned}
 \text{single} \quad & P(\text{age}+1, \text{sex}, 1, z+1) = P(\text{age}, \text{sex}, 1, z) \\
 & \quad - D(\text{age}, \text{sex}, 1, z) - C(\text{age}, \text{sex}, 1, z) + I(\text{age}, \text{sex}, 1, z) \\
 \text{married} \quad & P(\text{age}+1, \text{sex}, 2, z+1) = P(\text{age}, \text{sex}, 2, z) \\
 & \quad - D(\text{age}, \text{sex}, 2, z) + C(\text{age}, \text{sex}, 1, z) + C(\text{age}, \text{sex}, 3, z) + C(\text{age}, \text{sex}, 4, z) \\
 & \quad - W(\text{age}, \text{sex}, z) - S(\text{age}, \text{sex}, z) + I(\text{age}, \text{sex}, 2, z) \\
 \text{widowed} \quad & P(\text{age}+1, \text{sex}, 3, z+1) = P(\text{age}, \text{sex}, 3, z) \\
 & \quad - D(\text{age}, \text{sex}, 3, z) - C(\text{age}, \text{sex}, 3, z) + W(\text{age}, \text{sex}, z) + I(\text{age}, \text{sex}, 3, z) \\
 \text{divorced} \quad & P(\text{age}+1, \text{sex}, 4, z+1) = P(\text{age}, \text{sex}, 4, z) \\
 & \quad - D(\text{age}, \text{sex}, 4, z) - C(\text{age}, \text{sex}, 4, z) + S(\text{age}, \text{sex}, z) + I(\text{age}, \text{sex}, 4, z)
 \end{aligned}$$

The initial (SS Area) population  $P(\text{age, sex, marital status}, 0)$  is estimated from (1995) Census Bureau reports. Typically, each Trustees' report uses Census Bureau estimates from the previous two years.

**Joint lives** ( $xy$ ) of married couples are projected via the equation:

$$P_{j1}(x+1, y+1, z+1) = P_{j1}(x, y, z) - D_{j1}(x, y, z) + C_{j1}(x, y, z) - S_{j1}(x, y, z) + I_{j1}(x, y, z).$$

The initial joint distribution is from a 1980 Census Bureau report. This distribution is applied to the SS Area Population,  $P(\text{age, sex, ms, z})$ , using "iterative prorating" techniques to yield  $P_{j1}(x, y, z)$ .

### 3.3 Projection of Demographic Components

**3.3.1. Mortality.** Mortality is disaggregated by age, sex, and cause. Here, cause is broken down by 10 causes. These are:

Heart Disease	Congenital Malformations and Diseases of Early Infancy
Malignant Neoplasms (Cancer)	Diseases of the Digestive System
Vascular Diseases	Diabetes Mellitus
Accidents, Suicide and Homicide	Cirrhosis of the Liver
Diseases of the Respiratory System	Other Causes excluding AIDS

In addition, separate analyses are done for AIDS.

#### *Step 1. Calculate Historical Central Death Rates*

The historical central death rates, for ages under 65, come from the number of deaths by age, sex and cause tabulated by NCHS and the Census Bureau's estimates of US resident population. For ages 65 and over, Medicare records were used to determine rates by age and sex. Number of deaths by age, sex and cause tabulated by NCHS were used to decompose the Medicare age/sex rate by cause. The basic data are not by joint life.

The central death rates are broken down into 21 age groups, primarily five year age groupings. The central death rates are calculated as the number of deaths divided by the number of person years in each age group.

#### *Step 2 Calculate Starting Year Central Death Rates*

By cohort (age, sex, cause), examine the trend over the last 12 years. Use this to establish an initial set of central death rates.

#### *Step 3. Calculate Average Annual Percentage Reductions in Central Death Rates*

By cohort (age, sex, cause), calculate the average percentage decline since 1968. Use this average to project central death rates for 24 years.

**Step 4. Blend Ultimate Level Average Annual Percentage Reductions in Central Death Rates**

Beginning in the 24<sup>th</sup> year, use the ultimate levels from the Trustees. These are separated only into 5 age groups. Use this to project central death rates for the remainder of the projection period.

For the first 24 years, use a function of the average annual reduction calculated in Step 3 and the ultimate levels. The function is a logarithmic one, designed to gradually transform the empirical annual reduction to the ultimate one.

**Step 5. Convert Central Death Rates by Cause to Individual Age, Grouped Death Rates**  
Define  $q(\text{age}, \text{sex}, z)$  to be the projected death rates for  $z = 1, \dots, 75$ .

**Step 6. Calculate the Total Projected Number of Deaths**

The total is the sum over four marital status categories. We have:

$$\sum_{ms=1}^4 D(\text{age}, \text{sex}, \text{ms}, z) = q(\text{age}, \text{sex}, z) \times \left( \sum_{ms=1}^4 P(\text{age}, \text{sex}, \text{ms}, z) \right).$$

Future relative differences in death rates by marital status are assumed to be the same as those determined using 1980 and 1981 data. This yields  $D(\text{age}, \text{sex}, \text{ms}, z)$  by age, sex and marital status cohort.

To get alternative mortality assumptions, take (1) 50% of the empirical and ultimate percentage reductions in Steps 3 and 4 for the low-cost alternative and (2) 150% for the high-cost alternative.

**3.3.2. Widowings**

Calculate the probability that a marriage dissolves through death by assuming independence of male and female lives. Specifically, this probability is expressed as:

$${}^2q_{xy} = \text{Prob}(xy \text{ fails}) = 1 - (1 - {}^2q_x)(1 - {}^2q_y).$$

Here,  ${}^2q_x$  is the probability that a male age  $x$  dies and  ${}^2q_y$  is the probability that a female age  $y$  dies. Projections of these probabilities, say  ${}^2q_{xy,z}$ , are based on projections of mortality projections described above.

Thus, we have:

$$q(\text{age}, \text{sex}, \text{ms}=2, z) = D(\text{age}, \text{sex}, \text{ms}=2, z) / P(\text{age}, \text{sex}, \text{ms}=2, z)$$

$${}^2q_{xy,z} = 1 - (1 - q(x, \text{male}, \text{ms}=2, z))(1 - q(y, \text{female}, \text{ms}=2, z))$$

$$D_{JL}(x, y, z+1) = P_{JL}(x, y, z) \times {}^2q_{xy,z}$$

$$W(\text{age}, \text{sex}, z) = D_{JL}(x, y, z) - D(\text{age}, \text{sex}, \text{ms}=2, z).$$

Here, if  $\text{sex} = \text{male}$ , then  $\text{age} = x$  and if  $\text{sex} = \text{female}$ , then  $\text{age} = y$ .

**3.3.3. Fertility**

Define the central birth rate to a female age  $y$  in valuation year  $z$  as

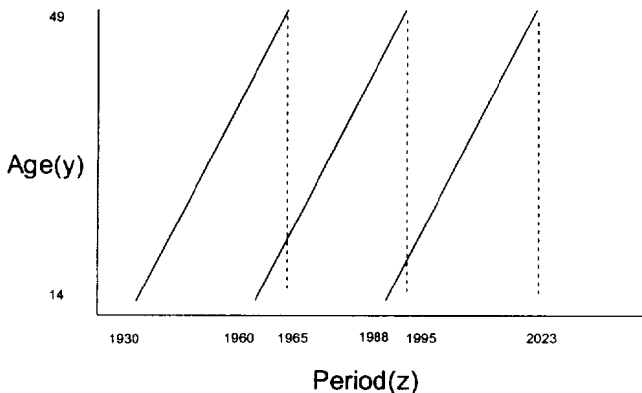
$$b_{y,z} = \frac{\text{number of births to a female age } y}{(\text{midyear}) \text{ number of females age } y}.$$

The total (period) fertility rate in valuation year  $z$  is  $\text{TFR}(z) = \sum_y b_{y,z}$ .

Step 1. Calculate  $b_{y,z}$  for historical years.

Step 2. Calculate an average fertility distribution.

Use the last 31 years of completed cohort rates  $\{b_{y,z}\}_{y=14}^{49}$  to calculate an average age-specific fertility distribution. The most recent completed cohort consists of women age 14 in 1960 and age 49 in 1995. (Provisional data for 1996 were available and used by SSA in their 1998 projections. These data are ignored for this discussion.) The first cohort consists of women age 14 in 1930 and age 49 in 1965. See Figure 1. Specifically, define  $\bar{b}_y = \sum_{z=1965}^{1995} b_{y,z-(49-y)} / 31$ . The fertility distribution,  $\{\bar{b}_y\}$ , is used as a weighting mechanism to project the completed cohorts in Step 3.



**Figure 1. Completed Cohorts. The diagonal lines along “ $y-14=z-1930$ ” follow a cohort. To illustrate, the most recently available completed cohort consists of women age 14 in 1960 and age 49 in 1995.**

Step 3. Project the fertility distribution.

We project  $b_{y,z}$  by grading historical values of  $b_{y,z}$  into  $b_{y,ultimate}$ , separately for each cohort of women, so that the ultimate total fertility rate is achieved in the 24<sup>th</sup> projection year.

Specifically, in Figure 1 we project rates by completing cohorts. The most recent completed cohort is identified in Figure 1. For the next cohort, consisting of women age 14 in 1961 and age 49 in 1996, only the information for fertility at age 49 in 1996 is not available. For the following cohort, consisting of women age 14 in 1962 and age 49 in 1997, only information for fertility at ages 48 and 49 are not available.

Thus, we recursively forecast, for  $z = 1961, \dots$ ,

$$\hat{b}_{y,z+y-14} = \hat{b}_{y,z+y-15} \times Factor(z), \quad \text{for } y = 14, \dots, 49$$

Here, the lagged (by period) cohort fertility rates,  $\hat{b}_{y,z+y-15}$ , are either actual fertility rates or computed from the prior recursion. To determine the period specific  $Factor(z)$ :

- We examine the sum of the actual cohort fertility rates and the lagged cohort fertility rates within the cohort identified by the period  $z$  for  $y = 14$ .
- We take a weighted average of this sum and the assumed ultimate total fertility rate. Here the weights use the fertility distribution,  $\{\bar{b}_y\}$ , computed in Step 2. These give

greater weight to the ultimate total fertility rate when less actual data are used in Step 3(a) and vice-versa.

c. This weighted average minus the sum of actual fertility rates is then rescaled to yield  $Factor(z)$ . This rescaling is done to insure that the projected total fertility rate grades into the ultimate.

Step 4. Calculate the Projected Number of New-Borns

$$P(0, \text{male}, 1, z) = \sum_{y=14}^{49} b_{y,z} \left( \sum_{ms=1}^4 P(y, \text{female}, ms, z) \right) \times (1.05/2.05).$$

$$P(0, \text{female}, 1, z) = \sum_{y=14}^{49} b_{y,z} \left( \sum_{ms=1}^4 P(y, \text{female}, ms, z) \right) \times (1.00/2.05).$$

For the intermediate assumption of the 1999 Trustees report, the 1999 fertility rate is 2.03 and reaches its ultimate value of 1.90 in 2023. The ultimate low-cost is 2.20 and high-cost is 1.60. The ultimate values are based on the opinions of the Trustees.

### 3.3.4. Marriage – number of new marriages by (xy).

Data are from the “Marriage Registration Area” (MRA), obtained from the National Center for Health Statistics (NCHS), 1957-1988. In 1988, the MRA consisted of 42 states and DC; it accounted for 80% of all marriages in the US (yet excludes Nevada). These data allow us to compute marriage rates:

central marriage rate for (xy) for year z

$$= mr_{xy,z} = \frac{\text{number of marriages for } (xy)}{\sqrt{\text{number of unmarried males aged } x} \sqrt{\text{number of unmarried females aged } y}}.$$

Here, the number of unmarried males and females are enumerated at midyear.

To summarize this, use the “age-adjusted central marriage rate,” which we interpret to be

$$\frac{\sum_{x,y} \text{number of marriages for } (xy)}{\sqrt{\sum_x \text{number of unmarried males aged } x} \sqrt{\sum_y \text{number of unmarried females aged } y}}.$$

Specifically, using the definition of the central marriage rate, we define the year z age-adjusted central marriage rate to be

$$MR_z = \frac{\sum_{x,y} mr_{xy,z} \sqrt{SP(\text{unmarried males aged } x)} \sqrt{SP(\text{unmarried females aged } y)}}{\sqrt{\sum_x SP(\text{unmarried males aged } x)} \sqrt{\sum_y SP(\text{unmarried females aged } y)}}.$$

Here, “SP” refers to the standard population, that is, the Marriage Registration Area population taken at midyear, 1982.

Step 1. Calculate  $mr_{xy,z}$  for each year z = 1957-1988.

Step 2. Calculate the marriage bivariate distribution.

Use 1978, 1979 and 1981-1988 (1980 was not available) historical rates of  $mr_{xy,z}$  to calculate an age-specific marriage distribution. Average and graduate these rates to get a single bivariate distribution, called  $amr_{xy}$ .

Step 3. Calculate the age-specific central marriage rates for provisional years 1989-1995.

For each provisional year, rescale the distribution in Step 2 ( $amr_{xy}$ ) so that the total number of marriages obtained by applying the rescaled values of  $amr_{xy}$  to estimates of unmarried population in the SS Area yields the estimate of the total number of new marriages in the SS Area.

Thus, determine the year  $z$  Factor through the expression:

$Factor(z) \times (2 \times \text{Number of Marriages in year } z) =$

$$\sum_{x,y} amr_{xy} \sqrt{\sum_{ms=1,3,4} (midyear) P(x, male, ms, z)} \sqrt{\sum_{ms=1,3,4} (midyear) P(y, female, ms, z)}.$$

This yields:

$$mr_{xy,z} = amr_{xy} / Factor(z).$$

**Step 4.** Calculate age-adjusted central marriage rates.

For each year 1957-1995, calculate the age-adjusted central marriage rates. The ultimate age-adjusted central marriage rate for 2021 and beyond is defined to be 95% of the average for 1989-1995. Determine the age-adjusted rates for 1996-2020 by blending the values between 1995 and 2021.

**Step 5.** Project the marriage distribution.

For every year after 1995, calculate  $mr_{xy,z}$  by rescaling  $amr_{xy}$  so that the age-adjusted central marriage rate determined in Step 4 is achieved.

These projections assume that the marriage possibilities are the same for single, widowed and divorced. Future relative differences in marriage rates by previous marital status were assumed to be the same as the average of those experienced during 1979 and 1981-1988. This yields  $mr_{xy,z}(ms)$  for  $ms = 1, 3, 4$ .

**Step 6.** Calculate the projected number of marriages

$C(x, male, ms, z) =$

$$\sum_y mr_{xy,z}(ms) \sqrt{(midyear) P(x, male, ms, z)} \sqrt{(midyear) P(y, female, ms, z)}, ms = 1, 3, 4.$$

$C(y, female, ms, z) =$

$$\sum_x mr_{xy,z}(ms) \sqrt{(midyear) P(x, male, ms, z)} \sqrt{(midyear) P(y, female, ms, z)}, ms = 1, 3, 4.$$

$C_{jl}(x, y, z+1) = mr_{xy,z} \times (midyear P_{jl}(x, y, z)).$

Here, these calculations are done iteratively because the population,  $P$ , is at beginning of the year.

### 3.3.5. Divorces – Number of divorces by $(xy)$ .

Data are from the “Divorce Registration Area” (DRA), obtained from the National Center for Health Statistics (NCHS), 1979-1988. In 1988, the DRA consisted of 31 states and accounted for about 48% of all divorces. These data allow us to compute divorce rates, defined as central divorce rate for  $(xy)$  for year  $z$

$$= dr_{xy,z} = \frac{\text{number of divorces for } (xy)}{(\text{midyear}) \text{ number of married couples } (xy)}.$$

To summarize this, use the “age-adjusted central divorce rate,” defined as



$$DR_z = \frac{\sum_{x,y} dr_{xy,z} SP(\text{married couples age } (xy))}{\sum_{x,y} SP(\text{married couples age } (xy))}$$

Here, "SP" refers to the standard population, that is, the Divorce Registration Area population taken at midyear, 1982. Note that for the denominator, we have:

$$\Sigma_{x,y} \text{ number of married couples } (xy) = \Sigma_{x,y} P(x, y) = \Sigma_x P(x, \text{males, ms}=2) = \Sigma_y P(y, \text{females, ms}=2).$$

Step 1. Calculate  $dr_{xy,z}$  for each year  $z = 1978-1988$ .

Determine the year  $z$  Factor through the expression:

$$\text{Factor}(z) = \frac{\text{(Number of Divorces in SSA population in year } z \text{)}}{\text{(Number of Divorces in DRA population in year } z \text{)}}$$

This yields:

$$dr_{xy,z} = \frac{\text{(number of divorces for } (xy) \text{ in DRA)} \times \text{Factor}(z)}{\text{(midyear number of married couples } (xy) \text{ in SSA)}$$

For these rates, calculate an age-adjusted central divorce rate.

Step 2. Calculate the divorce bivariate distribution.

Use 1978-1988 historical rates of  $dr_{xy,z}$  to calculate an age-specific divorce distribution. Average and graduate these rates to get a single bivariate distribution, called  $adr_{xy}$ .

Step 3. Calculate the age-specific central divorce rates for provisional years 1989-1995.

Use the most recent year from NCHS's estimates of total number of divorces to get the initial age-adjusted central divorce rate. Rescale the distribution in Step 2 to get age-specific divorce rates. Call the rescaled rates  $dr_{xy,z}$ . Because recent rates have been stable, use this as the projection of future divorce rates.

Step 4. Calculate the Projected Number of Divorces

$$S(x, \text{male}, z) = \sum_y dr_{xy,z} (\text{midyear}) P_{JL}(x, y, z).$$

$$S(y, \text{female}, z) = \sum_x dr_{xy,z} (\text{midyear}) P_{JL}(x, y, z).$$

$$S_{JL}(x, y, z+1) = dr_{xy,z} \times (\text{midyear } P_{JL}(x, y, z)).$$

Here, these calculations are done iteratively because the population,  $P_{JL}$ , is at beginning of the year.

### 3.3.6. Immigrants

In the 1999 Trustees Report, the estimate of net immigration is 900,000 per year for each of the next 75 years (central assumption).

Specifically, they assume 800,000 legal immigrants, 200,000 emigrants and 300,000 other-than-legal immigrants each year. The age-sex distribution of the legal immigrants was based on data supplied by the INS on immigration during 1978 through 1999. The age-sex distribution of the emigrants was based on an article by Warren and Peck (*Demography*, 1980). The age-sex distribution of other-than-legal immigrants was based on unpublished Census Bureau estimates of the undocumented population counted in the 1980 census.

These three pieces yield the age-sex distribution of net immigrants. The marital status was distribution as existed in the population at the beginning of the year.

## 4. Short-Range Employment and Earnings Projections

This section describes employment and earnings projections as they pertain to the OASDI covered economy. For both employment and earnings, we begin by developing projections as they pertain to the US economy, then convert them to the OASDI covered economy. We begin with two economic assumptions that underlie the projections: inflation (CPI-W) and GDP. This discussion includes consideration of the GDP price deflator. Models of employment use these assumptions, as well as labor force participation rates, unemployment rates and disability prevalence rates.

### 4.1. Inflation Rate and GDP

Relatively little attention is given to forecasts of inflation. Forecasts of GDP are more complex.

#### 4.1.1. Inflation Rate

The Bureau of Labor Statistics began publishing the CPI monthly in 1913 and the CPI-W in 1978. Social Security benefits are indexed using the CPI-W. Here, SSA OACT grades current quarterly growth rates into the ultimate assumptions over a five to ten year period sets the forecasts.

For the intermediate assumption of the 1999 Trustees report, the 1999 CPI-W is 1.9% and reaches its ultimate value of 3.3% in 2008. The ultimate low-cost assumption is 2.3% and high-cost is 4.3%. The ultimate values are based on the opinions of the Trustees.

#### 4.1.2. GDP

The projection of Gross Domestic Product (GDP) is more complex. These projections are used to project labor force participation in Section 4.2 and earnings in Section 4.3.

Underlying the projections of GDP is the concept of "potential GDP," denoted as KGDP, an estimate of what the economy *could* produce at high rates of resource utilization. If the potential is less than the actual GDP, then this signals an expansionary period. Here, constraints on capacity begin to bind and inflationary pressures build. Conversely, if the potential exceeds actual GDP, then this signals a recession. Thus, the ratio, real to potential,

$$RTP = (\text{real GDP})/(\text{KGDP})$$

is a measure of the business cycle.

The Congressional Budget Office (CBO) produces historical values of potential GDP. These are calculated by fitting neoclassical growth models to five sectors of the US economy. To illustrate, for the non-farm business sector (which comprised 77% of the US economy in 1994), the model was

$$\log(\text{GDP}) = \text{constant} + 0.7 \times \log(\text{Hours Worked}) + 0.3 \times \log(\text{capital}) + \text{residual}.$$

Here, the residual is generally ascribed to technological factors of production.

The primary advantage of using a growth model to calculate potential output is that it explicitly includes capital as a factor of production. A detailed discussion of the method of calculating potential GDP can be found in “CBO’s method for estimating potential output,” *CBO Memorandum*, October, 1995.

Potential GDP increases according to increases in hours worked (and thus size of the labor force), capital and technology factors of production. It grows smoothly over time, unlike actual GDP. For the short-run, KGDP growth is the sum of growth in each of full-employment labor force, the average number of hours worked per year and labor productivity (defined as output per hour worked). The labor productivity parameter includes both capital and technology factors of production.

For the SSA short-range assumptions, projections of KGDP were determined using an econometric model that initially assumed  $RTP = 1$ . Output from this model yields projections of full-employment employment. Projections of full-employment annual growth in hours worked and labor productivity are from the ultimate assumptions of the most recent Trustee intermediate assumptions; in 1998 these were -0.1% and 1.26%, respectively.

Short-range projections of GDP are computed using projections of KGDP, defined above, and projections of RTP. Projections of RTP are calculated using projections of the civilian unemployment rate. This is done through a regression equation, using current and lagged values of RTP as explanatory variables (“Okun’s Law”). The SSA OCACT uses the relationship:

$$\Delta UR_t = \beta_0 + \beta_1 \Delta RTP_t + \beta_2 \Delta RTP_{t-1} + \beta_3 \Delta RTP_{t-2} + \beta_4 \Delta RTP_{t-3} + \varepsilon_t,$$

where  $\Delta$  is the first difference operator. Using this relationship, forecast values of UR can be used to recursively forecast RTP. The SSA OCACT also uses forecast values of RTP to forecast UR, to make sure that these forecasts are in agreement (see Section 4.2.2).

The GDP price deflator index reflects domestic production only whereas the CPI reflects price changes in all components of consumption. The ultimate rates of the GDP price deflator are assumed to be smaller than the ultimate rates of CPI-W. The wedge, which is the difference in the growth of the price deflator and the growth of the CPI, is set by grading current values into the long-range value of -0.1%. (Alternative terminology: the “price adjustment” is the ratio of the GDP price deflator to the CPI).

## 4.2 Employment

In this section, we discuss SSA models of labor force participation rates and unemployment rates. These are roughly defined as:

$$\text{LFPR} = \text{labor force participation rate} = \frac{\text{number of people working or seeking work}}{\text{non-institutionalized population}}$$

and

$$\text{UR} = \text{unemployment rate} = 1 - \frac{\text{number of people working}}{\text{number of people working or seeking work}}$$

Monthly data are available from the Bureau of Labor Statistics (BLS). The goal is to produce quarterly projections of LFPR and UR, by cohort, using these variables as well as productivity (GDP) measures and disability prevalence rates as inputs. In this section, “cohort” refers to grouping by age, sex, marital status and presence of own child or children less than age six; there were 103 groups in 1998. Another possibility is to decompose employment by industry (as is done for earnings, see Section 4.3). Although the changing demographic makeup of future populations will change the employment picture, the same argument could be made for the changing industrial composition. Certainly, historical changes in industrial composition have precipitated large changes in aggregate employment. Nonetheless, this approach is not adopted, in part due to data limitations and in part due to the difficulty in predicting future changes in industrial composition.

To reiterate, this section begins with projections of US economy (BLS) concepts of labor and unemployment; Section 4.2.4 considers related concepts for the Social Security Area population. The models of this section, and Section 4.3, are also used by other governmental agencies including OMB and CBO.

### 4.2.1. Labor Force Participation Rates

As described above, cohorts are defined through age, sex, marital status and presence of children less than age six. For 1998, the age groups included 16 to 17, 18 to 19, five-year age groups from 20 to 84, and 85 and older. Further, the 60 to 64 age group was disaggregated to 60 to 61 and 62 to 64. Marital status types include married with a spouse present, married with an absent spouse and never married.

Most of the LFPRs were calculated from the March CPS, using the ratio of the civilian labor force to the civilian noninstitutional population. Some male LFPRs are defined as the ratio of the civilian labor force to the sum of the civilian noninstitutional population and the military; this allows us to assess the impact of the military size on the labor force. SSA OCACT has a detailed historical description of the size of the military

The model of LFPR is a cohort-specific, time series regression model. Specifically, for each cohort, the response is the LFPR, observed over a period of time. In 1998, for many cohorts the observation period was 1962-1997, for 36 observations. There are several exogenous variables; many of these are common to all cohorts and some specific to individual cohorts. Some of the common exogenous variables are:

1. Business cycle – RTP - the ratio of real to potential GDP, described in Section 4.1.2.
2. Disability prevalence ratio. This is the ratio of the number of disabled worker beneficiaries in current pay status to the Social Security Area population. If one is unable to work through disability, then one would not participate in the labor force.
3. Time trends are used to quantify trends in LFPRs. To illustrate, time trends account for the increasing participation by women in the labor force.

Many variables were specific to individual cohorts.

*Males*

1. Military rate. This is the ratio of those in the military to the sum of the civilian noninstitutional population and the military. These rates are for males, age groups containing ages 20-54, only. If one is in the military, then one would not participate in the civilian labor force. This variable allows us to separate the effect of the military.
2. Spouse labor force participation rate. Used for males age 25-44.

*Older Workers*

1. The adjusted replacement rate is the ratio of OASDI benefits to a person's earnings in the last year of work. It is used for males and females age 62-70. As the adjusted replacement rate increases, LFPRs should decrease.
2. The retirement earnings test is a variable representing the maximum amount of income a retired person can earn without having his or her benefit reduced. In the future, this is the ratio of the current year's maximum allowable earnings to the previous years average wage index. It is used for males and females age 62-71.

*Teen Workers*

1. The school rate is defined as the ratio of those in school to the civilian noninstitutional population.
2. The Federal minimum wage.

Further, SSA OCACT is contemplating adding the following variables to the teen model:

1. A variable for teen motherhood.
2. The dropout rate is defined as the ratio of high school dropouts to the population of high school students.

One must project each of these exogenous variables to obtain projections for the LFPRs.

In 1999, the labor force increased by 1.2%. Projections show that this increase grades down, reaching 0.1% in 2050.

**4.2.2. Unemployment Rates**

Let  $UR(\text{age}, \text{sex}, \text{year})$  be the age/sex unemployment rate by quarter. Estimate the equation:

$$\Delta UR(\text{age}, \text{sex}, t) = \beta_0(\text{age}, \text{sex}) + \beta_1(\text{age}, \text{sex}) \Delta RTP_t + \beta_2(\text{age}, \text{sex}) \Delta RTP_{t-1} + \beta_3(\text{age}, \text{sex}) \Delta RTP_{t-2} + \beta_4(\text{age}, \text{sex}) \Delta RTP_{t-3} + \varepsilon(\text{age}, \text{sex}, t) \text{ for historical } t.$$

This estimation yields  $b_j(\text{age}, \text{sex})$ , for  $j = 0, 1, 2, 3, 4$ . For future quarters  $z$ , project

$$\Delta UR(\text{age}, \text{sex}, z) = b_0(\text{age}, \text{sex}) + b_1(\text{age}, \text{sex}) \Delta RTP_z + b_2(\text{age}, \text{sex}) \Delta RTP_{z-1} + b_3(\text{age}, \text{sex}) \Delta RTP_{z-2} + b_4(\text{age}, \text{sex}) \Delta RTP_{z-3}$$

After 10 years, we assume no changes in the unemployment rate. That is, for future years  $z$

$$UR(\text{age}, \text{sex}, 10+z) = UR(\text{age}, \text{sex}, 10) \text{ for } z = 1, 2, \dots, 65.$$

For the intermediate assumption of the 1999 Trustees report, the unemployment rate is 4.6% in 1999. It reaches its ultimate value of 5.5% in 2005. The ultimate low-cost is 4.5% and high-cost is 6.5%. The ultimate values are based on the opinions of the Trustees.

#### 4.2.3. Employment by Sector

Using projections of the population, labor force participation rates and unemployment rates, we may summarize the age/sex household employment as

$$\text{number of workers}(\text{age}, \text{sex}, z) = LFPR(\text{age}, \text{sex}, z) \times (1 - UR(\text{age}, \text{sex}, z)) \times P(\text{age}, \text{sex}, z)$$

This yields total (BLS) household employment

$$\text{Employment}(z) = \sum_{\text{age,sex}} \{\text{number of workers}(\text{age}, \text{sex}, z)\}.$$

Because earnings are projected by sector of economy, it is of interest to decompose this forecast into economy specific pieces. The most important split is to decompose employment into agricultural and non-agricultural pieces. Another split is by the class of worker because we are interested in differences among wage workers, self-employed workers and unpaid family workers. Thus, there are six categories: agricultural (1) wage workers, (2) self-employed workers and (3) unpaid family workers, as well as nonagricultural (4) wage workers, (5) self-employed workers and (6) unpaid family workers.

#### 4.2.4. Covered Employment

US economy (BLS) employment described in Section 4.2.3 differs from OASDI covered employment in some important aspects. First, BLS employment includes some non OASDI employment such as qualified government employees, student workers, election workers and other small categories. Qualified government employees include Federal employees hired prior to 1984 and certain state and local government employees. Second, BLS employment covers employment for ages 16 and over whereas OASDI employment pertains to all age groups. Third, a worker need only work part of the year in

order to be covered under the OASDI program. However, LFPRs are determined by examining averages of weekly numbers of people in the labor force. Thus, the two concepts measure different aspects of participation in the labor force.

Use the following steps to forecast covered employment:

1. Use SSA administrative records to estimate the number of persons in covered employment for ages 16 and over as well as under age 16. Denote these series as  $CE16O(t)$  and  $CEU16(t)$ , respectively.
2. For under age 16, disaggregate these by age and sex and write each cohort as a proportion of the population,  $CEU16(age, sex, t)/P(age, sex, t)$ . Use a time series of each ratio to determine a projected constant (that varies by age and sex). Use this constant with the projected population to project the under age 16 number of covered workers,  $CEU16(age, sex, z)$ .
3. Forecast non OASDI covered employment for ages 16 and over,  $NCE16O(z)$ , by separately considering each type of employment. These include medically qualified government employees, student workers, election workers and other small categories. This yields  $NCE16O(age, sex, z)$ .
4. For each age and sex group ages 16 and over, forecast the total employed, denoted as  $TE16O(age, sex, z)$ . To do this:
  - 4.a First create historical values of

$$ratio(age, sex, t) = TE16O(age, sex, t) / (\text{Adjusted Employment} + \text{Military})(age, sex, t).$$

Here,  $TE16O(age, sex, t) = CE16O(age, sex, t) + NCE16O(age, sex, t)$ . The Adjusted Employment is BLS employment, taken as the maximum over four quarters, adjusted for unpaid family workers.

- 4.b Fit a regression equation of the form  $ratio(age, sex, t) = \text{function}(x1, RTP)$ , where  $x1 = (\text{Adjusted Employment} + \text{Military})(age, sex, t) / P(age, sex, t)$ .
- 4.c Use this fitted regression equation with projected values of  $x1$  and RTP to get projected values of  $ratio(age, sex, z)$ .
- 4.d Use projected values of  $(\text{Adjusted Employment} + \text{Military})(age, sex, z)$  and  $NCE16O(age, sex, z)$  to get projected values of  $CE16O(age, sex, z)$ .
- 4.e Defined projections of covered employment as

$$CE(age, sex, z) = CE16O(age, sex, z) + CEU16(age, sex, z)$$

5. For the self-employed, return to BLS household data. Denote  $EAS(age, sex, z)$  to be the agricultural, self-employed employment and  $EANS(age, sex, z)$  to be the non-agricultural, self-employed employment. Then, for covered employment, define self-employed forecast recursively as

$$SEO(age, sex, z) = SEO(age, sex, z-1) \times \frac{EAS(age, sex, z) + EANS(age, sex, z)}{EAS(age, sex, z-1) + EANS(age, sex, z-1)}$$

with an adjustment for qualified government employees.

6. Forecasts of wage-and-salary workers are derived as:

$$WSW(age, sex, z) = CE(age, sex, z) - SEO(age, sex, z).$$

7. Finally some adjustments are needed for combination workers, those with OASDI and self-employed net earnings and workers with some self-employed net earnings

### **4.3. Earnings**

SSA OCACT calls forecasting earnings by itself the “direct analysis.” The direct analysis covers real earnings in all covered OASDI employment (Yang and Goss, 1992). This direct analysis has been examined on a demographic cohort basis (age and sex). Although employment is projected on a demographic cohort basis, projections of earnings are done by examining different segments of the economy.

The approach is to first forecast US economy earnings. These are done using BEA National Income and Production Accounts (NIPA). Then, these earnings are converted to OASDI covered earnings. Section 5.1 describes the conversion of OASDI covered earnings to taxable earnings

#### **4.3.1 US Economy Earnings**

US economy earnings are forecast by sector of the economy, not demographic cohorts. These sectors are:

- (1) Sectors whose total nominal output is primarily defined as wage compensation  
These are: Government and government enterprises (federal civilian, federal military, state and local), private households and nonprofit institutions.
- (2) Private business excluding government enterprises. These are: agricultural and private nonagricultural business.

1. Forecast wages in government enterprises, private households and nonprofit institutions according to the following steps. These comprise sectors whose total nominal output is primarily defined as wage compensation.

- 1.a. Determine the average wage. Forecast this wage as function of historical trends. For government sectors, we also use knowledge of relevant pay raises plus grade creeps, knowledge of private sector average wage growth rates, and so on, for the forecasts.
- 1.b. Determine forecasts of total wages as forecasts of average wage from step (1) times population forecasts. Call these forecasts WS.
- 1.c. Determine forecasts of other labor income (OLI). OLI includes payments for fringe benefits such as life and health insurance.
- 1.d. Determine forecasts of employer contributions to social insurance (SOC). SOC includes OASDI contributions.
- 1.e. Determine forecasts of total earnings (which equals GDP for these sectors) as  $WSS = WS + OLI + SOC$ .

2. For the agricultural sector, forecast GDP using a crude supply/demand model. Call these projected values GDPPF.

3. For the private non-agricultural business, excluding government enterprises, determine projected values of GDP. Recall that forecasts of GDP were described in Section 4.1 2. This is computed as a residual. That is, define



$$\text{GDPPNA} = \text{GDP} - \text{GDPPF} - (\text{sum of government GDP} = \text{WSS}).$$

4. Relate labor returns to GDP for the agricultural and private non-agricultural business sectors.
- 4.a. Fit a model of GDP for the agricultural and private non-agricultural business sectors, GDPPNA and GDPPF, respectively. For each sector GDP, define the response as the return to labor,  $(\text{WSS} + \text{Y})/\text{GDP}$ . Here, Y is the proprietor's income, from the NIPA accounts. With this response, fit a regression model using RTP as an explanatory variable.
- 4.b. Using forecasts of RTP, forecast the response for each sector. Use forecasts of GDP to determine forecasts of  $\text{WSS} + \text{Y}$ . Split WSS and Y into separate components based on projected relative employment growth of wage and self-employed workers assuming constant relative earnings. This yields forecasts of WSS.
- 4.c. For each sector, forecast OLI and SOC.
- 4.d. For each sector, determine forecasts of wage and salaries as  $\text{WSS} = \text{WS} + \text{OLI} + \text{SOC}$ .

#### **4.3.2. OASDI Economy Earnings**

Using SSA administrative records, we may determine covered wages by sector. The sectors are: (1) Federal Civilian, (2) Federal Military, (3) State and Local, (4) Private Household, (5) Private Railroad, (6) Private Farm and (7) Private "Residual." We then use the relative sizes of these sectors with the projections of the relative sizes of the US economy earnings to determine projections of the OASDI economy earnings, by sector.

For self-employment earnings, consider both OASDI covered and non-covered earnings. For covered OASDI earnings, relate the growth rate to the growth in proprietor income from both the farm and non-farm sectors. This is then split into factors for self-employed only and combination workers, based on relative employment growths of the two types of workers (assuming constant relative earnings).

## 5. Short-Range Revenue Projections

This section begins with the Social Security covered population employment and earnings projections, developed in Sections 4.2 and 4.3. Following this, projections of taxable earnings are developed. These are used in the revenue projections described in Section 2.2.1.

### 5.1 Calendar Year Taxable Wages, by Sector

Section 4.3 developed OASDI covered earnings, by sector. Because earnings are only covered up to a maximum, we now bridge from covered earnings to taxable earnings. We first estimate taxable wages for each of the following sectors:

1. All wage workers                      4. State and Local
2. Federal Civilian                      5. Farm.
3. Military

Taxable wages for the private non-farm sector is computed as the difference between (1) and the sum of (2)-(5).

For the all wage "sector," the SSA OCACT examines an historical distribution of wages. To illustrate, the 1999 Trustees Report uses 1997 SSA administrative data. This distribution is rescaled by dividing by the average covered wage. Then, for each projection year, we examine

$$ratio1_z = \frac{\text{maximum taxable wage}_z}{\text{average covered wage}_z}.$$

We examine this ratio in the context of our distribution. This allows us to calculate the appropriate OASDI annual taxable ratio, that is, the ratio of taxable to covered wages, as

$$ratio2_z = \frac{\int w f(w) dw}{\int w f(w) dw},$$

where  $f$  is the density of wages. These taxable ratios are adjusted to take into account the secular decrease in the ratio over time. These taxable ratios are applied to projections of covered wages to get projections of taxable wages.

For sectors (2)-(5), we use similar procedures. The wage distribution may come from other sources (not necessarily SSA administrative records) and often is not as recent as the all wage sector.

## 5.2 Multi-Employer Refund Wages

Employees having total wages exceeding the taxable maximum that worked for more than one employer during the year are eligible for a refund of social security taxes if their total contribution exceeds the maximum tax. The SSA OCACT estimates the amount of wages on which refunds are owed by computing the ratio of refund wages to total covered wages as a function of (1) the ratio of taxable wages excluding refunds to total covered wages and (2) the unemployment rate.

## 5.3 Taxable Self-Employment Earnings

For self-employed only workers, the SSA OCACT uses historical sample data or earnings distributions to estimate taxable ratios.

Also consider combination workers, those wage workers who also have earnings from self-employment. The SSA OCACT uses historical data on the total earnings distribution of combination workers and data on the wage distribution. With these data, estimates of wages below the taxable maximum are made. This then yields the taxable self-employment earnings of combination workers.

## 5.4 OASDI Tax Collections

The amount of tax collections for the Federal government sector follows equation (2.5). That is,

$$\begin{aligned} \text{Contributions}(z) = & \text{Employee Taxable Wages}(z) \times \text{Employee Payroll Tax Rate}(z) \\ & + \text{Employer Taxable Wages}(z) \times \text{Employer Payroll Tax Rate}(z) \\ & + \text{Self Employment Taxable Earnings}(z) \times \text{Self-Employed Tax Rate}(z). \quad (2.5) \end{aligned}$$

However, for other sectors, the payment of taxes on these liabilities occurs with at lag. To compute collections, estimates of quarterly taxable wages are needed. Adjustments are also done for the proportion of tax liabilities to that collected. Special adjustments are required for the self-employed who often pay much of their tax liability in the following year.

## 6. Short-Range Benefit Projections

We begin with some terminology. A worker obtains *fully insured status* when his or her quarters of coverage reaches 40 (this can vary in some minor ways by age and year). *Permanently insured status* is achieved when the worker is fully insured at his or her age and has a sufficient number of quarters to be fully insured at normal retirement age. *Currently insured status* is a weaker form. It requires only six quarters of coverage within the 13-quarter period ending with the quarter of death or entitlement to old-age benefits. *Disability insured status* requires fully insured status plus a recent connection to the labor force.

Future benefit payments are estimated by projecting the number of beneficiaries and the average benefit, by type of beneficiary. However, the short-range projections differ substantially from the long-range projections. In general, the short-range projections are (1) more frequent (done on a quarterly basis) and (2) handle finer gradations of beneficiary classes. This section considers short-range projections.

To project benefits, we first project the number of beneficiaries and then the average benefit amount. Specifically, Section 6.1 describes the projection of the fully insured and disability insured population. Section 6.2 describes the projection of the disability beneficiaries, including disabled workers and their auxiliaries. Section 6.3 provides analogous description for the old age and survivor beneficiaries. Section 6.4 projects benefit amounts, both for new awards and awards that are in current-payment status.

### 6.1. Insured Population

#### 6.1.1. Projection of Fully Insured Population

The projection of the number of workers who are fully or permanently insured is based on data from the Continuous Work History Sample (CWHS). This is a 1-percent sample of the Masters Earnings File combined with data on the same sample from the Master Beneficiary Record. The CWHS contains reliable information on workers but has incomplete reporting on deaths. Thus, the raw count of fully insured workers is overstated. Techniques are used to impute missing deaths and improve the estimates of fully insured workers.

These projections are also used for Medicare and DI benefits.

#### 6.1.2. Projection of Disability Insured Population

For disability insured status, we first compute the historical ratios

$$\text{Ratio}(age, sex, t) = \frac{\text{number in disability insured status}(age, sex, t)}{\text{number in fully insured status}(age, sex, t)}$$

We then estimate the equation  $\text{Ratio}(age, sex, z) =$

$$= \beta_0(age, sex) + \beta_1(age, sex) \text{LFPR}(age, sex, z) + \beta_2(age, sex) z + \varepsilon(age, sex, z)$$

for historical  $z$ . Here, the errors are assumed to follow an  $AR(1)$  distribution.

We then project the ratios using projected values of the labor force participation rates (LFPR) as:

$$\text{Ratio}(age, sex, z) = b_0(age, sex) + b_1(age, sex) \text{LFPR}(age, sex, z) + b_2(age, sex) z$$

for future  $z$ .

The projected ratios are combined with projected numbers in fully insured status to get projected numbers in disability insured status. That is,

$$\begin{aligned} & \text{number in disability insured status}(\text{age, sex, z}) \\ &= \text{Ratio}(\text{age, sex, z}) \times \text{number in fully insured status}(\text{age, sex, z}) \text{ for future } z \end{aligned}$$

## 6.2. Disability Beneficiaries

### 6.2.1. Disabled Worker Beneficiaries

The numbers of disabled-worker beneficiaries are projected by use of incidence, termination and withheld rates. Under this method, incidence rates are applied to the disability insured population who are not already disabled to determine the number of newly entitled beneficiaries each year. Termination rates are applied to the beneficiary population to determine the number of beneficiaries whose benefits terminate each year. Further, benefits may be withheld for various reasons. This method is suitable because the number of disabled beneficiaries is a relatively small percentage of the potential and may not remain stable in the future.

Specifically, the disability incidence rate is

$$\frac{\text{number of new entitlements to disability benefits}}{\text{average number of disability insured workers}} (\text{age, sex, cause}).$$

The denominator excludes those entitled to benefits. Projections of the incidence rate are developed based on the judgement of the OCACT staff reflecting recent trends and long term averages.

Termination can occur as a result of (a) death, (b) recovery, (c) conversion to retirement and (d) for other reasons. Termination rates are developed by age/sex/reason. For short-range projections, there is little anticipated change due to mortality. The pattern of projected recovery rates is based on workload estimates of scheduled disability reviews.

Disability benefits may be withheld due to (a) refusal to accept rehabilitation services, (b) a pending determination of continuing disability, (c) worker's compensation benefit or (d) extended period of disability requirements. Withheld percentages are calculated by age/sex.

The number of beneficiaries *in force* minus the *number withheld* equals the number of beneficiaries in *current-payment status*

### 6.2.2. Auxiliaries of Disabled Worker Beneficiaries

The following are categories of auxiliary beneficiaries:

(a) young wives, (b) young husbands, (c) aged wives, (d) aged husbands, (e) minor children, (f) disabled children and (g) student children.

For all but young wives and husbands, we project based on historical trends in

$\frac{\text{number of auxiliary awards}}{\text{number of disabled worker awards}}$  For young wives and husbands, we use  $\frac{\text{number of auxiliary awards}}{\text{number of minor children awards}}$  because of the requirement of the presence of a minor child under age 16.

### 6.3. Old-Age and Survivor Beneficiaries

#### 6.3.1 Retired Worker and Insured Widow(er) Beneficiaries

As with disability beneficiaries, we update retired worker beneficiaries as:

number of retired-worker beneficiaries(*age, sex, z*) =  
 number of retired-worker beneficiaries(*age -1, sex, z -1*)  
 + number of retirees(*age, sex, z*)  
 - number of terminations(*age, sex, z*)  
 + number of conversions(*age, sex, z*)

The termination rates are defined as the number terminated divided by the number of beneficiaries. These are projected based on historical trends and on the projected mortality rates.

The rates of retirement are based on the number of benefit awards to retired workers and insured widow(er)s divided by the fully insured population minus the number of workers entitled to insured benefits. Here, insured benefit is either a retired worker benefit, a disabled worker benefit, or an insured widow(er) benefit. The rates of retirement are developed by an analysis of historical trends, including the effects of changes in the retirement test exempt amounts.

A portion of the number of retired-worker beneficiaries come from conversion of disabled worker beneficiaries at normal retirement age.

#### 6.3.2. Young Auxiliary of Retired or Deceased Worker Beneficiary

The numbers of minor children of retired and deceased workers are related to the non-orphan and orphan populations, respectively.

##### 6 3 2.a Child Beneficiaries of Retired Workers

These are projected by single year of age by adding the number of new awards to awards in force and subtracting the number of terminated awards. The projected number of new awards is based on the number of non-orphan children. To go from in force to in current payment status, the withheld rates are projected to be at a constant level.

##### 6 3 2 b Child Beneficiaries of Deceased Workers

These are projected similarly to the Section 6.3.2.a. The projected number of new awards is based on the number of orphan children.

#### *6.3.2.c Disabled Child Beneficiaries of Retired and Deceased Workers*

These are projected by single year of age by adding the number of new awards to beneficiaries in force and subtracting the number of terminations.

#### *6.3.2.d Student Child Beneficiaries of Retired and Deceased Workers*

These are projected by single year of age by adding the number of new awards to beneficiaries in force and subtracting the number of terminations. The number of student children awarded each year is greater than the number in force, indicating that virtually the entire student child population is replaced each year.

#### *6.3.2.e Young Spouse Beneficiaries of Retired Workers*

Either a young wife or a young husband may be entitled because they are the parents of an eligible child of a retired worker. These are projected by applying a percentage to the projected number of eligible child beneficiaries in force.

#### *6.3.2.f Mother/Father Beneficiaries of Deceased Workers*

These beneficiaries are entitled because they are the parents of an eligible child of a deceased worker. These are projected by applying a percentage to the projected number of eligible child beneficiaries of deceased workers in force.

### **6.3.3. Aged Auxiliary of Retired or Deceased Worker Beneficiary**

#### *6.3.3.a Disabled Spouse Beneficiaries of Deceased Workers*

These beneficiaries are entitled because they are the surviving spouse of an insured worker, and they are disabled. They are projected in two age groups – ages 50-59 and 60-64 – by applying a percentage to the projected uninsured female/male population in the applicable age group. The applicable percentages are projected by time series regression.

#### *6.3.3.b Aged Spouse and Uninsured Widow(er) Beneficiaries of Retired or Deceased Workers*

These beneficiaries include divorced wives and husbands, as well as surviving uninsured divorced wives and husbands.

#### *6.3.3.c Parent Beneficiaries of Deceased Workers*

These beneficiaries are entitled because they are the parents of a deceased insured worker, and they are not insured on their own earnings record. They are projected by applying a factor to the number of parent beneficiaries receiving benefits six months prior.

## **6.4. Benefit Projections**

We split types of beneficiaries first by the Old-Age Insurance (OAI) and Disability Insurance (DI) benefits, then by whether the benefit is current (in current-payment) or a new award. We also subdivide as to whether the award is paid to a primary beneficiary, that is, an individual who merits the benefit based on his or her own history,

or an auxiliary beneficiary, an individual who merits benefits based on someone else's history.

This subsection describes projection of benefits amounts and how to combine projections of benefit amounts and number of beneficiaries to get projected benefit payments.

Projections of the average benefit at award are based on the Continuous Work History Sample (CWHS); this is a 1% sample of all people with covered earnings. Various modifications to the CWHS are made because, although it is a sample of the population, it may not appropriately represent the experience of future populations. To illustrate, it is expected that the percentage of females eligible for retirement benefits will increase in the future.

#### 6.4.1. Average Benefit for Newly Entitled Beneficiary

Begin with a 10% sample of the CWHS; this results in a 0.1% sample of the SSA population. To illustrate, there were 2,229 new awards in 1988. Type of beneficiary includes male/female old-age beneficiary, male/female disabled worker and young/aged/disabled survivor. We do not consider dependents of workers; only retired and disabled workers, and survivor beneficiaries. (Benefits for dependents are assumed to be proportional to the primary beneficiary.) Thus, the number sampled is generally less than 1/1000 of the number of actual awards.

Number of Newly-Entitled Beneficiaries in 1998		
Type of Beneficiary	Actual Awards (in thousands)	Number from Sample
Male old-age beneficiary	956	919
Female old-age beneficiary	689	628
Young survivor	385	95
Aged survivor	442	322
Disabled survivor	15	15
Male disabled worker	273	162
Female disabled worker	142	88
Totals	2,902	2,229

This sample is modified to make it more representative of the population (see Barrick and Zayatz, 1996, pages 114-116). Specifically, 80 males and 220 females were added that have some earnings but not enough to be insured for old-age benefits. Further, 100 females were added that are 62 but have no earnings. The idea is to make this sample representative of future (full) population. The records were created to make the sample comparable to population survey information. Thus, the total sample was  $2,229 + 300 + 100 = 2,629$ .

The sample gives earnings history of workers by age and sex. To account for future patterns of employment and earnings levels, the earnings of each worker in the sample are updated to represent those workers to whom benefits would be awarded in each (future) year of the (ten-year) projection period. Then, at each year, we can compute the old-age benefit using actual and imputed wage histories, by age and sex. [The details are in Barrick and Zayatz, 1996, pages 114-116. In some instances, only earnings up to the SS wage base were available; an excess wage distribution was required. SSA also



adjusted earnings for male/female labor force participation rates and male/female earnings differentials. Earnings before 1951 were not available; adjustments were necessary.] Section 8.4.4 provides details for the long-range projections.

We then project the sample forward by type of beneficiary and sex to calculate the average benefit for a new award. The projections began in 1988 but information up to 1995 was known. Thus, the distribution was rescaled to give the 1995 actual amounts.

This gives us projections for old-age and disabled worker benefits, by age and sex. Constant proportions, developed using the 1995 distributions, are used to get projected new awards for dependent and auxiliary benefits.

*Constant proportions required for:*

Male or female spouses of disabled workers

Children (minor, disabled and student) of disabled workers

The 11 types of survivors to deceased workers are:

1. young survivor (minor child, disabled child, student child, mother, and father),
2. aged disabled survivor (disabled widow and widower) and
3. aged non-disabled survivor (aged widow and widower and female and male parent).

Average new award amounts to dependent beneficiaries of retired workers are projected using a constant percentage of the average retired workers' benefit.

#### **6.4.2. Average Benefit for Beneficiary in Current Payment Status - Disability**

For each type of disability beneficiary, the total amount in force of the disability benefit (*DB*) is projected quarterly as:

$$DB(\text{type}, \text{current quarter}) = DB(\text{type}, \text{prior quarter})$$

$$+ \text{New Amounts}(\text{type}, \text{current quarter}) - \text{Terminated Amounts}(\text{type}, \text{current quarter}).$$

Here, we have:

$$\text{New Amounts}(\text{type}, \text{quarter}) = \text{Average New Award}(\text{type}, \text{quarter})$$

$$\times \text{Number of New Awards}(\text{type}, \text{quarter}).$$

$$\text{Terminated Amounts}(\text{type}, \text{quarter})$$

$$= \text{Average Amount Terminated}(\text{type}, \text{quarter}) \times \text{Number of Terminations}(\text{type}, \text{quarter}).$$

The new award quantities are described in Sections 6.2 and 6.4.1. The average amount terminated is estimated as a ratio times the average amount in force at the beginning of the quarter. The number of disability terminations is described in Section 6.

The *type* is comprised of:

1. male and female disabled workers
2. young wives, young husbands, aged wives, aged husbands of disabled workers
3. minor, disabled and student children of disabled workers

Projections of benefits in force are then split into (1) current payment status benefits and (2) non-current payment benefits. The largest component of non-current payment benefits to disabled workers consists of benefits payable for periods of

retroactive entitlement. These retroactive payments to disabled workers are projected separately.

The average benefit in current-payment status is derived from the average benefit in force, based on the historical relationship between the two.

#### **6.4.3. Average Benefit for Beneficiary in Current Payment Status – Old-Age and Survivors Insurance**

These projections are similar to the disability benefits projections described in Section 6.4.2, except these are on an annual basis whereas disability projections are performed on a quarterly basis. Specifically, for each type of old-age and survivors beneficiary, the total amount of benefit in force (*Ben*) is projected as:

$$Ben(type, z) = Ben(type, z-1) + New Amounts(type, z) - Terminated Amounts(type, z).$$

Here, we have:

$New Amounts(type, z) = Average New Award(type, z) \times Number of New Awards(type, z)$   
and

$Terminated Amounts(type, z)$

$$= Average Amount Terminated (type, z) \times Number of Terminations(type z)$$

The average new award quantities are described in Section 6.4.1 and the number of new awards quantities are described in Section 6.3. The number of terminations is also described in Section 6.3.

For historical  $z$ , the terminated amounts are determined as a residual item, thus reflecting benefit recomputations and other factors. For future  $z$ , we examine the ratio of average amount terminated to the average award (*Ben* divided by the number of awards in force). This ratio is projected based on historical trends. Future average amounts terminated are determined as the product of this forecast ratio to the benefit in force at the beginning of the year.

The average benefit in current-payment status is then derived from the average benefit in force, based on the historical relationship between the two.

The average benefit for young and aged wives and for young and aged husbands is based on projecting the proportion of dependent benefit to primary benefit, using a regression equation with a time trend.

The *type* is comprised of:

1. male and female retired workers
2. child survivors (minor, disabled and student)
3. aged widows and widowers, mothers and fathers of child survivors, parents of deceased workers and disabled widows and widowers.

The average benefit for minor, disabled and student children of old-age beneficiaries is based on projecting the proportion of dependent benefit to primary benefit, using a regression equation with number of beneficiaries as an explanatory variable.

Barrick and Zayatz (1996, Section III.E., page 142) provides additional details.

## 7. Long-Range Revenue Projections

### 7.1 Employment

The short-range model of employment was described in Section 4.2. In particular, forecasts of the labor force participation rates were described in Section 4.2.1.

Recall

LFPR = labor force participation rate =  $\frac{\text{number of people working or seeking work}}{\text{non-institutionalized population}}$  and

UR = unemployment rate =  $1 - \frac{\text{number of people working}}{\text{number of people working or seeking work}}$ .

This section links LFPR and UR, that are US economy concepts, to “covered workers,” an OASDI concept. Covered workers are those who have paid some Social Security tax during the year.

#### 7.1.1. Unemployment Rates

Let  $UR(\text{age}, \text{sex}, \text{year})$  be the age/sex unemployment rate by year. Estimate the equation:

$$UR(\text{age}, \text{sex}, t) = \beta_0(\text{age}, \text{sex}) + \beta_1(\text{age}, \text{sex}) (1-RTP_t) + \beta_2(\text{age}, \text{sex}) (1-RTP_{t-1}) + \varepsilon(\text{age}, \text{sex}, t) \text{ for historical } t.$$

This estimation yields  $b_j(\text{age}, \text{sex})$ , for  $j = 0, 1, 2$ . For future years  $z$ , project

$$UR(\text{age}, \text{sex}, z) = b_0(\text{age}, \text{sex}) + b_1(\text{age}, \text{sex}) (1-RTP_z) + b_2(\text{age}, \text{sex}) (1-RTP_{z-1}) \quad (7.1)$$

After 10 years, we assume no changes in the unemployment rate. That is, for future years  $z$

$$UR(\text{age}, \text{sex}, 10+z) = UR(\text{age}, \text{sex}, 10) \text{ for } z = 1, 2, \dots, 65.$$

#### 7.1.2. Covered Worker Rates

The number of covered workers is available from SSA administrative records. The projected rates are adjusted to reflect coverage of Federal Civilian employees and illegal immigrants not participating in OASDI who were not included in historical rates. Define

$$\text{CWR} = \text{covered worker rate} = \frac{\text{number of covered workers}}{\text{SS Area population}}.$$

The “age-sex total unemployment rate” is

$$UR(z) = \frac{\sum_{\text{age,sex}} UR(\text{age}, \text{sex}, z) \times P(\text{age}, \text{sex}, 1997) \times LFPR(\text{age}, \text{sex}, 1997)}{\sum_{\text{age,sex}} P(\text{age}, \text{sex}, 1997) \times LFPR(\text{age}, \text{sex}, 1997)}. \quad (7.2)$$

Here,  $\sum_{\text{age,sex}} P(\text{age}, \text{sex}, 1997) \times LFPR(\text{age}, \text{sex}, 1997)$  is the 1997 labor force.

For each age/sex group, use a regression equation

$$CWR(age, sex, t) = \beta_0(age, sex) + \beta_1(age, sex) LFPR(age, sex, t) + \beta_2(age, sex) UR(t) + \varepsilon(age, sex, t)$$

for historical  $t$ .

This estimation yields  $b_0(age, sex)$ ,  $b_1(age, sex)$  and  $b_2(age, sex)$ . For future years  $z$ , project

$$CWR(age, sex, z) = b_0(age, sex) + b_1(age, sex) LFPR(age, sex, z) + b_2(age, sex) UR(z) \quad (7.3).$$

Covered worker rates may be either above or below labor force participation rates. A worker need only work part of the year in order to be covered under the OASDI program. However, LFPRs are determined by examining averages of weekly numbers of people in the labor force. Thus, the two concepts measure different aspects of participation in the labor force.

### 7.1.3. Covered Workers

To estimate the number of covered workers, we use the SSA population, a non-institutionalized population that includes the military both at home and abroad ( $P_0$ ) and the covered worker rates from equation (7.3). Thus, we have

$$\text{Number of covered workers}(age, sex, z) = P_0(age, sex, z) \times CWR(age, sex, z).$$

## 7.2. Economic Assumptions - GDP

Other economic assumptions, the interest and inflation rates, were described in Sections 2.2.4 and 4.1.1, respectively. This section describes forecasts of GDP using the “potential GDP” concept, introduced in Section 4.1.2.

### 7.2.1. Full-Employment Labor Force Participation Rates

According to Yang and Goss (1992, page 15), future changes in the full-employment labor force participation rate are estimated “based on historical data.” These historical data were produced by the Council of Economic Advisors and are now produced by the Congressional Budget Office (CBO). According to Yang and Goss, 1992, page 41, the relationship between actual and full-employment LFPRs was analyzed using differences between actual and full-employment unemployment rates.

For the 1999 Trustees reports, the SSA OCACT used as inputs to this projection “elastic factors” and RTP (that is, real to potential GDP in 1992 dollars). It turns out that RTP is very close to one, so this is used for the projections. Thus, full-employment labor force participation rates equal the actual labor force participation rates. Denote the projected values as  $LFPR_{FE}(age, sex, z) = LFPR(age, sex, z)$ .

### 7.2.2. Full-Employment Unemployment Rates

Full-employment unemployment rate are assumed to be fixed rates for each age-sex group, representing the lowest sustainable rates of unemployment in a normally operating economy without rising rates of inflation in prices. The overall full-employment unemployment rate will change over time due to the changing age/sex composition of the labor force. Denote the projected values as  $UR_{FE}(z)$ .

For the 1999 Trustees report, the SSA OCACT used as inputs RTP (that is, real to potential GDP in 1992 dollars). As with labor force participation rates, it turns out that RTP is very close to one, so this is used for the projections. Thus, full-employment unemployment rates equal the actual unemployment rates. Denote the projected values as  $UR_{FE}(age, sex, z) = UR(age, sex, z)$ .

### 7.2.3. Potential GDP

According to Yang and Goss (1992, page 15), future changes in the average number of hours worked per week and labor productivity (defined as output per hour worked) are estimated “based on historical data.” Denote these projections as  $Hours(z)$  and  $PH(z)$ . Here,  $PH$  is GDP in constant dollars divided by total number of hours worked (from BLS).

Begin by calculating projections of “full-employment” employment in year  $z$  as:  $Employment_{FE}(z) = \sum_{age, sex} LFPR_{FE}(age, sex, z) \times (1 - UR_{FE}(age, sex, z)) \times P(age, sex, z)$ .

Next, calculate potential GDP as

$$KGDP(z) = Employment_{FE}(z) \times Hours(z) \times 52 \times PH(z). \quad (7.4)$$

Forecasts of hours worked,  $Hours(z)$ , are based on the ultimate projection of a decline of 0.1% per year, described in Section 7.3 below. Similarly, Forecasts of labor productivity,  $PH(z)$ , are based on an assumed ultimate growth rate of 1.26% per year, described in Section 7.3 below.

### 7.2.4. Forecasts of Real to Potential GDP

For the long-range projections, the projected values of  $RTP(z)$  do not vary over forecast period, so  $RTP(z) = RTP$ . Specifically,  $RTP$  was determined from the ultimate assumed value of the unemployment rate; this was 5.5% for the 1999 Trustees report. Thus, using equations (7.1) and (7.2), we have

$$0.055 = UR(ultimate) = b_0(z) + b_1(z)(1 - RTP) + b_2(z)(1 - RTP), \quad (7.5)$$

where we use

$$b_j = \frac{\sum_{age, sex} b_j(age, sex) \times P(age, sex, 1997) \times LFPR(age, sex, 1997)}{\sum_{age, sex} P(age, sex, 1997) \times LFPR(age, sex, 1997)}, \quad j = 0, 1, 2.$$

Solution of equation (7.5) yields the long-range projection of  $RTP$ .

### 7.2.5. Forecasts of GDP

We forecast (nominal) GDP using potential GDP (KGDP), real to potential GDP (RTP) and the GDP price deflator described in Sections 7.2.3, 7.2.4 and 4.1.2, respectively. The projected values are:

$$GDP(z) = KGDP(z) \times RTP(z) \times (GDP \text{ price deflator})(z).$$

For the intermediate assumption of the 1999 Trustees report, the annual growth in real GDP is 2.6% in 1999, 2.0% in 2000-2007 and trends down to 1.2% in 2075.

### 7.3. Earnings

SSA OCACT calls forecasting earnings by itself the “direct analysis.” The direct analysis covers real earnings in all covered OASDI employment (Yang and Goss, 1992). This direct analysis has been examined on a demographic cohort basis (age and sex)

Forecasts of earnings take a different tact. First, economic cohorts, that is, sectors of the economy, now segregate the models. Further, in lieu of forecasting average earnings by itself, earnings are related to productivity. This allows one to decompose wages into intuitively meaningful pieces. The decomposition is:

$$\frac{\text{Earnings}}{\text{Worker}} = \frac{\text{Earnings}}{\text{Compensation}} \frac{\text{Compensation}}{\text{Production}_n} \frac{\text{Production}_r}{\text{Hour}} \frac{\text{Hour}}{\text{Worker}} \frac{\text{GDP Deflator}}{\text{CPI} - W} R$$

Symbolically, we have  $A = W \times C \times PH \times H \times G \times R$ , where

Symbol	Description
$A = \frac{\text{Earnings}}{\text{Worker}}$	Average real wage per worker. Aggregate earnings (from BEA) divided by average weekly US employment during the year.
$W = \frac{\text{Earnings}}{\text{Compensation}}$	Ratio of wages to compensation. Compensation is measured by BEA and is reported in the National Income and Product Accounts as total employee compensation, for wage-and-salary workers, and net proprietors income, for the self-employed. For the self-employed, earnings = compensation. For wage-and-salary workers, compensation includes fringe benefits.
$C = \frac{\text{Compensation}}{\text{Production}_n}$	Compensation per unit of production. Production is GDP in nominal dollars
$PH = \frac{\text{Production}_r}{\text{Hour}}$	Units of production per hour worked, called “productivity” or “labor productivity.” Total value of production (GDP in real dollars) divided by total number of hours worked (from BLS) The hours worked come from unpublished data from BLS. It is comparable to the productivity from the total US economy Here, we use productivity due to all types of workers, including government workers. This is in lieu of the more common measure from BLS that refers to productivity from “private non-farm business sector ”
$H = \frac{\text{Hour}}{\text{Worker}}$	Average hours worked per week per worker $\times 52$ Numbers of workers are from BLS CPS reflecting numbers of person employed, not number of jobs.
$G = \frac{\text{GDP Deflator}}{\text{CPI} - W}$	Price adjustment; it is the ratio of the GDP price deflator index to the CPI for Urban Wage Earners and Clerical Workers.
$R$	Residual. There may be inconsistencies in reporting

This analysis is done by (1) wage workers and (2) the self-employed. Yang and Goss (1992, Section V.D) describes how GDP is split into these two components.

For the projections, let  $\Delta$  denote percentage change. Then, from  $A = W \times C \times PH \times H \times G \times R$ , we have

$$1 + \frac{\Delta_A}{100} = \left(1 + \frac{\Delta_W}{100}\right) \left(1 + \frac{\Delta_C}{100}\right) \left(1 + \frac{\Delta_{PH}}{100}\right) \left(1 + \frac{\Delta_H}{100}\right) \left(1 + \frac{\Delta_G}{100}\right) \left(1 + \frac{\Delta_R}{100}\right).$$

This yields  $\Delta_A \approx \Delta_W + \Delta_C + \Delta_{PH} + \Delta_H + \Delta_G + \Delta_R$ . To summarize these relationships, here are the ultimate values used in the 1999 Trustees Report (page 148) for wage and salary workers. Self-employed workers are similar except that we assume  $\Delta_W = 0$  for each alternative. The ultimate values are based on the opinions of the Trustees.

1999 Trustees Ultimate Assumptions for Wage and Salary Workers				
Symbol	Description	Ultimate Assumption		
		Low-Cost (I)	Intermediate (II)	High-Cost (III)
$\Delta_W$	Earnings/Compensation	-0.1	-0.2	-0.3
$\Delta_C$	Compensation/Production <sub>n</sub>	0.0	0.0	0.0
$\Delta_{PH}$	Production <sub>n</sub> /Hour	1.6	1.3	1.0
$\Delta_H$	Hour/Worker	0.0	-0.1	-0.2
$\Delta_G$	GDP Deflator/CPI-W	-0.1	-0.1	-0.1
$\Delta_R$	R	0.0	0.0	0.0
$\Delta_A$	Earnings/Worker	1.4	0.9	0.4

#### 7.4. Effective Taxable Payroll

As described in Section 2.2.1, Effective Taxable Payroll (*ETP*) consists of total earnings subject to OASDI tax, including wages in military service. *ETP* is composed of covered earnings of wage-and-salary workers and self-employed workers. Further, earnings of wage-and-salary workers are decomposed into the employee and employer portion. These are slightly different due to adjustments for multi-employer “excess wages.”

Thus, there are three types of taxable earnings: employee taxable wages, employer taxable wages and effective taxable self-employment income (*SEI*). Thus, we have

$$ETP = \frac{1}{2} \text{Employee Taxable Wages} + \frac{1}{2} \text{Employer Taxable Wages} + \text{Effective Taxable SEI}.$$

##### 7.4.1 Wage-and-Salary Workers

For wage-and-salary workers, earnings are equivalent to wages. To project taxable wages, we use:

$$\text{Employee(er) Taxable Wages} = (\text{Nominal GDP}) \times \frac{\text{Compensation}}{\text{Production}_n} (\text{WS}) \times \frac{\text{Earnings}}{\text{Compensation}} (\text{WS})$$

$$\times \frac{OASDI \text{ Covered Earnings}}{Earnings} (WS) \times \frac{OASDI \text{ Taxable Earnings}}{OASDI \text{ Covered Earnings}} (WS) .$$

The projection of nominal GDP was described in Section 7.2.5. The projections of earnings per compensation and compensation per production for wage and salary workers (WS) were described in Section 7.2.

Growth in OASDI covered earnings are anticipated to differ from the real wage assumption because (a) real wages are averages over the total US economy as compared to the OASDI economy and (b) measurements methods differ, so discrepancies will arise. Further, OASDI taxable earnings differ from OASDI covered earnings due to the annual cap on wages.

To get historical values of the ratio of OASDI covered earnings to total earnings, OASDI earnings are available from SSA administrative records and total earnings are available from BLS NIPA accounts. Recent historical values of the ratio of OASDI taxable to covered earnings are also available from SSA administrative records. This is because, beginning in 1994, total earnings are subject to HI tax. Prior to this, these were imputed.

For the long-range projections of these two ratios, the SSA OCACT uses the final values from the short-range projections as the ultimate. These were described in Section 4.3.2. Specifically, the ratio of OASDI covered earnings to earnings is determined by four sectors of the economy: Private, Federal Civilian, Federal Military and State and Local. Only the Federal Civilian is projected to increase after the ten-year short-range period. This is due to bringing of these employees into the OASDI system.

Generally, both employees and employers pay SS Tax up to an annual cap in equal amounts, with one exception. When an employee works for more than one employer and combined wages exceed the cap, the employee can apply for a refund of excess contributions. Except for this difference, we have

$$Employee \text{ Taxable Wages} = Employer \text{ Taxable Wages}$$

#### 7.4.2. Self-Employed Workers

The method for projecting taxable earnings from self-employed (SE) workers is similar to wage-and-salary workers. The ratio of OASDI Covered Earnings to total US earnings is lower for the self-employed, in part due to the fact that if a worker's self-employed income is less than \$400, then no tax is due. To project taxable earnings, we use:

$$Effective \text{ Taxable SEI} = (Nominal \text{ GDP}) \times \frac{Compensation}{Production_n} (SE) \\ \times \frac{OASDI \text{ Covered Earnings}}{Earnings} (SE) \times \frac{OASDI \text{ Taxable Earnings}}{OASDI \text{ Covered Earnings}} (SE)$$



## 8. Long-Range Benefit Projections

As with the short-range projections, future benefit payments are estimated by projecting the number of beneficiaries and the average benefit, by type of beneficiary. Projections are made for each sex in three categories of beneficiaries. These are (*type*): (i) disabled-worker beneficiaries and their auxiliaries, (ii) retired-worker beneficiaries and their auxiliaries and (iii) survivor beneficiaries.

$$\begin{aligned} \text{Annuity Benefits}(z) = & \sum \text{Number of current beneficiaries}(\text{sex}, \text{type}, z) \times \text{Average benefit}(\text{sex}, \text{type}, \\ & + \sum \text{Number of newly awarded beneficiaries}(\text{sex}, \text{type}, z) \times \text{Average benefit}(\text{sex}, \text{type}, \\ & + \sum \text{Number of newly awarded beneficiaries}(\text{sex}, \text{type}, z) \times \text{retroactive payments}(\text{sex}, \text{type}, \end{aligned}$$

$$\text{Average Benefit} = \text{Average primary insurance (PIA) amount} \times \% \text{ PIA payable.}$$

Retroactive payments are payments to cover the time from date of filing for benefits to date of first payments. A provision in the law allows a beneficiary to receive up to 6 months' of benefits retroactively (12 for disabled-worker beneficiaries).

Section 8.1 describes the projection of the fully insured and disability insured population. Section 8.2 describes the projection of the disability beneficiaries, including retired workers and their auxiliaries. Section 8.3 provides analogous description for the old age and survivor beneficiaries. Section 8.4 projects benefit amounts, both for new and current awards.

### 8.1. Insured Population

#### 8.1.1. Projection of Fully Insured Population

Age/sex projections of fully insured rates are made for each birth cohort. They are based on theoretical distributions of workers by accumulated quarters of coverage (QC), as constructed from past and projected coverage rates and amounts of earnings required for crediting with quarters of coverage. Model feature – persons at the low end of the wage distribution are more likely to earning 0 QCs, whereas persons at the high end of the wage distribution are more likely to earning 4 QCs. Model parameters reproduce experience since 1970.

Prior to 1979, earnings were reported quarterly. Thus, a different definition of “quarters of coverage” was in place than is the case presently. The current (1999) definition is: one QC for each \$740 of wages and self-employment income, reported annually, up to a maximum of 4. Here, the \$740 changes with changes in the National Wage Index.

Projection of the fully insured population is accomplished as follows:

1. Estimate a distribution of wages from 1990 earnings, using the CHWS. Rescale wages by dividing by the median.
2. Begin with projections of the SSA population. Use the covered worker rates, described in Section 7.1, to project the number of workers by single year of age.
3. For historical years, estimate median earnings by sex/single year of age group.

4. For each year, define the cutoffs, as a percentage of the median earnings, required for 0, 1, 2, 3, and 4 QCs. (There are four cutoffs.) Calculate the fraction of the distribution calculated in Step 1 falling into each of the five categories. This provides the fraction falling into 0, 1, 2, 3 and 4 QCs. For years prior to 1979, use different definitions of QC. For years 1979 and on, the cutoffs are of the form

$$c \times 250 / (\text{median earnings}(\text{age, sex, year})), \text{ for } c=1, 2, 3, 4.$$

5. Now organize these percentages by sex and birth cohort. When calibrating the model with real data from CWHS, there is a tendency to “stick” in two categories. Specifically, following a birth cohort over time, there is a tendency for people with 0 QCs in one year to have 0 QCs in the following year. Similarly, people with 4 QCs in one year tend to have 4 QCs in the following year. Thus, the percentages in 0 QCs and 4 QCs are adjusted for this stickiness.

6. The average number of QCs earned by a cohort (followed over time) is estimated by accumulating each cohort’s covered worker rates up to the current year, after multiplying the average number of QCs earned by the covered workers in that year. That is,

*average number of QCs*( $z$ ) =  $\sum_{t \leq z}$  covered worker rate ( $\text{age}-t, \text{sex}, t$ )  $\times$  QC( $\text{age}-t, \text{sex}, t$ ). Here, QC( $\text{age}, \text{sex}, t$ ) is the “expected” number of quarters in year  $t$  for the age/sex group.

7 Apply the definition of fully insured status to the average number of QCs in Step 6. The maximum number of QCs required is 40.

8 To subdivide the fully insured rates by marital status, we use labor force participation rates. Variations in labor force participation rates by marital status were used to estimate variations in the covered worker rate by marital status. This yields a preliminary estimate of fully insured status by marital status. Then, for each age, sex, and marital status, an estimate was made of what proportion of their past working lifetime was spent in each marital status. The final estimates of fully insured status by marital status are a weighed average of the preliminary estimates.

### **8.1.2. Projection of Disability Insured Population**

Examine the ratio of disability insured to fully insured, by age/sex group. Project these ratios to get the projected disability insured population. Uses data from the CWHS.

## **8.2. Disability Beneficiaries**

### **8.2.1. Disabled Worker Beneficiaries**

As with the short-range projections, the numbers of disabled-worker beneficiaries are projected by use of incidence and termination rates. Further, these projections began with anticipated duration of entitlement. Incidence and termination rates vary by age and sex.

Projections of the incidence rate, by age and sex, are developed based on the judgement of the OCACT staff. Ultimate assumptions are available from the Trustees Report. These projections are based on 1984-1986 experience. They are updated via a projection factor that reaches its ultimate value in year 2013. The projections are done to reflect recent experience as well as scheduled increases in the normal retirement age. The incident rates are applied to the disability insured population (minus those already receiving disabled-worker benefits) to get the number of new entitlements each year.

Termination can occur as a result of (a) death, (b) recovery, (c) conversion at retirement and (d) for other reasons. Death and recovery rates are projected by age, sex and duration of entitlement. These are applied to the disabled-worker population to get the number of terminations. Disabled-worker beneficiaries at normal retirement age are automatically converted to retired-worker beneficiary status. These projections are based on 1977-1980 experience. They are updated by cause-specific factors. To illustrate, the ultimate values of the recovery rates projection factor are attained in 2013; these ultimate values are 50% lower than experienced in 1977-1980.

### **8.2.2. Auxiliaries of Disabled Worker Beneficiaries**

Auxiliary beneficiaries consist of (a) aged and young spouse and (b) child beneficiaries.

Spouse beneficiaries were projected by age, sex and year. These projections begin with  $P(\text{age, sex, } ms=2, z)$ , that is, the married population. Terminology: the “account holder” is the disabled worker that has sufficient credits of work for Social Security benefits. They examine the following ratios:

1. The account holder is under the normal retirement age.
2. The account holder is disability insured.
3. The account holder is disabled and receiving a disabled-worker’s benefit.
4. The spouse is not fully insured.
5. Other factors, including the probabilities that the spouse is not earning enough to have his or her benefits withheld under the retirement earnings test.

These same factors were applied to the divorced population,  $P(\text{age, sex, } ms=4, z)$ , with two additional factors. These were:

1. The former spouse (account holder) is still alive.
2. The divorced spouse must have been married to the account holder for at least 10 years.

The number of child beneficiaries of disabled workers were projected by age, sex and year. These projections begin with the child population, taken from  $P(\text{age, sex, } ms=1, z)$ . They examine the following ratios:

1. The account-holder parent under the normal retirement age.
2. The account-holder parent is disability insured.
3. The account-holder parent is disabled and receiving a disabled-worker’s benefit.
4. For minor children, a residual factor to account for the discrepancy between the past actual and estimated number of children.
5. For student children, include the probability of being a full-time secondary student.
6. For disabled children, include the probability of being disabled since age 18.

### **8.3. Old-Age and Survivor Beneficiaries**

In contrast to disability, numbers of retired and survivor beneficiaries are projected by use of prevalence rates. These rates are applied to the SS Area population by age, sex, marital status and year.

### **8.3.1 Old-Age Beneficiaries**

#### *8.3.1.a Retired-Worker Beneficiaries*

A portion of the number of retired-worker beneficiaries come from conversion of disabled worker beneficiaries at normal retirement age.

To get the number of non-converted retired-worker beneficiaries, apply SS Area population, by age and sex, to the following factors:

1. The proportion fully insured.
2. The proportion not disabled.
3. The proportion not an insured widow or widower beneficiary.
4. The retirement prevalence rate.

The proportion fully insured (1) was described in Section 8.1.1. The number not disabled (2) was described in Section 8.2.1. The proportion not an insured widow or widower beneficiary (3) will be described in Section 8.3.2. If the worker's benefit is much lower than the widow(er)'s benefit, then the worker may not file a claim. The fourth factor represents the probability that the worker has actually filed a claim for benefits and is not earning an amount sufficient to have benefits withheld.

The retirement prevalence rates shown (Wilkin, 1988, Table 6) are the number of retired-worker beneficiaries in current-pay status divided by the "exposed population," by age and sex cohort. Here, the exposed population is the number of fully insured workers minus the sum of (i) the number of DI beneficiaries that are converted to retirement status, (ii) number of widows and (iii) number of widowers. In general, these prevalence rates are projected to decrease, reflecting the scheduled increases in the normal retirement age (Offsetting this trend is the scheduled changes in delayed retirement credit. This, as well as the scheduled increases in the normal retirement age, will substantially alter the ratio of the Monthly Benefit Amount to the Primary Insurance Amount )

#### *8.3.1.b Aged-Spouse Beneficiaries of Retired Workers*

The benefits of aged-spouse beneficiaries are based on the earnings records of their husbands or wives, who are referred to as the "account holders." Aged-spouse beneficiaries were projected by age, sex and year. These projections begin with  $P(\text{age, sex, } ms=2, z)$ , that is, the married population. To get the number of beneficiaries, apply the population to the following factors:

1. The proportion of account holders age 62 or over.
2. The proportion of account holders fully insured.
3. The proportion of account holders in current-pay status.
4. The proportion of account holders where the spouse is not fully insured.
5. The proportion of account holders where spouse is not earning enough to have his or her benefits withheld.
6. The proportion of account holders where the spouse's benefit is not being withheld because of receipt of a significant government pension based on earnings in non-covered employment.

6. A residual factor. This accounts for past discrepancies between the actual and estimated number of beneficiaries. To illustrate, data are not available to account for the requirement that spouses be married for at least 10 years. This is assumed to part of the residual factor.

These same factors were applied to the divorced population,  $P(\text{age, sex, } ms=4, z)$ , with two changes. These were:

1. Do not apply the third factor because divorced spouses do not need to wait for the account holder to receive benefits.
2. The former spouse (account holder) is still alive.

#### *8.3.1.c Child Beneficiaries of Retired Workers*

The number of child beneficiaries of retired workers were projected by age, sex and year. These projections begin with the child population, taken from  $P(\text{age, sex, } ms=1, z)$ . They examine the following ratios:

1. The account-holder parent 62 or over.
2. The account-holder parent is fully insured.
3. The retirement prevalence rate for insured retired workers.
4. For minor children, a residual factor to account for the discrepancy between the past actual and estimated number of children.
5. For student children, include the probability of being a full-time secondary student.
6. For disabled children, include the probability of being disabled since age 18.

For each year and age of child, the population model projects the number of children by  $(x, y)$ , the age of the mother and the age of the father. It also projects children of single parents (never married and with deceased spouse).

#### *8.3.1.d Young-Spouse Beneficiaries of Retired Workers*

Young-spouse beneficiaries were projected by age, sex and year. These projections begin with  $\sum_{ms=2,3,4} P(\text{age, sex, } ms, z)$ ; this is the "once-married" population, that is, the married ( $ms=2$ ), widowed ( $ms=3$ ) and divorced ( $ms=4$ ) population. They examine the following ratios:

1. The probability that a person has a child who is a child beneficiary of a retired worker and the child is either under age 16 or disabled.
2. The person is not earning enough to have benefits withheld under the retirement earnings test.
3. A residual factor

### 8.3.2 Survivor Beneficiaries

#### 8.3.2.a Aged-Spouse Beneficiaries of Deceased Workers

After retired-workers, this is the most prevalent type of benefit paid. It is also the most complex to project. Aged-spouse beneficiaries were projected by age, sex and year. These projections begin with  $\sum_{ms=2,3,4} P(\text{age, sex, ms, z})$  over age 60; this is the “once-married” population, that is, the married ( $ms=2$ ), widowed ( $ms=3$ ) and divorced ( $ms=4$ ) population, over age 60.

To get the number of *uninsured* widow(er) beneficiaries, apply the population to the following factors:

1. The proportion of deceased account-holders fully insured at the time of death.
2. The proportion of widow(er)s not fully insured.
3. The proportion where the widow(er) is not earning enough to have his or her benefits withheld under the earnings retirement test.
4. The proportion where the widow(er) is not earning enough to have his or her benefits withheld because of receipt of a significant government pension based on own earnings.
5. The proportion where the widow(er) is not a young-spouse beneficiary.
6. A residual factor.

To get the number of *insured* widow(er) beneficiaries, repeat the steps above but:

1. In step 2, use the proportion of widow(er)s not insured.
2. Do not use Step 5, thus assuming that all young spouse beneficiaries were not fully insured.
3. Use different factors for Steps 3 and 6.

These same factors were applied to the divorced population,  $P(\text{age, sex, ms}=4, z)$ , with two changes. These were:

1. The former spouse (account holder) is still alive.
2. The divorced spouse must have been married to the account holder for at least 10 years.

#### 8.3.2.b Disabled-Spouse Beneficiaries of Deceased Workers

There are relatively small numbers in this category. Disabled spouse benefits are not available to disabled spouses of retired or disabled workers.

These projections begin with  $\sum_{ms=2,3,4} P(\text{age, sex, ms, z})$  ages 50-64; this is the “once-married” population, that is, the married ( $ms=2$ ), widowed ( $ms=3$ ) and divorced ( $ms=4$ ) population, ages 50-64. They examine the following ratios:

1. The proportion of deceased account-holders fully insured at the time of death.
2. The proportion of widow(er)s disabled and not entitled to a higher disabled-worker benefit or to a young spouse of a deceased worker benefit.

These same factors were applied to the divorced population,  $P(\text{age, sex, ms}=4, z)$ , with one change. This was, for the second factor, also account for the fact that the marriage must have lasted at least 10 years.

#### 8.3.2.c Child Beneficiaries of Deceased Workers

These are projected similarly to the number of child beneficiaries of retired workers.

## 8.4. Benefit Projections

### 8.4.1. Average Benefit for Newly-Awarded Beneficiary

For the 1999 Trustees Report, the average PIA was estimated from a sample of the Master Beneficiary Records (MBR). This was a stratified sample of 1997 Old Age, Survivor and Disability new awards. The Old Age and Survivor stratification was based on age; a 1% sample was selected from ages 62-65 and a 5% sample was selected from ages 66-70. There were 13,801 awards in this sample. Also included was a 5% sample of 1997 Disability new awards; there were 11,257 beneficiaries in this sample. From the MBR, information about age, sex and year of entitlement were available. From the Continuous Work History Sample (CWHS), a history of earnings was available.

For projecting into the future, the main difficulty is due to the fact that earnings before 1995 were censored at the taxable maximum. (In 1994, the maximum was removed for HI taxes. Thus, the MBR began to retain uncensored wage records.) A complex method is used to approximate the distribution of earnings before 1995 *as if* the taxable maximum were not in effect. With this distribution, one can “simulate” future earnings for each individual. With the complete “simulated” earnings history on these 25,058 (=13,801+11,257) new awards, they can be projected into the future. Then, for each projection year, we can compute the benefit using the projected benefit formula. With this approach, the age distribution of future new awards does not change.

#### *Projection of Future Wage Distributions*

An outline of this procedure is described as follows.

1. For each historical year  $t = 1951, \dots, 1997$ , compute the wage distribution. Let  $F_t(w)$  be the proportion with wages less than  $w$ , where the argument  $w$  is a multiple of the taxable maximum in year  $t$ . We consider discrete steps of 0.05. Thus,  $w = 1$  represents the taxable maximum in year  $t$  and, due to the censoring,  $F_t(1 + \epsilon) = 1$  for each  $t$ .

2. Define  $\text{logit}(y) = \ln\left(\frac{y}{1-y}\right)$ . For each  $t$ , fit a regression function to the model

$$\text{logit}(F_t(w)) = \alpha_t + \beta_t w + \epsilon, \quad \text{for } w=0.05, 0.10, 0.15, \dots, 0.95, 1.00.$$

Call these estimated coefficients  $a_t$  and  $b_t$ . We will use the fitted equation

$$\text{logit}(F_t(w)) = a_t + b_t w$$

to estimate wages for those individuals at the taxable maximum.

3. For each year  $t$ , consider the sample of individuals at the taxable maximum. This proportion is  $1 - F_t(1.00)$ . For this proportion, count those individuals who:
- do not earn the taxable maximum in any of the next four years. Call this proportion  $p_0(t)$ .
  - are at the taxable maximum only once in four years. Call this proportion  $p_1(t)$ .
  - are at the taxable maximum twice in four years. Call this proportion  $p_2(t)$ .
  - are at the taxable maximum thrice in four years. Call this proportion  $p_3(t)$ .
  - are at the taxable maximum for all four of four years. Call this proportion  $p_4(t)$ .

Thus, we have  $p_0(t) + p_1(t) + p_2(t) + p_3(t) + p_4(t) = 1 - F_t(1.00)$ .

Estimate earnings for each group by first solving for wage  $w$  in each of the following equations:

- $\text{logit}(F_t(1.00)) = a_t + b_t w_{0,t}$
- $\text{logit}(F_t(1.00) + p_0(t)) = a_t + b_t w_{1,t}$
- $\text{logit}(F_t(1.00) + p_0(t) + p_1(t)) = a_t + b_t w_{2,t}$
- $\text{logit}(F_t(1.00) + p_0(t) + p_1(t) + p_2(t)) = a_t + b_t w_{3,t}$
- $\text{logit}(F_t(1.00) + p_0(t) + p_1(t) + p_2(t) + p_3(t)) = a_t + b_t w_{4,t}$

Alternatively, one could define  $w_{0,t}$  to be the taxable maximum (= 1).

We also require  $w_{5,t}$ , an estimated wage for those individuals corresponding to the proportion  $p_4(t)$ . To estimate  $w_{5,t}$  for each historical year  $t$ , identify the age of the oldest worker. To illustrate, for projections done with 1997 data, the oldest retiree is 70. For each year  $t$  prior to 1997, the oldest retiree in the 1997 new award sample is age  $y(t) = 70$  (1997- $t$ ). The proportion of taxpayers in the sample that are at the taxable maximum in year  $t$  is  $1 - F_t(1.00)$ . Now, examine the pattern of individuals over time for this age  $y(t)$  that are at the taxable maximum. Extrapolate this pattern and call the ultimate proportion  $1 - F_{t,ultimate}$ . Define  $w_{5,t}$  as the solution of

$$\text{logit}(F_{t,ultimate}) = a_t + b_t w_{5,t}$$

For each of the five groups,  $j = 1, \dots, 5$ , a weighted average wage is computed,  $w_{j,t}$  as a linear combination of  $w_{j,t}$  and  $w_{j-1,t}$ . Then, the following probabilities and wages are used to complete the specification of the wage distribution.

Probabilities	Wages
$p_0(t)$	$w_{1,t}^*$
$p_1(t)$	$w_{2,t}^*$
$p_2(t)$	$w_{3,t}^*$
$p_3(t)$	$w_{4,t}^*$
$p_4(t)$	$w_{5,t}^*$



Three additional adjustments are made to the earnings history:

1. Because labor force participation rates differ historically from those projected into the future, the covered worker rates are adjusted to reflect future anticipate behavior. In particular, women are expected to participate more in the work force in the future.
2. Earnings were adjusted by the ratio of the Average Taxable Earnings to the Average Covered Earnings. This adjustment is described in Section 7.4.
3. The earnings history goes back to 1951. Thus, for new awards in 1997 who retire at age 70, no earnings history is available for their working years 16-23. Some small adjustments were made to impute these missing data.

*Percentage of PIA Payable*

This is for groups affected by early retirement reduction and/or delayed retirement credit, including (i) retired worker beneficiaries, (ii) aged spouse beneficiaries and (iii) aged surviving spouse beneficiaries. The projections reflect the effects of movement toward earlier retirement.

Let  $x$  be the age at entitlement (in years) and let  $NRA(z)$  is the normal retirement age in year  $z$ . Round  $x$  to the nearest month. Thus, for  $x \geq NRA(z)-5$ , we have

% PIA payable( $x, z$ ) = *Actuarial Reduction Factor* =

$$\begin{cases} 1 & x \geq NRA \\ 1 - 12 \times (NRA - x) \frac{5}{9} \% & NRA - 3 \leq x \leq NRA \\ 0.80 - 12 \times (NRA - 3 - x) \frac{5}{12} \% & NRA - 5 \leq x \leq NRA - 3 \end{cases}$$

For individuals that retire after the normal retirement age, a delayed retirement credit is available. Here, for individuals who delay retirement in year 2005 and beyond, benefits will increase by 8% for each year of delaying retirement. However, no credit is received for delayed retirement beyond age 70.

Specifically, the (monthly) credits that individuals can earn are:

$$\text{Monthly DRC Factor} = \begin{cases} 13 / 24\% & \text{for years 1999 - 2000} \\ 14 / 24\% & \text{for years 2001 - 2002} \\ 15 / 24\% & \text{for years 2003 - 2004} \\ 16 / 24\% & \text{for years 2005 and later} \end{cases}$$

For individuals retiring at age  $x$  in year  $z$ , these monthly factors are summed to form a *DRC Factor*. Thus, we have

$$\%PIA \text{ payable}(x, z) = \text{Delayed Retirement Credit} = 1 + (\text{DRC Factor})$$

where  $NRA \leq x \leq 70$ .

#### 8.4.2. Average Benefit for Beneficiary in Current Pay Status

The average benefit for current in-payment beneficiaries can be updated directly based on a cost of living adjustment as well as a post entitlement factor. That is,

$$\begin{aligned} \text{Average Benefit}(\text{age, duration from award, sex, type, } z+1) \\ = \text{Average Benefit}(\text{age}-1, \text{duration from award } -1, \text{sex, type, } z) \\ \times (1 + \% \text{cost-of-living}) \times \text{Post-Entitlement Factor}(\text{sex, duration from award}). \end{aligned}$$

The post-entitlement factor reflects (1) mortality and (2) earnings. The mortality portion is due to the fact that individuals with higher earnings enjoy lower mortality. The earnings portion is due to the fact that individuals with higher earnings enjoy more post retirement earnings, and thus have benefits lowered, due to the earnings test.

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