

# **Long-Range OASDI Projection Methodology**

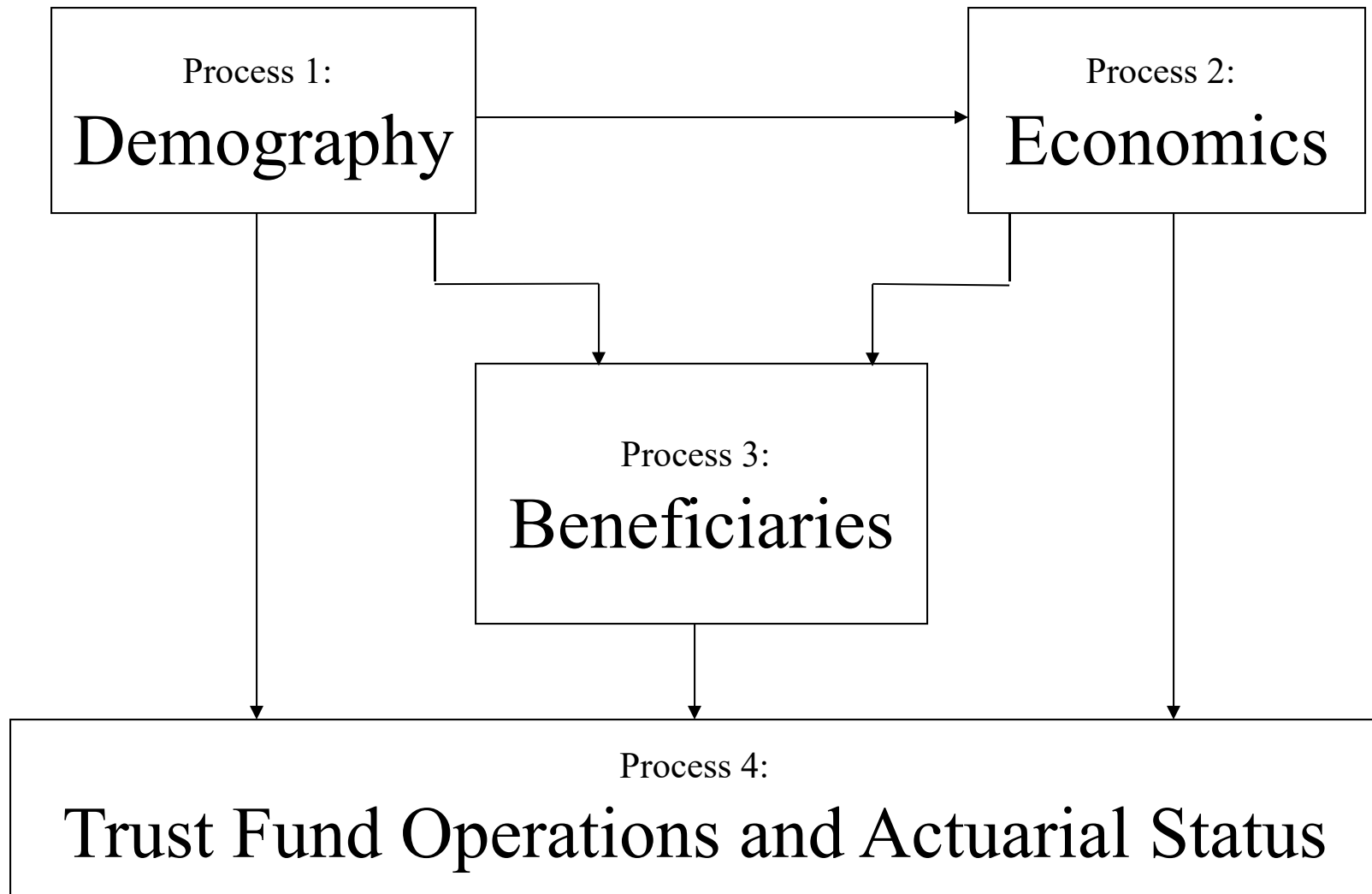
## **Intermediate Assumptions of the 2018 Trustees Report**

**June 2018**

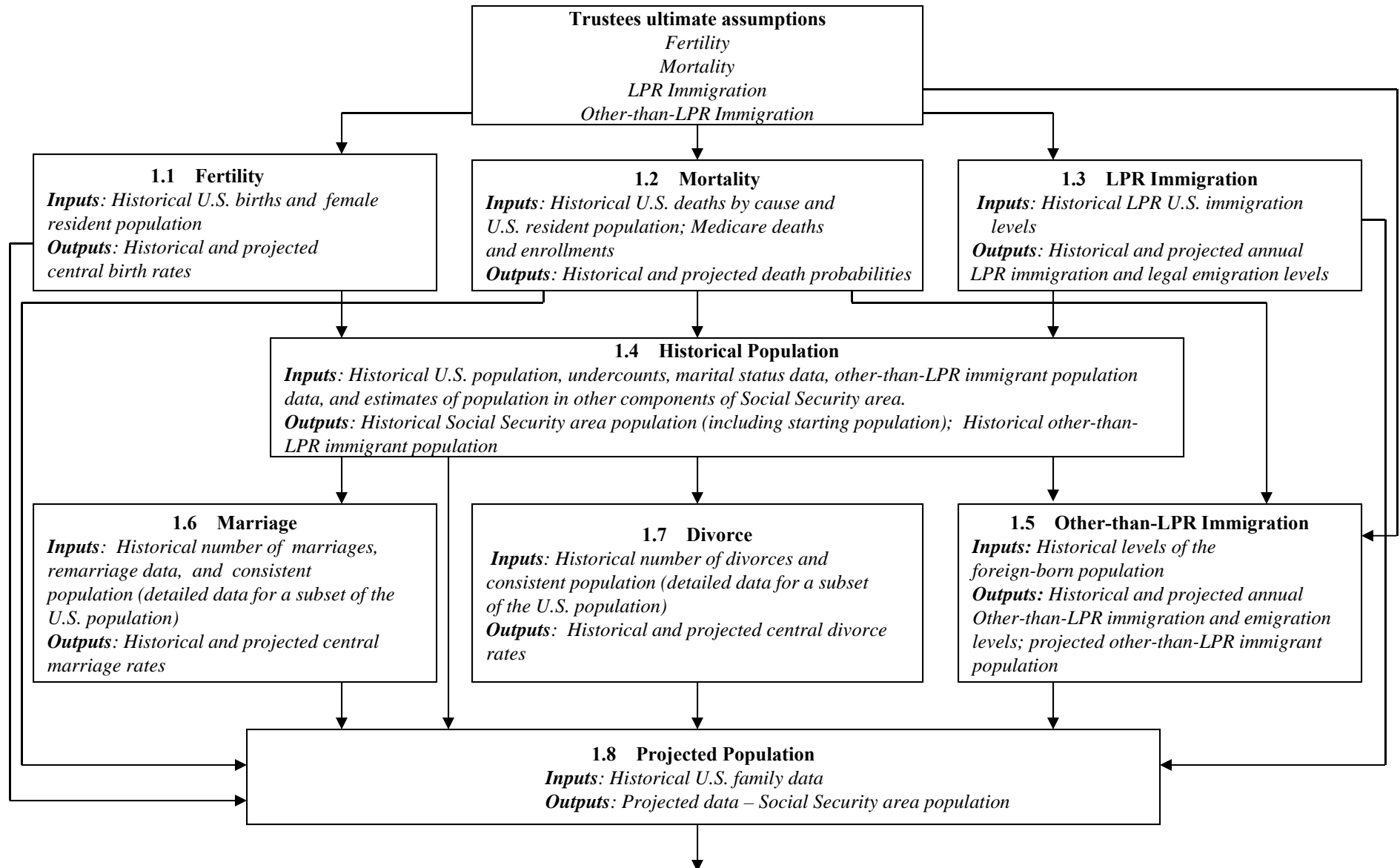
**Office of the Chief Actuary  
Social Security Administration**

# **A. Flow Charts**

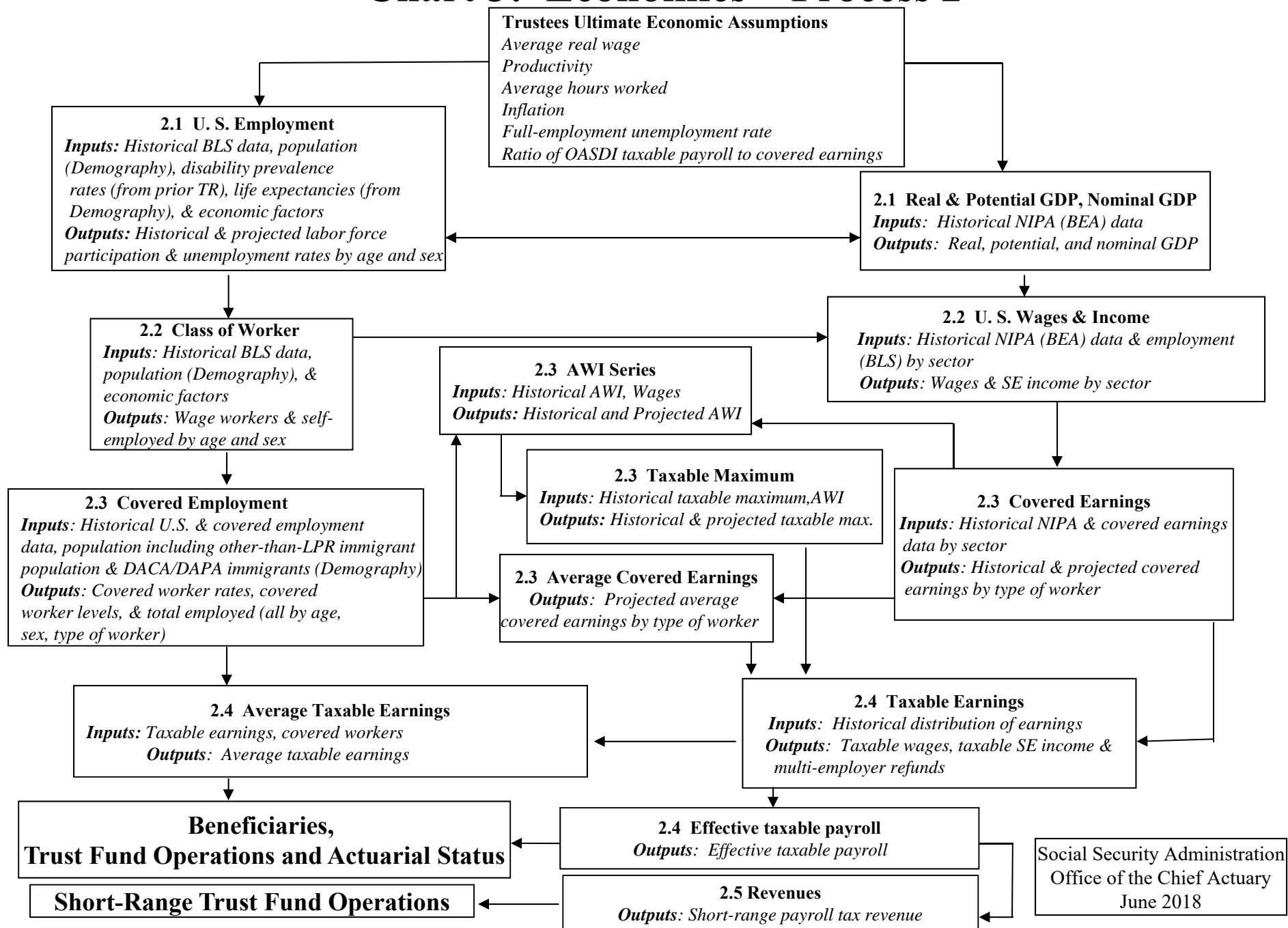
# Chart 1: Overview of Long-Range OASDI Projection Methodology



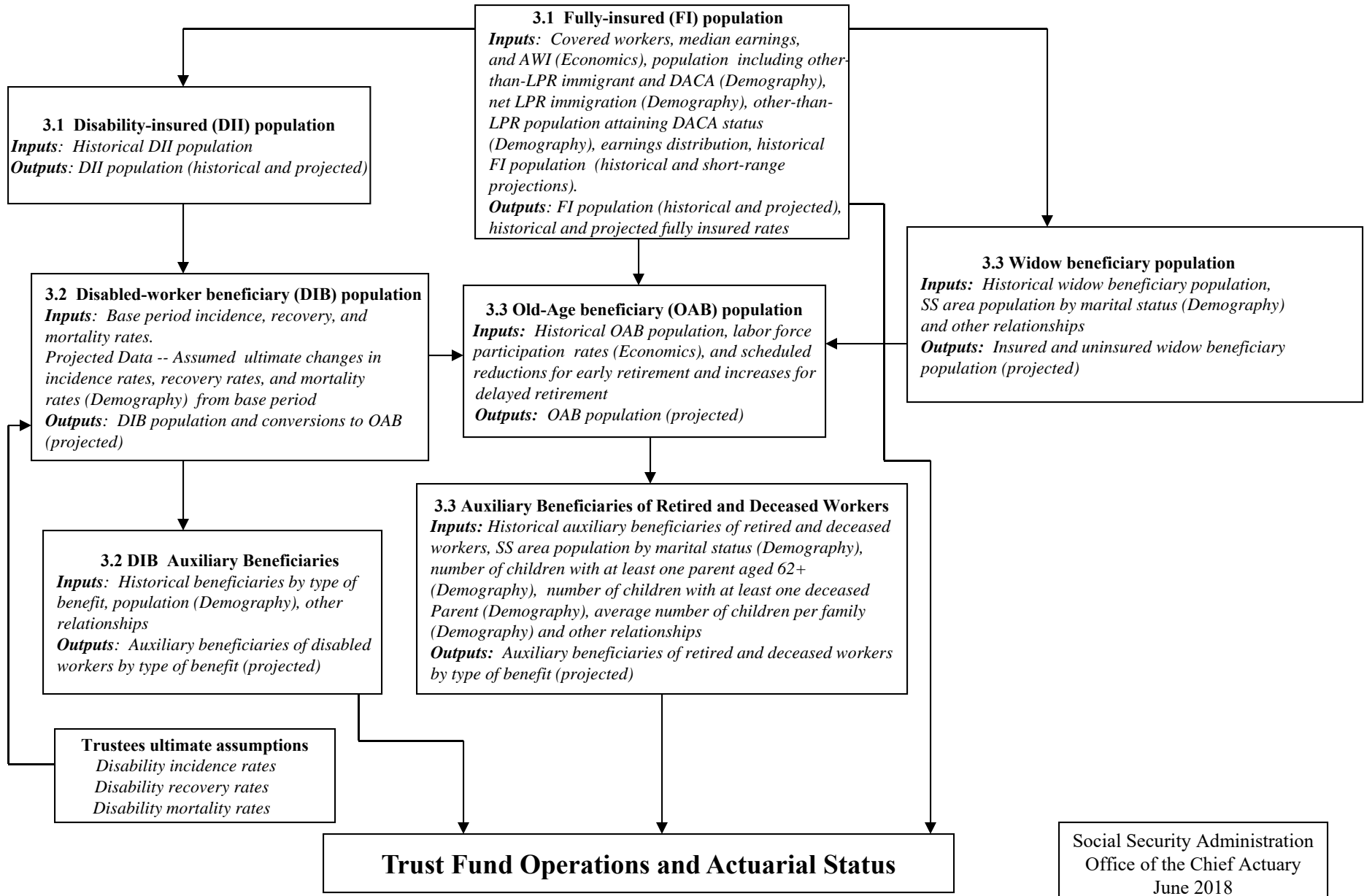
# Chart 2: Demography – Process 1



# Chart 3: Economics – Process 2

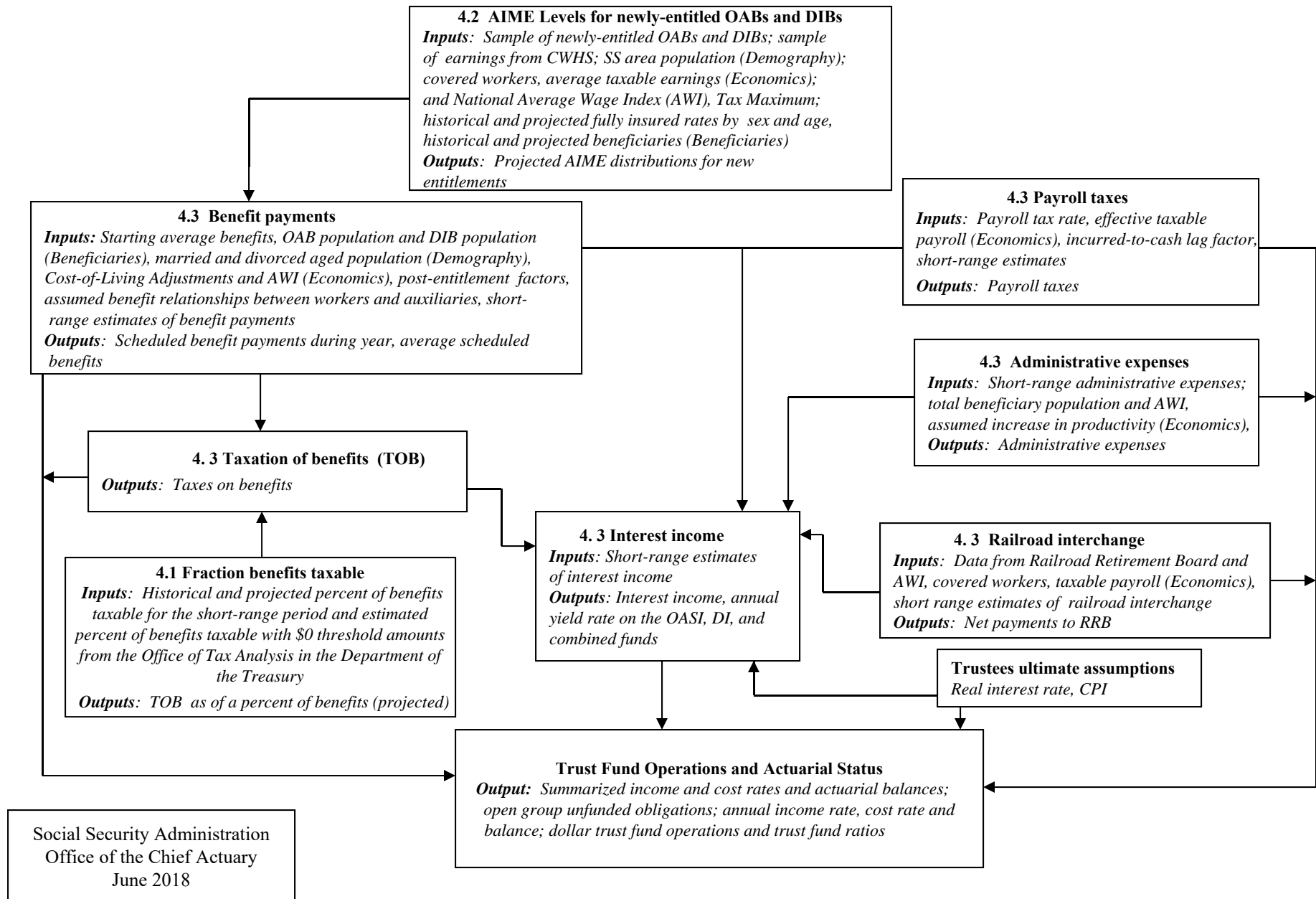


# Chart 4: Beneficiaries – Process 3



Note: Insured widow refers to widow beneficiaries who are insured for OAIB benefits, but not receiving those benefits.

# Chart 5: Trust Fund Operations and Actuarial Status – Process 4



# B. Process Descriptions

The long-range programs used to make projections for the annual Trustees Report are grouped into four major processes. These include Demography, Economics, Beneficiaries, and Trust Fund Operations and Actuarial Status. Each major process consists of a number of subprocesses. Each subprocess is described in terms of three elements:

- This overview attempts to provide a general description of the purpose of each subprocess. This element introduces key projected variables used in the subprocess. Some variables are represented as being dependent in an equation, where the dependent variable is *defined* in terms of one or more independent variables. Independent variables may include previously calculated dependent variables or data provided from outside the subprocess. Other key variables are referenced by “(·)” following the variable name. This symbol indicates that the calculation of this variable cannot easily be communicated by an equation and, thus, requires a more complex discussion.
- Input Data – Data used in the subprocess are described. These data include those from other subprocesses, ultimate long-range assumptions provided by the Board of Trustees of the OASDI Trust Funds, data from other offices of the Social Security Administration, and data from outside the Social Security Administration (e.g., estimates of the U.S. population). Data description includes data source and data detail (e.g., define age detail of data). In addition, this element includes how often additional data are expected to be received.
- Development of Output – The key variables are described in greater detail, including the level of disaggregation of the data.



# **Process 1:**

# **Demography**

## *1. Demography*

The primary purpose of the Demography Process is to provide estimates of the projected Social Security area population<sup>1</sup> for each year of the 75-year projection period in the Trustees Report. For the 2018 report, the projection period covers the years 2018 through 2092. The Demography Process receives input data mainly from other government agencies, and provides output data to the Economics, Beneficiaries, and Trust Fund Operations and Actuarial Status processes.

The Demography Process is composed of eight subprocesses: FERTILITY, MORTALITY, LPR (Lawful Permanent Resident) IMMIGRATION, HISTORICAL POPULATION, OTHER-THAN-LPR IMMIGRATION, MARRIAGE, DIVORCE, and PROJECTED POPULATION. The following chart displays the key outputs of each subprocess:

<b>Subprocess</b>	<b>Key Outputs</b>
FERTILITY	<ul style="list-style-type: none"> <li>• Birth rates, by age of mother</li> </ul>
MORTALITY	<ul style="list-style-type: none"> <li>• Probabilities of death, by age and sex</li> </ul>
LPR IMMIGRATION	<ul style="list-style-type: none"> <li>• LPR immigrants, by age and sex</li> <li>• Legal emigrants, by age and sex</li> <li>• Adjustments of status from other-than-LPR status to LPR status, by age and sex</li> </ul>
HISTORICAL POPULATION	<ul style="list-style-type: none"> <li>• Historical estimates of the Social Security area total population, by age, sex, and marital status</li> <li>• Historical estimates of the other-than-LPR population, by age and sex</li> </ul>
OTHER-THAN-LPR IMMIGRATION	<ul style="list-style-type: none"> <li>• Other-than-LPR immigrants, by age and sex</li> <li>• Other-than-LPR emigrants, by age and sex</li> <li>• Projected other-than-LPR populations, by age, sex, and type (never-authorizeds, nonimmigrants, visa-overstayers)</li> <li>• Historical estimates of the other-than-LPR population, by age, sex, and type</li> </ul>
MARRIAGE	<ul style="list-style-type: none"> <li>• Marriage rates, by age-of-husband crossed with age-of-wife</li> </ul>
DIVORCE	<ul style="list-style-type: none"> <li>• Divorce rates, by age-of-husband crossed with age-of-wife</li> </ul>
PROJECTED POPULATION	<ul style="list-style-type: none"> <li>• Projected total populations, by age, sex, and marital status</li> </ul>

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<sup>1</sup> The Social Security area population is composed of: (1) residents of the 50 States and the District of Columbia (adjusted for net census undercount); (2) civilian residents of Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Northern Mariana Islands; (3) Federal civilian employees and persons in the U.S. Armed Forces abroad and their dependents; (4) non-citizens living abroad who are insured for Social Security benefits; and (5) all other U.S. citizens abroad.

## 1.1. FERTILITY

### 1.1.a. Overview

The National Center for Health Statistics (NCHS) collects data on annual numbers of births by single year of age of mother and the U.S. Census Bureau produces estimates of the resident population by single year of age for females. Age-specific birth rates ( $b_x^z$ ) for a given year  $z$  are defined as the ratio of (1) births ( $B_x^z$ ) during the year to mothers at the specified age  $x$  to (2) the midyear female population ( $P_x^z$ ) at that age. The total fertility rate ( $TFR^z$ ) summarizes the age-specific fertility rates for a given year  $z$ . The total fertility rate for a given year  $z$  equals the sum of the age-specific birth rates for all ages  $x$  during the year. One can also interpret the total fertility rate as the average number of children that would be born to a woman if she were to survive her childbearing years and experience, at each age in her life, the age-specific birth rate of year  $z$ .

The FERTILITY subprocess combines the historical values of  $b_x^z$  and  $TFR^z$  and assumed future values of the  $TFR^z$  to develop projections of  $b_x^z$ . The primary equations of this subprocess are given below:

$$b_x^z = b_x^z(\cdot) \quad (1.1.1)$$

$$TFR^z = \sum_x b_x^z \quad (1.1.2)$$

### 1.1.b. Input Data

#### *Trustees Assumptions -*

1. Each year the Board of Trustees of the OASDI Trust Funds sets the assumed ultimate values for the TFR. For the 2018 Trustees Report, the ultimate TFR is 2.0 and it is assumed to be reached in 2027. The Trustees also assign assumed TFRs for each year through the ultimate year.

#### *Other input data -*

2. From the NCHS, annual numbers of births by age of mother<sup>2</sup> (10-14, 15, 16, 17, ..., 48, 49-54) for years 1980-2016. In general, the NCHS provides an annual update including one additional year of final birth data. Previous historical years are only updated if the NCHS makes a historical revision to their data.

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<sup>2</sup> Births at ages less than 14 are treated as having occurred at age 14, and births reported to mothers older than 49 are treated as having occurred at age 49.

3. From the U.S. Census Bureau, estimates of the July 1st female resident population by single year of age for ages 14-49 for 1980-2016. In general, each year, Census provides updated data for years after the most recent decennial census.
4. From the NCHS, historical birth rates, by single year of age of mother (14-49) for the period 1917-1979. No updates of these data are needed.
5. From the NCHS, provisional first quarter 2017 birth rates by five-year age-group. In general, the NCHS provides data for a new year through at least the first quarter annually.

### 1.1.c. *Development of Output*

#### *Equation 1.1.1 - Age-specific birth rates*

The FERTILITY subprocess produces the age-specific birth rates, by childbearing ages 14 through 49, for years 1941 through the end of the 75-year projection period. For historical years prior to 1980, age-specific birth rates come from the NCHS. For years 1980 through the remaining historical period, age-specific birth rates are calculated as:  $b_x^z = \frac{B_x^z}{P_x^z}$ , using birth data from the NCHS and estimates of the July 1<sup>st</sup> female resident population from the U.S. Census Bureau.

The age-specific birth rates are projected using a process that is consistent with both the observed trends in recent data and the assumed ultimate total fertility rate. This process consists of the following steps:

1. Averaged birth rates by age group,<sup>3</sup> designated as  ${}_5b_x^z$ , are calculated from the age-specific birth rates  $b_x^z$  for each year during the period 1980-2016.
2. The starting values of the projection process are the  ${}_5b_x^z$  values from the last historical data year (2016).
3. For each  ${}_5b_x^z$  age group series, the slope of the least squares line is calculated based on a regression over the period 1991-2016.
4. For 2017, each of the seven starting values of  ${}_5b_x^z$  (from Step 2) is projected forward by adding 100 percent of their respective slope (from Step 3).
5. Then, a preliminary total fertility rate for 2017,  $TFR_p^{2017}$ , is calculated such that, in general, it is equal to 5 times the sum of each  ${}_5b_x^{2017}$ . For the age group 14-19, 6 times the sum is used since this age group actually contains one additional age.

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<sup>3</sup> The average is calculated by giving each age in the group equal weight without regard to population. The age groups calculated are: 14-19, 20-24, 25-29, 30-34, 35-39, 40-44, and 45-49.

6. For 2017, the Trustees assume the  $TFR^{2017}$  is about 1.80 based on provisional first quarter NCHS data.
7. To ensure the assumed total fertility rate is achieved for 2017, each value of  ${}_5b_x^{2017}$  (from Step 4) is now multiplied by the ratio of the assumed  $TFR^{2017}$  (from Step 6) and the respective value of  $TFR_p^{2017}$  (from Step 5).
8. For 2018, each final  ${}_5b_x^z$  for 2017 is projected forward by adding 90.9 percent of the respective slope (from Step 3). For subsequent projection years (2019-2042), an arithmetically decreasing portion of the slopes, until 0% is reached,<sup>4</sup> is added to the previous year's final values of  ${}_5b_x^z$  to get preliminary values of  ${}_5b_x^z$ .
9. For years 2018 and later, a preliminary total fertility rate,  $TFR_p^z$ , is calculated from the preliminary values of  ${}_5b_x^z$  in Step 8 and is calculated in the same manner as in Step 5.
10. Then, for each year, an adjustment is made so that the annual  $TFR^z$  is consistent with the Trustees' assumed TFR.  $TFR^z$  is assumed to increase from  $TFR^{2017}$  until reaching the ultimate value in 2027. However, the increases are larger in the middle of the 2017 – 2027 period and slower at the ends of this period.
11. To ensure the assumed total fertility rate is achieved, each value of  ${}_5b_x^z$  (Step 8) is multiplied by the ratio of the assumed  $TFR^z$  (Step 10) and the respective value of  $TFR_p^z$  (Step 9).
12. The final step of the projection method disaggregates the adjusted  ${}_5b_x^z$  into single age birth rates by multiplying the final  ${}_5b_x^z$  values for each year (Steps 7 or 11) by the ratio of the single year  $b_x^z$  to the  ${}_5b_x^z$  for each of the respective ages and age groups as calculated in the last year of complete historical data (Step 1). Then, minor adjustments correct rounding issues.

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<sup>4</sup> For each year of the projection, the percentage of the slopes added to each  ${}_5b_x^z$  is reduced linearly such that 0% of the slope is used in the ultimate year. Thus, 0% is used for 2028 and later.

## 1.2 MORTALITY

### 1.2.a. Overview

The National Center for Health Statistics (NCHS) collects data on annual numbers of deaths and the U.S. Census Bureau produces estimates of the U.S. resident population. Central death rates ( ${}_yM_x$ ) are defined as the ratio of (1) the number of deaths occurring during the year to persons between exact ages  $x$  and  $x+y$  to (2) the midyear population between exact ages  $x$  and  $x+y$ . For historical years prior to 1968,  ${}_yM_x$  are calculated from NCHS and Census data by sex. For historical years beginning in 1968, the same data are used in the calculations for ages under 65, but data from the Centers for Medicare and Medicaid Services (CMS) are used for ages 65 and over. Based on death by cause data from the NCHS, the  ${}_yM_x$  are distributed by cause of death for years 1979 and later.<sup>5</sup>

Over the last century, death rates have decreased substantially. The historical improvement in mortality is quantified by calculating the average annual percentage reduction ( ${}_yAA_x$ ) in the central death rate. In order to project future  ${}_yM_x$ , the Board of Trustees of the OASDI Trust Funds assumes an ultimate average annual percentage reduction ( ${}_yAA_x^u$ ) that will be realized during the projection period for each sex and cause of death.

The basic mortality outputs of the MORTALITY subprocess that are used in projecting the population are probabilities of death by age and sex ( $q_x$ ). The probability that a person age  $x$  will die within one year ( $q_x$ ) is calculated from the central death rates (the series of  ${}_yM_x$ ).

Period life expectancy ( $e_x$ ) is defined as the average number of years of life remaining for people who are age  $x$  and are assumed to experience the probabilities of death for a given year throughout their lifetime. It is a summary statistic of overall mortality for that year.

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<sup>5</sup> Data needed in order to project central death rates by cause of death were obtained from Vital Statistics tabulations for years since 1979. For the years 1979-1998, adjustments were made to the distribution of the numbers of deaths by cause. The adjustments were needed in order to reflect the revision in the cause of death coding that occurred in 1999, making the data for the years 1979-1998 more comparable with the coding used for the years 1999 and later. The adjustments were based on comparability ratios published by the National Center for Health Statistics.

Age-adjusted death rates (*ADR*) are also used to summarize the mortality experience of a single year, making different years comparable to each other. Age-adjusted death rates are a weighted average of the  ${}_yM_x$ , where the weights used are the numbers of people in the corresponding age groups of the standard population, the 2010 U.S. Census resident population ( ${}_ySP_x$ ). Thus, if the age-adjusted death rate for a particular year and sex is multiplied by the total 2010 U.S. Census resident population, the result gives the number of deaths that would have occurred in the 2010 U.S. Census resident population if the  ${}_yM_x$  for that particular year and sex had been experienced. Age-sex-adjusted death rates (*ASDR*) are calculated to summarize death rates for both sexes combined and are calculated as a weighted average of the  ${}_yM_x$ , where each weight is the number of people in the corresponding age and sex group of the 2010 U.S. Census resident population.

MORTALITY projects annual  ${}_yM_x$ , which are then used to calculate additional outputs. The equations for this subprocess are given below:

$${}_yM_x = {}_yM_x(\cdot) \quad (1.2.1)$$

$${}_yAA_x = {}_yAA_x(\cdot) \quad (1.2.2)$$

$$q_x = q_x(\cdot) \quad (1.2.3)$$

$$\bar{e}_x = \bar{e}_x(\cdot) \quad (1.2.4)$$

$$ADR_s^z = \frac{\sum_x {}_ySP_x \cdot {}_yM_{x,s}^z}{\sum_x {}_ySP_x} \quad (1.2.5)$$

$$ASDR^z = \frac{\sum_s \sum_x {}_ySP_{x,s} \cdot {}_yM_{x,s}^z}{\sum_s \sum_x {}_ySP_{x,s}} \quad (1.2.6)$$

where  ${}_yM_{x,s}^z$  refers to the central death rate between exact age  $x$  and  $x+y$ , by sex, in year  $z$ ;  ${}_ySP_x$  denotes the number of people in the standard population (male and female combined) who are between exact age  $x$  and  $x+y$ ; and  ${}_ySP_{x,s}$  denotes the number of people, by sex, in the standard population who are between exact age  $x$  and  $x+y$ .

### 1.2.b. *Input Data*

#### *Trustees Assumptions -*

1. Each year the Board of Trustees of the OASDI Trust Funds sets the assumed ultimate values for the  ${}_yAA_x$  by sex, age group,<sup>6</sup> and cause of death.<sup>7</sup> The average annual percentage reductions reach their ultimate values in the 25th year of the 75-year

<sup>6</sup> Age groups are: less than 15, 15-49, 50-64, 65-84, and 85+

<sup>7</sup> The five causes of death are: Cardiovascular Disease, Cancer, Violence, Respiratory Disease, and Other

projection period. The ultimate rates of reduction by sex, age group, and cause of death can be found in Appendix 1.2-1.

*NCHS Data -*

2. Annual numbers of registered deaths by sex and age group for the period 1900-1978. These data are not updated. Registered deaths refer to deaths in the Death Registration area. Since 1933, the Death Registration area has included all of the U.S.
3. Annual numbers of deaths by sex, age group, and cause for the period 1979-2015. Generally, a new year of data is received each year. In addition, revised data are often available for years beginning with 1999. (1999 was the starting year of the latest international classification of diseases – ICD10.)
4. The monthly number of births, by sex, for years 1938-2015. These data are updated annually, when the NCHS provides an additional year of data.
5. The number of infant deaths, by age, sex, and age group,<sup>8</sup> for years 1938-2015. These data are updated annually, when the NCHS provides an additional year of data.
6. The population of states in the Death Registration area by age group<sup>9</sup> and sex, for years 1900-1939. These data are not updated.
7. The number of registered deaths, by sex and age group (85-89, 90-94, and 95+), for the years 1900-1967. These data are not updated.
8. From the NCHS public use records, deaths by sex, single year of age, and marital status from 1968-2015. Marital status is not available until 1979.

*U.S. Census Bureau Data -*

9. Estimates of the July 1 resident population by single year of age (0 through 100+) for years 1980-2015. Each year, Census provides an additional year of data and also provides updated data for years after the most recent decennial census.
10. The resident population at ages 75-79 and 80-84, by sex, for years 1900-1940 (at ten year intervals). These data are not updated.
11. The resident population, by sex and age group,<sup>10</sup> for 1940-2000. These data are not updated.

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<sup>8</sup> Age groups are: under 24 hours, 1-2 days, 3-6 days, 7 -27 days, 28 days-1 month, 2 months, 3 months, ... , 11 months, 1 year, 2 years, 3 years, and 4 years

<sup>9</sup> Age groups are: 0, 1-4, 5-14, 15-24, ..., 75-84, and 85+

<sup>10</sup> Age groups for years prior to 1980 are: 0, 1-4, 5-9, ..., 80-84, and 85+. For years 1980 and later, the age groups are: 0, 1-4, 5-9, ..., 90-94, and 95+.



12. Estimates of the population by marital status, sex, and age from the American Community Survey (ACS) public use microdata sample (PUMS) files for years 2000 – 2015. In general, an additional year of data is available each year.

*CMS Data -*

13. Annual numbers of deaths of Medicare enrollees who are also Social Security or Railroad Retirement Board beneficiaries, by sex and single year of age (ages 65 and over), for the period 1988-2015. Prior to 1988, annual numbers of deaths of all Medicare enrollees were used. These data are updated annually, when the CMS provides an additional year of preliminary data and replaces the prior year’s preliminary data with final data.
14. Annual numbers of Medicare enrollees who are also Social Security or Railroad Retirement Board beneficiaries, by sex and single year of age (ages 65 and over), for the period 1988-2016. Prior to 1988, annual numbers of all Medicare enrollees were used. These data are updated annually, when the CMS provides an additional year of preliminary data and replaces the prior year’s preliminary data with final data.

**1.2.c. Development of Output**

*Equation 1.2.2 - Average Annual Percentage Reduction in the Central Death Rates ( ${}_yAA_x$ )*

The  ${}_yAA_x$ , by sex and cause, are calculated based on the decline in the  ${}_yM_x$  for the period 2005 through 2015, and distributed by 21 age groups,<sup>11</sup> 2 sexes, and 5 causes of death.<sup>12</sup> The values are calculated as the complement of the exponential of the slope of the least-squares line through the logarithms of the  ${}_yM_x$ .

The assumed ultimate values for the central death rates ( ${}_yAA_x^u$ ), as set by the Board of Trustees of the OASDI Trust Funds, are assumed to be reached in the 25<sup>th</sup> year of the 75-year projection period. These ultimate values are specified by five causes of death for the following five age groups: under 15, 15-49, 50-64, 65-84, and 85 and older. Male and female values are assumed to be equal to each other.

The starting values of  ${}_yAA_x$ , by the 21 age groups, sex, and cause, are assumed to equal the average decline in the  ${}_yM_x$  for the period 2005-2015 when that average is non-negative. However, if that average is negative, then the starting values are assumed to be 75 percent of the average. Available Medicare preliminary data is used for overall levels with the last available NCHS data year cause of death percentages carrying forward. For each year after the last data year, the  ${}_yAA_x$  are calculated by transitioning from the starting values of  ${}_yAA_x$  to the Trustees’

<sup>11</sup> Age groups are: 0, 1-4, 5-9, 10-14, ..., 90-94, and 95+

<sup>12</sup> The five causes of death are: Cardiovascular Disease, Cancer, Violence, Respiratory Disease, and Other.

assumed ultimate values,  ${}_yAA_x^u$ . This is accomplished by repeating the following steps for each historical year after the last data year and for the first 24 years of the projection:

1. The difference between the prior year's calculated  ${}_yAA_x$  and the assumed ultimate  ${}_yAA_x^u$  is calculated. Note that for the first year of this process, the starting values of  ${}_yAA_x$ , as defined above, are used instead of the prior year's  ${}_yAA_x$ .
2. The current year's  ${}_yAA_x$  is the assumed ultimate  ${}_yAA_x^u$  plus 80 percent of the difference calculated in step 1.

For the 25<sup>th</sup> year of the projection, the  ${}_yAA_x$  are set equal to their assumed ultimate values,  ${}_yAA_x^u$ .

#### *Equation 1.2.1 – Central Death Rates ( ${}_yM_x$ )*

Values of  ${}_yM_x$  are determined for each historical and projected year by the 21 age groups, 2 sexes, and 5 causes of death. The starting year for the projections of the  ${}_yM_x$  is 2015, and is the most recent data year in the historical period. However, instead of using the historical data for  ${}_yM_x$  in this year as the starting point for mortality projections, starting  ${}_yM_x$  values are calculated to be consistent with the trend inherent in the last 12 years of available data. Each starting value for the  ${}_yM_x$ , by sex and cause of death, is computed as the exponential of the value for the most recent year falling on a weighted least square line, where the logarithm of  ${}_yM_x$  is regressed on year, over the last 12 years. The weights are 0.2, 0.4, 0.6, and 0.8 for the earliest four years of the 12 years and are 1.0 for all other years.

For years after 2015,  ${}_yM_x$  are projected, by sex and cause of death, by applying the respective  ${}_yAA_x$  to the prior year  ${}_yM_x$ .

#### *Equation 1.2.3 – Probabilities of death ( $q_x$ )*

In order to project population by age and sex, probabilities of death are applied to determine the projected number of deaths that will occur in the population. These probabilities, denoted as  $q_x$ , reflect the probability a person age  $x$  will die within one year, where  $x$  refers to age last birthday as of the beginning of each year. For each year in the historical and projection period, separate  $q_x$  series are estimated by sex.

Different methods of projecting  $q_x$  are used for age 0, for ages 1 through 4, for ages 5 through 94, and for ages 95 and above. The following descriptions provide a brief discussion of these different methods. Additional detail is provided in Actuarial Study number 120. This study, titled Life Tables for the United States Social Security area 1900-2100, can be found at: <http://www.socialsecurity.gov/OACT/NOTES/s2000s.html>. (Choose study number 120.)

- *Values for  $q_x$  at Age 0:* During the first year of life, mortality starts at an extremely high level, which becomes progressively lower. This is unlike mortality at other ages, which

does not change very much within a single year of age. Thus, it is particularly important at age 0 to estimate accurately the pattern of mortality throughout the year of age, as described above, for the calculation of  $q_0$ . For the period 1940 through the last historical year,  $q_0$  is calculated directly from tabulations of births by month and from tabulations of deaths at ages 0, 1-2, 3-6, 7-28 days, 1 month, 2 months, ..., and 11 months. After the last historical year,  $q_0$  is calculated from  ${}_1M_0$ , assuming that the ratio of  $q_0$  to  ${}_1M_0$  measured for the last historical year would remain constant thereafter.

- *Values for  $q_x$  at Ages 1 – 4:* For the period 1940 through the last year of historical data, probabilities of death at each age 1 through 4 ( $q_x$ ,  $x = 1, 2, 3, 4$ ) are calculated from tabulations of births by year and from tabulations of deaths at ages 1, 2, 3, and 4 years. After the last historical year, each  $q_x$  (where  $x = 1, 2, 3, 4$ ) is calculated from  ${}_4M_1$  assuming that the ratio of  $q_x$  to  ${}_4M_1$  measured for the last historical year would remain constant thereafter.
- *Values for  $q_x$  at Ages 5 – 94:* Probabilities of death for these ages are calculated from the projected central death rates,  ${}_5M_x$ . As mentioned above, the calculations are discussed in detail in Actuarial Study number 120.
- *Values for  $q_x$  at Ages 95+:* It has been observed that the mortality rates of women, though lower than those of men, tend to increase faster with advancing age than those of men. An analysis of Social Security charter Old-Age Insurance beneficiaries has shown that at the very old ages mortality increases about five percent per year of age for men and about six percent per year for women. For men, probabilities of death at each ages 95 and older are calculated as follows:

$$q_x = q_{x-1} \cdot \left( \frac{q_{94}}{q_{93}} \cdot \frac{99-x}{5} + 1.05 \cdot \frac{x-94}{5} \right) \quad x = 95, 96, 97, 98, 99$$

$$q_x = 1.05 \cdot q_{x-1} \quad x = 100, 101, 102, \dots$$

For women, the same formulas are used, except that 1.06 is substituted for 1.05. The larger rate of growth in female mortality would eventually, at a very high age, cause female mortality to be higher than male mortality. At the point where this crossover would occur, female mortality is set equal to male mortality.

The values of  $q_x$  used in projecting the population are based on age last birthday and are calculated by sex for  ${}_{1/2}q_0$  (neonatal) and for  $q_x$ , where  $x$  represents age last birthday for ages 0 through 100 (with 100 representing the age group 100 and older). Because life table values of probabilities of death are based on exact ages, values for  $q_x$  representing age last birthday are derived as follows:

$${}_{1/2}q_0 = 1 - L_0 / l_0 \quad \text{for neonatal}$$

$$q_x = 1 - L_{x+1} / L_x \quad \text{for ages 0 to 99}$$

$$q_{100} = 1 - T_{101} / T_{100} \quad \text{for age group 100 and older}$$

See Actuarial Study number 120 for the definitions of the life table terms. This study can be found at: <http://www.socialsecurity.gov/OACT/NOTES/s2000s.html>. (Choose study number 120; then section IV.A in the table of contents.)

In addition, probabilities of death are broken down further into marital status. Historical data indicate that differential in mortality by marital status is significant. To reflect this, projected relative differences in death rates by marital status are projected to be the same as observed during calendar years 2011-2015. These rates were developed by:

1. Taking the five-year age-group deaths from the public use NCHS data by marital status and dividing by the equivalent population sums from the ACS to get preliminary five-year age-group death rates by marital status.
2. Adjusting the older age groups death rates for consistency with prior age groups.
3. Adjusting the older age groups death rates further so that all marital statuses gradually reach the same value at the 95+ age group.
4. Converting these five-year age-group death rates to single year of age by using a modified H.S. Beers method of interpolation.
5. Converting these death rates to probabilities of death.

#### *Equation 1.2.4 –Life expectancy*

Actuarial Study number 120 presents background information on the calculation of life expectancy,  $e_x$ , from the probabilities of death ( $q_x$ ). This study can be found at: <http://www.socialsecurity.gov/OACT/NOTES/s2000s.html>. (Choose study number 120; then IV.A in the table of contents.)

## Appendix: 1.2-1

The Board of Trustees of the OASDI Trust Funds sets the ultimate rates of mortality reduction by age group and cause of death. For comparison purposes, rates are also presented for two historical periods. Note that although the ultimate rates are the same for males and females, the historical rates differ.

**Table 2.3: Average Annual Rates of Reduction in Central Death Rates by Age Group, Sex, and Cause**

	Historical		Alternative II*		Historical		Alternative II*	
	1979 to 2015	2005 to 2015	2017 TR	2018 TR	1979 to 2015	2005 to 2015	2017 TR	2018 TR
			2041 to 2091	2042 to 2092			2041 to 2091	2042 to 2092
<b>Under Age 15</b>	<b>Male</b>				<b>Female</b>			
Cardiovascular Disease	2.73	2.53	2.3	2.3	2.63	2.32	2.3	2.3
Cancer	2.28	1.20	1.5	1.5	1.91	1.43	1.5	1.5
Violence	2.78	2.01	1.0	1.0	2.34	2.39	1.0	1.0
Respiratory Disease	2.48	1.37	2.0	2.0	2.50	0.86	2.0	2.0
Other	2.29	2.42	1.7	1.7	2.17	2.17	1.7	1.7
Resulting Total **	2.41	2.27	1.54	1.54	2.21	2.14	1.58	1.57
<b>Ages 15 - 49</b>	<b>Male</b>				<b>Female</b>			
Cardiovascular Disease	1.94	1.62	1.5	1.5	1.18	1.17	1.5	1.5
Cancer	1.90	2.31	1.5	1.5	1.67	1.89	1.5	1.5
Violence	0.74	0.57	0.7	0.7	-0.05	-0.46	0.7	0.7
Respiratory Disease	0.79	0.37	0.5	0.5	-0.21	-0.21	0.5	0.5
Other	0.69	2.20	0.8	0.8	-0.33	0.66	0.8	0.8
Resulting Total **	1.14	1.28	0.88	0.87	0.56	0.65	0.94	0.94
<b>Ages 50 - 64</b>	<b>Male</b>				<b>Female</b>			
Cardiovascular Disease	2.95	1.33	2.2	2.2	2.56	1.37	2.2	2.2
Cancer	1.64	1.40	1.5	1.5	1.41	1.47	1.5	1.5
Violence	-0.10	-2.12	0.5	0.5	-0.79	-3.10	0.5	0.5
Respiratory Disease	0.99	-0.49	0.7	0.7	-0.48	-1.04	0.7	0.7
Other	-0.47	-0.69	0.6	0.6	-0.49	-0.65	0.6	0.6
Resulting Total **	1.55	0.41	1.07	1.07	1.10	0.42	1.06	1.06
<b>Ages 65 - 84</b>	<b>Male</b>				<b>Female</b>			
Cardiovascular Disease	3.22	2.75	2.2	2.2	2.90	3.07	2.2	2.2
Cancer	0.97	2.00	0.9	0.9	0.09	1.42	0.9	0.9
Violence	0.52	-0.41	0.5	0.5	-0.14	-0.52	0.5	0.5
Respiratory Disease	0.71	1.31	0.3	0.3	-1.76	0.37	0.3	0.3
Other	-0.77	-0.58	0.3	0.3	-1.45	-0.54	0.3	0.3
Resulting Total **	1.59	1.51	0.77	0.77	0.79	1.24	0.72	0.72
<b>Ages 85 and older</b>	<b>Male</b>				<b>Female</b>			
Cardiovascular Disease	1.75	2.35	1.2	1.2	1.93	2.72	1.2	1.2
Cancer	-0.13	1.11	0.5	0.5	-0.44	0.42	0.5	0.5
Violence	-0.67	-1.04	0.3	0.3	-1.29	-2.07	0.3	0.3
Respiratory Disease	-0.38	1.45	0.2	0.2	-1.57	0.72	0.2	0.2
Other	-2.25	-1.53	0.2	0.2	-3.09	-1.60	0.2	0.2
Resulting Total **	0.34	0.86	0.51	0.51	0.13	0.68	0.48	0.49
<b>Total</b>	<b>Male</b>				<b>Female</b>			
Cardiovascular Disease	2.63	2.32			2.40	2.67		
Cancer	1.00	1.70			0.54	1.31		
Violence	0.49	-0.26			-0.23	-1.10		
Respiratory Disease	0.39	1.15			-1.43	0.30		
Other	-0.82	-0.59			-1.54	-0.79		
Resulting Total **	1.22	1.11	0.74	0.74	0.64	0.90	0.69	0.69

\* Alternative 1 is 1/2 times Alternative 2; Alternative 3 is 5/3 times Alternative 2.

\*\*Resulting total represents average annual percent reduction in age-adjusted death rates for the last 50 years of the 75-year projection period.

## 1.3. LPR IMMIGRATION

### 1.3.a. Overview

LPR immigration is defined as those persons who have been admitted into the United States and been granted lawful permanent resident status. Legal emigration consists of LPR immigrants and U.S. Citizens who depart the Social Security area population to reside elsewhere.

For each year  $z$  of the projection period, the LPR IMMIGRATION subprocess produces estimates of LPR immigration ( $L^z$ ) and legal emigration ( $E^z$ ), by age and sex, based on assumptions set by the Trustees for each category. In addition, the LPR IMMIGRATION subprocess disaggregates the estimates of  $L^z$  into those who have been admitted into the United States during the year ( $NEW^z$ ) and those who adjusted from the other-than-LPR population to LPR status ( $AOS^z$ ).

Each fiscal year,<sup>13</sup> the Department of Homeland Security (DHS) collects data on the number of persons granted LPR status by age, sex, and class of admission. The U.S Census Bureau provided OCACT with an unpublished estimate of the annual number of legal emigrants, by sex and age, based on the change between the 1980 and 1990 censuses. These historical data are used as a basis for developing age-sex distributions that are applied to the Trustees' aggregate immigration assumptions to produce annual LPR immigration and annual legal emigration estimates by age and sex.

The primary equations of LPR IMMIGRATION, by age ( $x$ ) and sex ( $s$ ), for each year ( $z$ ) of the 75-year projection period are summarized below:

$$NEW_{x,s}^z = NEW_{x,s}^z (\cdot) \quad (1.3.1)$$

$$AOS_{x,s}^z = AOS_{x,s}^z (\cdot) \quad (1.3.2)$$

$$L_{x,s}^z = NEW_{x,s}^z + AOS_{x,s}^z \quad (1.3.3)$$

$$E_{x,s}^z = E_{x,s}^z (\cdot) \quad (1.3.4)$$

$$NL_{x,s}^z = L_{x,s}^z - E_{x,s}^z \quad (1.3.5)$$

where  $NL_{x,s}^z$  are the number of net LPR immigrants by age ( $x$ ) and sex ( $s$ ) for year  $z$ .

### 1.3.b. Input Data

#### *Trustees Assumptions -*

1. Each year the Board of Trustees of the OASDI Trust Funds specifies the total annual assumed values for LPR immigration and legal emigration. For the 2018 Trustees Report, the ultimate values for LPR immigration and legal emigration are 1,050,000 and

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<sup>13</sup> The federal fiscal year begins on October 1 of the previous calendar year and ends on September 30 of the specified calendar year.

262,500, respectively (both reached in 2019).

*Department of Homeland Security –*

2. Historical LPR immigration by fiscal year (1941-1973), 5-year age group (0-4, 5-9, ..., and 80-84), and sex. These data will not be updated.
3. Legalizations due to Immigration Reform and Control Act of 1986 (IRCA) by type (pre-1982s and SAWs), single year of age (0-99 and unknown age), sex (including unknown) and month for the years 1989-2011. These data will not be updated.
4. Historical LPR immigration by fiscal year (1973-2016), single year of age (0 through 99, and unknown age), sex (including unknown), and class of admission (New Arrival, Adjustment of Status, Refugee, and Asylee). These data are updated annually, with the DHS providing an additional year of data each year.
5. Total adjustments of status for the years 1966 to 1972 (OCACT further estimates total adjustments of status for 1963-1965). These data will not be updated.

*U.S. Census Bureau –*

6. Unpublished estimates of annual legal emigration by five-year age groups (0-4, 5-9, ..., and 80-84) and sex for 1990 based on the change between the 1980 and 1990 censuses. These data are updated occasionally (based on having new data from an outside source and on OCACT resource time constraints).

*Other input data -*

7. Legal emigration conversion factors. These estimates were developed internally by five-year age groups (0-4, 5-9, ..., and 80-84) and sex to reflect the fact that the estimated number of people leaving the United States is not equivalent to the number of people leaving the Social Security area. These data are updated when annual legal emigration estimates are updated (see above).

**1.3.c. *Development of Output***

*Equations 1.3.1 and 1.3.2 – LPR Immigration*

The Trustees specify the aggregate number of LPR immigrants for each year of the 75-year projection period. In order to incorporate the numbers of new immigrants into the Social Security area population projections, the total level of new immigrants is disaggregated by age and sex.

There are two ways for an immigrant to be admitted into the U.S. for lawful permanent residence:

- (1) New arrivals, such as persons living abroad who are granted an LPR visa and then enter the U.S. through a port of entry. Refugees and asylees that are granted LPR status are also treated as new arrivals in the OCACT model.
- (2) Adjustments of status, who are people already residing in the U.S. as other-than-LPR immigrants and have an application for adjustment to LPR status approved by the DHS.

The DHS provides data on LPR immigrants by sex, single year of age, classification of admission, and fiscal year of entry. The 10 most recent years of data are used to calculate separate age-sex distributions for both new arrivals and adjustments of status by taking the following steps:

1. Refugee and Asylee LPR admissions are subtracted from the DHS adjustment of status data and added into the new arrival category.
2. The data are converted from fiscal year data to calendar year data.
3. For each class of admission (new arrivals and adjustments of status), the historical data for the last 10 years (from 2007-2016) are combined to create an average age-sex distribution.

$NEW_{x,s}^z$ , the expected number of new arrival LPR immigrants by age (x) and sex (s) for each year (z), is calculated by applying the age-sex distribution for new arrivals to the Trustees' assumed level of new arrivals. The Trustees' assumed number of adjustments of status is multiplied by the age-sex distribution of adjustments of status to calculate  $AOS_{x,s}^z$ .

#### *Equation 1.3.4 – Legal Emigration*

The Trustees specify the aggregate amount of legal emigration for each year of the projection period. This is done by assuming a ratio of legal emigration to LPR immigration. For the 2018 Trustees Report, the ratio is assumed to be 25 percent.

In order to produce the number of emigrants from the Social Security area population, the total level of emigrants is disaggregated by age and sex. The disaggregation is based on a distribution of emigrants, by sex and five-year age groups, provided to OCACT in unpublished estimates by Census that are based on changes between the 1980 and 1990 censuses. Since the emigration numbers estimated by Census are for all people leaving the United States, they are adjusted downward by a series of conversion factors so the data correspond to the number of people leaving the Social Security area population.

For each sex (s), the Beers formula is used to interpolate and distribute each five-year age group into a single year of age (x) distribution,  $EDIST_{x,s}$ . For each projection year, this distribution is used to distribute the assumed level of total legal emigrants by age and sex using the following equation:

$$E_{x,s}^z = .25 \left( \sum_{s=m}^f \sum_{x=0}^{100} L_{x,s}^z \right) * EDIST_{x,s}$$





## 1.4. HISTORICAL POPULATION

### 1.4.a. Overview

The HISTORICAL subprocess provides estimates of the Social Security area population for each year in the period December 31, 1940, through December 31, 2015. The Social Security area population consists of:

- U.S. resident population and armed forces overseas *plus*
- Net census undercount *plus*
- Civilian residents of Puerto Rico, the Virgin Islands, Guam, the Northern Mariana Islands, and American Samoa *plus*
- Federal civilian employees overseas *plus*
- Dependents of armed forces and federal civilian employees overseas *plus*
- Residual beneficiaries living abroad *plus*
- Other citizens overseas

The U.S. Census Bureau collects population data by age, sex, and marital status (and by other characteristics) every ten years for the decennial census. Generally, each subsequent year, the Census Bureau publishes a “post-censal” population estimate. This subprocess combines these census and post-censal estimates, along with the estimates of the other components of the Social Security area population listed above, and components of change described in sections 1.1 to 1.3, to develop historical estimates of the total Social Security area population ( $P_{x,s}^z$ ) and other-than-LPR population ( $O_{x,s}^z$ ). Combining the total populations by single year of age and sex with an estimated marital status matrix provides the total Social Security area historical population by single year of age, sex, and marital status ( $P_{x,s,m}^z$ ). These estimates are then used as the basis for the PROJECTED POPULATION subprocess described in section 1.8. The primary equations for this subprocess are given below:

$$P_{x,s}^z = P_{x,s}^z(\cdot) \quad (1.4.1)$$

$$P_{x,s,m}^z = P_{x,s,m}^z(\cdot) \quad (1.4.2)$$

$$O_{x,s}^z = O_{x,s}^z(\cdot) \quad (1.4.3)$$

### **1.4.b. Input Data**

#### *Long-Range OASDI Projection Data -*

##### Demography

1. Probabilities of death from the MORTALITY subprocess, by age last birthday and sex, for years 1941-2016. These data are updated every year.
2. The number of new LPR immigrants by age and sex for years 1941-2015. These data are from the LPR IMMIGRATION subprocess and are updated each year.
3. The number of legal emigrants by age and sex for years 1941-2015. These data are from the LPR IMMIGRATION subprocess and are updated each year.
4. The number of adjustments of status by age and sex for years 1941-2015. These data are from the LPR IMMIGRATION subprocess and are updated each year.
5. The number of other-than-LPR immigrants legalized under the Immigration Reform and Control Act of 1986 (IRCA) from the LPR IMMIGRATION subprocess. These data are reproduced each year and updated if new data is available.
6. Birth rates by single year of age of mother (14-49) for the years 1941-2016 from the FERTILITY subprocess. These data are updated each year.

#### *U.S. Census Bureau Data -*

7. Estimates of U.S resident population and Armed Forces overseas population as of each July 1 (1940-1979) by sex and single-year of age through 84, and for the group aged 85 and older. These data are generally not updated.
8. Estimates of the U.S. resident population for each decennial census (April 1) 1970 – 2010 by sex and single year of age 0 through 85+. New decennial census estimates come out about every ten years.
9. Estimates of total U.S. resident population and total U.S. resident population plus Armed Forces overseas population for each January of each decennial census year from 1990 and 2010. New decennial census estimates come out about every ten years.
10. Estimates of U.S resident population, and U.S. resident plus Armed Forces overseas population as of each July 1 (1980-2016) by sex and single year of age 0 through 99, and ages 100 and older. Generally, the U.S. Census Bureau restates the data back to the most recent decennial census and includes one additional year of data.
11. Estimates of U.S resident population, and U.S. resident population plus Armed Forces overseas population as of each January 1 (1981-2016) by sex and single-year of age 0

through 99, and ages 100 and older. Generally, the U.S. Census Bureau restates the data back to the most recent decennial census (April) and includes one additional year of data.

12. Estimates of the population by marital status, sex, and age from the American Community Survey (ACS) public use microdata sample (PUMS) files for years 2000 – 2016. In general, an additional year of data is available each year.
13. Undercount factors by single year of age (0-85+) and sex, estimated using post-censal survey data. These data are updated after each decennial census.
14. The total annual population estimates for Puerto Rico, Virgin Islands, Guam, Northern Mariana Islands, and American Samoa for years 1951-2016. For each Trustees Report, an additional data year is downloaded from the U.S. Census Bureau's international database. Historical data back to 1951 is also obtained if any changes have occurred.
15. Decennial census population estimates, by varying degree of age detail and sex, for decennial censuses from 1950 – 2000 for territories and components outside the 50 states, D.C., and armed forces overseas. Most data are aggregated into 18 age groups for each sex, though single year of age data is available for young ages in the territories for 1960 and 1970 and for all ages starting in 1980. New estimates are added as they become available.
16. July populations of the territories by single year of age and sex from 2000 – 2016. An additional year of data is available each year.
17. From the ACS PUMS, number of existing marriages from 2000 – 2016 by age of husband crossed with age of wife. In addition, starting with the 2012 ACS, number of existing marriages by age of each spouse is available for same-sex couples. Final grids for same-sex couples are adjusted based on reported same-sex marriages from the states. Generally, an additional year of data is available each year.
18. From ACS PUMS, flows of foreign-born ins and Cuban ins by single year of age, sex, and year of entry used to produce total other-than-LPR estimates for January 1, 2013 – 2016.
19. From decennial census PUMS (via the University of Minnesota's IPUMS website), number of existing marriages for decennial census years 1940 – 2000 by age group of husband crossed with age group of wife. New estimates are added as they become available.
20. From decennial census PUMS (via the University of Minnesota's IPUMS website), estimates of the population by marital status, age, and sex for decennial census years 1940 – 2000. New estimates are added as they become available.
21. Estimates of net immigration by age and sex of the U.S. resident population plus armed forces overseas (USAF) population from April 1, 2000, through July 1, 2016. An

additional year of data is available each year.

22. Total Americans overseas estimate based on international data sources and estimates of federal employees and military in Iraq and Afghanistan. The data from the various international sources are derived from different years but center around the year 2003. Additional data will be updated as they become available.

*Other input data -*

23. From the Department of State, old historical total estimates of outside area populations (federal employees overseas, overseas dependents of federal employees and military, and other Americans overseas) for various years between 1951 and 1990.
24. The SSA Annual Statistical Supplement provides estimates of the total number of OASDI beneficiaries living abroad as of December 31, for most years 1953 – 2015. Age group data is also available. For each Trustees Report, an additional year of data is available. Age group data is updated for each decennial census year.
25. From the National Center for Health Statistics (NCHS), the sex ratio (number of males born per female) for years 1941 – 2015. Each year, NCHS provides another year of data. For 2016, the sex ratio is assumed to be 1.048, the same as the assumed projected sex ratio.
26. From the NCHS, National Survey of Family Growth (NSFG) public-use data that help split up the population eligible for same-sex marriage into marital statuses starting in 2013. These survey data are from 2011-2015. This data is updated as they become available.
27. From the Department of Homeland Security (DHS), the number of unauthorized immigrants and nonimmigrants from January 1, 2005 – 2012. In addition, other estimates from the Unauthorized Immigrant Population Reports are used to estimate January 1, 2013, through January 1, 2016, unauthorized immigrants and nonimmigrants including an adjustment for shift in reference date, undercount of nonimmigrants, legally resident immigrants, foreign-born flows from 1980 and later of LPR immigrants, mortality, and emigration.
28. From the Office of Personnel Management (OPM), total estimates of the number of federal employees overseas from July 1, 1998 – 2013. These estimates are updated as they become available on the OPM website.
29. From the OPM, the number of federal employees overseas by single year of age and sex from a subset of the OPM data source above. Years 1980 – 2016 are available. These estimates are updated as they become available.
30. From the Department of Defense, total numbers of armed forces in Puerto Rico, the Virgin Islands, Guam, and American Samoa each decennial census year starting in 1990.

These data are updated as they become available.

31. Using 2015 TR death rates and historical populations, an assumed December 31, 1940, 85+ distribution. These data are not updated.
32. Assumed January total populations added to the Social Security for years 1951, 1957, and 1961 when new territories were added to the Social Security area. These data are not updated.

### **1.4.c. Development of Output**

#### *Equation 1.4.1 – Historical Population by age and sex ( $P_{x,s}^z$ )*

The Census Bureau's estimate of the residents of the 50 States, D.C., and U.S. Armed Forces overseas is used as a basis for calculating  $P_{x,s}^z$ . The base estimate is adjusted for net census undercount and increased for other U.S. citizens living abroad (including residents of US territories) and for non-citizens living abroad who are insured for Social Security benefits.

The estimates of the number of residents of the fifty States and D.C. and Armed Forces overseas, as of July 1 of each year, by sex for single years of age through 84, and for the group aged 85 or older, are obtained from the Census Bureau. January 1 and April 1 estimates by sex for single years of age through 84, and for the group aged 85 or older for selected years starting in 1990 and 1970, respectively, are also obtained from the Census Bureau. Adjustments for net census undercount are estimated using post-censal survey data from the Census Bureau. Population counts over age 65 after the last Census year are modified to be consistent with OCACT mortality and Census USAF net immigration data. The numbers of persons in the other components of the Social Security area as of July 1 are estimated by sex for single years of age through 84, and for the group aged 85 or older, from data of varying detail. Numbers of people residing in Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Northern Mariana Islands are estimated from data obtained from the Census Bureau. Numbers of Federal civilian employees overseas are based on estimates from the Office of Personnel Management (OPM). Dependents of Federal civilian employees and Armed Forces overseas are based on the stock of Federal civilian employees from OPM and the stock of armed forces overseas from the Census Bureau. Other citizens overseas covered by Social Security are also based on estimates compiled by the Census Bureau. The overlap among the components, believed to be small, is ignored.

The first step of the process is to estimate  $P_{x,s}^z$  as of January 1<sup>st</sup> for certain “tab years” (1941, 1951, 1957, 1961, each decennial Census year [1970 through 2010], and the last year of historical data [2016 for the 2018 Trustees Report]). For ages 0-84,  $P_{x,s}^z$  for each tab year, is set equal to an undercount adjustment plus other component populations plus:

- The averaged surrounding July 1 U.S. population and armed forces overseas counts

- from the Census Bureau prior to 1970
- Modified April 1 U.S. populations from the Census Bureau for decennial census years from 1970 through 2000.
- The January 1 U.S. population and armed forces overseas counts from the Census Bureau modified by OCACT mortality rates and Census USAF net immigration for ages over 65 for 2010 and 2016.

For ages 85 and over,  $P_{x,s}^z$  for each tab year is set equal to [Built Up Pops Age x, Sex s] \* [Total 85+ for Sex s]/[Total Built Up 85+ for Sex s], where the built up estimates are created by taking into account deaths and immigration data from the previous tab year and [Total 85+ for Sex s] is the sum of the calculated U.S. population and armed forces overseas calculated using the same method listed above for each year for ages 0-84.

For years between the tab years, populations are estimated taking into account the components of changes due to births, deaths, legal emigration, adjustments of status, and net LPR immigration (or total net immigration, if known) during that time period. These estimates are then multiplied by the appropriate age-sex-specific ratios so that the error of closure at the tab years is eliminated.

*Equation 1.4.2 – Historical Population by age, sex, and marital status ( $P_{x,s,m}^z$ )*

Since eligibility for auxiliary benefits is dependent on marital status, the Social Security area population is disaggregated by marital status. The four marital states are defined as single (having never been married), married, widowed, and divorced.

The distribution of the number of existing marriages are available for decennial census years 1940 – 2000 from Census public use microdata sample (PUMS) files. These data are aggregated by age group of husband crossed with age group of wife. Additional tabulations from the American Community Survey from 2000 – 2016 are incorporated to adjust these marital prevalence grids for changes since 2000. The grids are transformed from age grouped numbers to single year of age figures from ages 14 to 100+ for husband and wife using the two dimensional H.S. Beers method of interpolation.

Percentages of single, married, widowed, and divorced persons are calculated by using the H.S. Beers method of interpolation on compiled data by age group and sex based on Census and/or ACS PUMS. Data is converted to a December basis for each year by taking a weighted average of surrounding Census and/or ACS data. Note that the ACS is not used until 2006, the first year grouped quarters were included. These percentages are multiplied by the total populations calculated in Equation 1.4.1 for each age, sex, and year to get a preliminary population for each age, sex, and marital status.

To keep the marriage prevalence grids and the marital status percentages smooth and consistent, several algorithms are used. First, the married population is adjusted so that the number of married males equals the number of married females (though, this is not forced to be ultimately true once same-sex marriages were federally recognized as described in the next paragraph). Then, the number of married persons for each age and sex is set equal to the marginal total of the

associated year's marital prevalence grid. Finally, the other marital statuses population totals are adjusted to keep the total number of people in all marital statuses the same as calculated before splitting into marital statuses.

The population is modeled to include the following population statuses for December 31, 2013, and later: heterosexual, gay, and lesbian. Gay and lesbian populations are broken out assuming 3.0% of the male population is gay and 4.0% of the female population is lesbian (note that this means we assume 3% of males and 4% of females are in an existing same-sex marriage, or would same-sex marry, versus opposite-sex marry). Marriage grids of age of older spouse crossed with age of younger spouse for same-sex couples are needed starting December 31, 2013. The grids and populations were produced using data from the American Community Survey, National Survey of Family Growth, and state-level same-sex marriage data.

*Equation 1.4.3 – Historical Other-Than-LPR Population by age and sex ( $O_{x,s}^z$ )*

This subprocess also estimates historical levels of other-than-LPR in the population, by age and sex. For each year, an initial net residual estimate by single year of age and sex is backed out from estimates of beginning and end of year populations, births, deaths, LPR immigrants, adjustments of status, and legal emigrants. This net residual equals the implied initial other in minus other out. These residuals are then modified to ensure reasonableness. Next, using these modified net residuals, along with adjustments of status and other-than-LPR deaths (using the same death rates as for the total population), an initial other-than-LPR stock is built. These stocks are then modified to ensure reasonableness. After 2000, one further adjustment is done to the stocks. From January 2001 through January 2004, the total other-than-LPR populations are set equal to the values that linearly grade from the final OCACT January 2000 total other-than-LPR population to a DHS-based January 2005 total other-than-LPR population. From January 2005 through January 2012, the total other-than-LPR population is forced to match DHS-based total other-than-LPR population estimates. For January 2013 – January 2016, the total other-than-LPR populations are based on the DHS method but no DHS publication is available.



## 1.5. OTHER-THAN-LPR IMMIGRATION

### 1.5.a. Overview

The term “other-than-LPR immigration” refers to persons entering the U.S. in a manner other than being lawfully admitted for permanent residence and who reside in the U.S. for at least 6 months. This includes temporary immigrants (persons lawfully admitted for a limited period of time, such as temporary workers and foreign students), also called nonimmigrants, in addition to undocumented immigrants living in the U.S. These undocumented immigrants can be split into those that were never authorized to enter the U.S. and those that were nonimmigrants but overstayed their visas (visa-overstayers). The term “other-than-LPR emigration” refers to those in the other-than-LPR immigrant population who leave the Social Security area.

For each year  $z$  of the projection period, the OTHER-THAN-LPR IMMIGRATION subprocess produces estimates of other-than-LPR immigration ( $OI_{x,s,t}^z$ ), by age ( $x$ ), sex, and type ( $t$ ) based on assumptions set by the Trustees. Estimates of projected other-than-LPR emigration ( $OE_{x,s,t}^z$ ), by age, sex, and type are also developed in this subprocess.

The Department of Homeland Security (DHS) estimated the stock of nonimmigrants by age group and sex for April 2008 and for the end of 2010. The HISTORICAL POPULATION subprocess already produces historical estimates of other-than-LPR immigrants. These historical data are used to develop recent estimates of the other-than-LPR stock by age, sex, and type, where type is never-authorizeds, nonimmigrants, and visa-overstayers.

The primary equations of OTHER-THAN-LPR IMMIGRATION, by age ( $x$ ), sex ( $s$ ), and type ( $t$ ) for each year ( $z$ ) of the 75-year projection period are summarized below:

$$OI_{x,s,t}^z = OI_{x,s,t}^z (\cdot) \quad (1.5.1)$$

$$OE_{x,s,t}^z = OE_{x,s,t}^z (\cdot) \quad (1.5.2)$$

$$NO_{x,s,t}^z = OI_{x,s,t}^z - OE_{x,s,t}^z - AOS_{x,s,t}^z \quad (1.5.3)$$

where  $NO_{x,s,t}^z$  are the number of net other-than-LPR immigrants, by age ( $x$ ), sex ( $s$ ), and type ( $t$ ) for year  $z$ , and  $AOS_{x,s,t}^z$  are the number of adjustments to LPR status from the LPR IMMIGRATION subprocess, by age ( $x$ ), sex ( $s$ ), and type ( $t$ ) for year  $z$ ;

$$OP_{x,s,t}^z = OP_{x-1,s,t}^{z-1} + OI_{x-1,s,t}^z - OE_{x-1,s,t}^z - AOS_{x-1,s,t}^z - OD_{x-1,s,t}^z \quad (1.5.4)$$

where,  $OP_{x,s,t}^z$  is equal to the other-than-LPR immigrant population, by age ( $x$ ), sex ( $s$ ), and type ( $t$ ) as of December 31<sup>st</sup> of each year ( $z$ ),  $OD_{x,s,t}^z$  are the number of deaths in the other-than-LPR immigrant population by age ( $x$ ), sex ( $s$ ), and type ( $t$ ) for each year ( $z$ ), and  $AOS_{x,s,t}^z$  are the number of adjustments to LPR status by age ( $x$ ), sex ( $s$ ), and type ( $t$ ) for each year ( $z$ ).

### **1.5.b. *Input Data***

#### *Trustees Assumptions -*

1. Each year the Board of Trustees of the OASDI Trust Funds specifies the assumed total annual values for other-than-LPR immigration. The ultimate annual level was set at 1,350,000 persons per year for each year beginning in 2022. The level of other-than-LPR immigration is estimated at 1,450,000 in 2016. The Trustees assume other-than-LPR immigration will increase to 1,550,000 in 2018 and 2019, followed by a gradual decrease, reaching the ultimate value in 2022.

#### *Long-Range OASDI Projection Data -*

##### Demography

2. Historical and projected probabilities of death by age last birthday (including a neonatal mortality factor, single year of age for ages 0-99, and age group 100+) and sex, for years 1941-2100. These data are updated each year from the MORTALITY program.
3. Historical net other-than-LPR immigration by single year of age (-1-99+)<sup>14</sup> and sex for years 1961-2015. These data are updated each year from the HISTORICAL program.
4. Historical December 31 other-than-LPR immigrants by single year of age (0-100+) and sex for years 1963-2015. These data are updated each year from the HISTORICAL program.
5. Historical July 1 other-than-LPR immigrants by single year of age (0-100+) and sex for years 1964-2015. These data are updated each year from the HISTORICAL program.
6. Historical new arrivals by single year of age (-1-100+) and sex for years 1941-2015. These data are updated each year from the LPR IMMIGRATION program.
7. Historical and projected adjustments of status by single year of age (-1-100+) and sex for years 1941-2100. These data are updated each year from the LPR IMMIGRATION program.

#### *Department of Homeland Security –*

8. Components of the unauthorized immigrant population by year for 2005-2012. These data are updated as new data become available.
9. Nonimmigrant stock in April 2008 and December 2010 by age-group and sex. These data are updated as new data become available and internal resources are sufficient to

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<sup>14</sup> Age -1 represents births that occur during the year.

examine and interpret such new data.

10. Nonimmigrant admissions by class of admission for various fiscal years 1981 – 2014. These data are updated as new data become available and internal resources are sufficient to examine and interpret such new data.
11. Total nonimmigrants as of January 1, 2005 – 2012, from the Unauthorized Immigrant Population Reports. Total nonimmigrants as of January 1, 2013 – 2016, estimated based on the Nonimmigrant Population Reports. These data are updated as new data become available.

*U.S. Census Bureau –*

12. From the American Community Survey (ACS), foreign-born new persons by ACS year (2000-2016), entry year (1900-2016), age (0-100) and sex. These data are updated as new data become available.
13. From the ACS, total foreign-born population and total population for 2000 – 2016, and total population in Puerto Rico for 2005 – 2016, used to calculate undercount factors (Note that the population referred to in each case is the beginning-of-year population). These data are updated as new data become available.
14. From the 2012 ACS, persons, by entry year (1900-2012), age (0-100) and sex, that are:
  - Foreign-born citizens
  - Foreign-born non-citizens that are in school or are high-school graduates
  - Non-citizen parents of citizen children
  - Non-citizen parents of citizen children that are in school or are high school graduatesThese data are not updated.
15. From the 2012 ACS, persons, by entry year (1900-2012), age (0-100) and sex, that are eligible for temporary protected status (TPS) based on originating from various countries by certain dates and are:
  - Foreign-born citizens
  - Foreign-born non-citizens that are in school or are high-school graduates
  - Non-citizen parents of citizen children
  - Non-citizen parents of citizen children that are in school or are high school graduatesThese data are not updated.

*Other input data -*

16. The number of those potentially eligible under the 2012 Deferred Action for Childhood Arrivals (DACAs) initiative by age group and an overall gender split, from the Migration Policy Institute. These data are updated as new data become available and internal resources are sufficient to examine and interpret such new data.
17. Internally developed numbers of those that were potentially eligible under the 2014

DACA initiative that were not eligible under the 2012 DACA initiative by age and sex. These data will not be updated.

18. Internally developed numbers of those that were potentially eligible under the Deferred Action for Parents of Americans and LPRs (DAPA) initiative, by age and sex. These data will not be updated.
19. Internally developed factors of potential DACA stock attaining DACA status by sex and ages 5-100 for the initial and ultimate DACA years. These data are updated as new data become available and internal resources are sufficient to examine and interpret such new data.
20. Internally developed factors to apply to other-than-LPR immigrants that enter as nonimmigrants. These data will not be updated.
21. Internally developed factors used to split the total number of adjustments of status into a single year of age distribution. These data will not be updated.
22. Internally developed overstay percentages by age. These data are based off a RAND Corporation document using data from the 1980s, and are adjusted based on insights from the DHS. These data are updated as new data become available and internal resources are sufficient to examine and interpret such new data.
23. Internally developed rates of departure for the non-DACA/DAPA potential/actual never-authorizeds for non-recent arrivals. These data are updated as new data become available and internal resources are sufficient to examine and interpret such new data.
24. Internally developed rates of departure for the non-DACA/DAPA potential/actual non-immigrants for non-recent arrivals. These data are set to initial rates in 2015 (when the Executive Actions went into effect including decreased deportation of non-felons) and then gradually increase to the ultimate rates in 2025. These data are updated as new data become available and internal resources are sufficient to examine and interpret such new data.
25. Internally developed rates of departure for the non-DACA/DAPA potential/actual visa overstayers. These data are updated as new data become available and internal resources are sufficient to examine and interpret such new data.
26. Internally developed rates of departure for non-DACA potential/actual never authorizeds for non-recent arrivals to use prior to 2015 (when the Executive Actions went into effect including decreased deportation of non-felons). These data are updated as new data become available and internal resources are sufficient to examine and interpret such new data.
27. Internally developed rates of departure for non-DACA potential/actual nonimmigrants for non-recent arrivals to use prior to 2015 (when the Executive Actions went into effect

including decreased deportation of non-felons). These data are updated as new data become available and internal resources are sufficient to examine and interpret such new data.

28. Internally developed rates of departure for the non-DACA potential/actual visa overstayers to use prior to 2015 (when the Executive Actions went into effect including decreased deportation of non-felons). These data are updated as new data become available and internal resources are sufficient to examine and interpret such new data.
29. Internally developed number of other-than-LPR immigrants, by age and sex, for years 1999-2010. These data will not be updated.

### 1.5.c. *Development of Output*

The ACS provides data to help derive the number of foreign-born new arrivals, which is then used to separate the historical net other-than-LPR immigration into those entering and those leaving. There are several other key inputs that go into this calculation, including an estimated undercount factor. This factor accounts for (1) differences between the foreign-born data from the ACS and the component pieces obtained from DHS, (2) differences between the ACS (Public Use Microdata Sample) and Census' total population, and (3) the foreign-born residing in Puerto Rico. The estimated other-than-LPR immigration is calculated by taking the foreign born from the ACS (after smoothing and applying the undercount factors) and subtracting the LPR new arrivals. The estimated historical other-than-LPR emigration is then calculated as the difference between the net other-than-LPR immigration (calculated in the HISTORICAL subprocess) and the estimated historical other-than-LPR immigration. A series of steps are then taken to smooth the two categories. Based on various assumptions, the historical other-than-LPR immigrants are split into those who arrive or depart the Social Security area as a never-authorized immigrant, nonimmigrant, and visa-overstayer immigrant.

#### *Equation 1.5.1 – Other-Than-LPR Immigration*

For each projection year, an age-sex-type distribution is used to distribute the aggregate number of other-than-LPR immigrants by age, sex, and type. This age-sex-type distribution is denoted as  $ODIST_{x,s,t}$  and is developed by using average historical estimates of other-than-LPR immigrants entering the country from 2000 through 2007.

The assumed total level of other-than-LPR immigration is denoted by  $TO^z$ . Thus, for each year (z) other-than-LPR immigration is defined by the following equation:

$$OI_{x,s,t}^z = TO^z * ODIST_{x,s,t}$$

#### *Equation 1.5.2 – Other-Than-LPR Emigration*

$OE_{x,s,t}^z$  denotes the annual number of other-than-LPR immigrants who depart the Social Security area by age (x), sex (s), and type (t). These estimates are based on 2014 TR build-up of stocks from 2008 through 2010 including other-than-LPR immigration discussed above, deaths,

adjustments of status (from the LPR IMMIGRATION subprocess), and assumptions about the number of departures from each type. Deaths for the other-than-LPR immigrant population use the same death probabilities as the total population:

$$OD_{x,s,t}^z = q_{x,s}^z * OP_{x,s,t}^z$$

Then, for this 2008 – 2010 period, rates are calculated by dividing  $OE_{x,s,t}^z$  by  $OP_{x,s,t}^z$  for each age, sex, and type. After smoothing and adjusting for the effects of the recent recession, these rates are used to calculate  $OE_{x,s,t}^z$  in projected years by being applied to the other-than-LPR stock populations  $OP_{x,s,t}^{z-1}$  for the overstayer and nonimmigrant stocks. For the never authorized stock, these rates are further adjusted and split into two categories so that recent arrivals are exposed to twice the rates as the residual never authorized stock. For the potential DACA population, and for those that are already in the DACA population, the exit rates are lower than for those not eligible for DACA.

This subprocess also splits historical other-than-LPR immigrants into the various categories. It is assumed that all other-than-LPR immigrants were nonimmigrants as of December 31, 1963. Between December 31, 1963, and December 31, 2010, the percentage of total other-than-LPR immigrants by age and sex in each type is linearly interpolated from the percentages at those two points in time. A final adjustment ensures the total nonimmigrants are appropriate, based on DHS nonimmigrant admissions or, if available, stock estimates.

Finally, this subprocess also projects the Deferred Action for Childhood Arrivals (DACA) population, a subset of the other-than-LPR immigrant population, by age (x) and sex (s). The DACA population consists of other-than-LPR immigrants who meet specific criteria and are granted authorization to work. The eligible DACA population is estimated separately by those that meet the age, residency, and educational requirements. Rates are applied to the eligible population to estimate the net number of individuals who actually apply and obtain DACA status.

Note that the DAPA and the 2014 DACA are no longer being applied to this subprocess. Furthermore, it is assumed that there will be no new 2012 DACA's after 2017, and that all existing 2012 DACA's will be phased out by March 2020. These assumptions may change according to future laws, executive actions, and/or court rulings that may affect the DACA program.

## 1.6. MARRIAGE

### 1.6.a Overview

The National Center for Health Statistics (NCHS) collected detailed data on the annual number of new marriages in the Marriage Registration Area (MRA), by age of husband crossed with age of wife, for the period 1978 through 1988 (excluding 1980). In 1988, the MRA consisted of 42 States and D.C. and accounted for 80 percent of all marriages in the U.S. Estimates of the unmarried population in the MRA, by single year of age (or age group if single year of age was not available) and sex, were obtained from the NCHS. Marriage rates for this period are calculated from these data. The age-of-husband crossed with age-of-wife marriage grid rates are transformed from age grouped numbers to single year of age figures from ages 14 to 100+ for husband and wife using the two dimensional H.S. Beers method of interpolation.

Beginning in 1989, the NCHS no longer collected data on the annual number of new marriages in the MRA. However, for years 1989-1995, they supplied less detailed data on new marriages from a subset of the MRA. Beginning in 2008, the American Community Survey (ACS) started asking if a person was married in the last 12 months. Using this question, along with ages of spouses, grids of new marriages by age-group-of-husband crossed with age-group-of-wife were developed for years 2007 and later. For the years between 1995 and 2007, the marriage grids were linearly interpolated.

Age-specific marriage rates ( $\hat{m}_{x,y}^z$ ) for a given year ( $z$ ) are defined as the ratio of (1) the number of marriages for a given age-of-husband ( $x$ ) crossed with age-of-wife ( $y$ ) to (2) a theoretical midyear unmarried population at those ages ( $P_{x,y}^z$ ). The theoretical midyear population is defined as the geometric mean<sup>15</sup> of the midyear unmarried males and unmarried females.

An age-adjusted central marriage rate ( $\hat{AMR}^z$ ) summarizes the  $\hat{m}_{x,y}^z$  for a given year. The standard population chosen for age adjusting is the unmarried males and unmarried females in the Social Security area population as of July 1, 2010. The first step in calculating the total age-adjusted central marriage rate for a particular year is to determine an expected number of marriages by applying the age-of-husband-age-of-wife specific central marriage rates for that year to the geometric mean of the corresponding age groups in the standard population.

The  $\hat{AMR}^z$  is then obtained by dividing:

- The expected number of marriages by
- The geometric mean of (1) the number of unmarried males, ages 15 and older, and (2) the unmarried females, ages 15 and older, in the standard population.

The MARRIAGE subprocess projects annual  $\hat{m}_{x,y}^z$  by age-of-husband crossed with age-of-wife. The equations for this subprocess are given below:

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<sup>15</sup> The geometric mean, as used in this document, is the square root of the product of two numbers.

$$\hat{m}_{x,y}^z = \hat{m}_{x,y}^z(\cdot) \quad (1.6.1)$$

$$\hat{AMR}^z = \frac{\sum_{x,y} P_{x,y}^S * \hat{m}_{x,y}^z}{\sum_{x,y} P_{x,y}^S} \quad (1.6.2)$$

where  $x$  and  $y$  refer to the age of males and females, respectively, and  $P_{x,y}^S$  is the theoretical unmarried population in the Social Security area population as of July 1, 2010 (the geometric mean of the corresponding age groups in the standard population).

### 1.6.b. Input Data

#### Long-Range OASDI Projection Data -

##### Demography

1. Estimates of the Social Security area population as of December 31, by age, sex, and marital status for years 1978-2015, excluding 1980. These data are updated each year based on output of the HISTORICAL POPULATION subprocess.

##### *Assumptions -*

2. For each Trustees Report, ultimate values for the  $\hat{AMR}^z$  are assumed. The  $\hat{AMR}^z$  reaches its ultimate value in the 25th year of the 75-year projection period. For the 2018 report, the ultimate  $\hat{AMR}^z$  assumption is 4,000 per 100,000 unmarried couples.

##### *NCHS Data -*

3. Number of new marriages in the MRA, by age-of-husband crossed with age-of-wife, for calendar years 1978 through 1988, excluding 1980. These data are not available for years after 1988. The data vary in detail by year. They are broken out by single year age-of-husband crossed with single year age-of-wife for many ages (particularly younger ages).
4. Number of unmarried males and females in the MRA for calendar years 1978 through 1988, excluding 1980. These data are not available for years after 1988. The data are generally broken out by single year age for ages under 40 and by age groups 40-44, 45-49, 50-54, 55-59, 60-64, 65-74, and 75+.
5. Number of new marriages, in a subset of the MRA, by age-group-of-husband crossed with age-group-of-wife (age groups include 15-19, 20-24, 25-29, 30-34, 35-44, 45-54, 55-64, and 65+), for calendar years 1989-1995. These data are updated as new data become available and internal resources are sufficient to examine and interpret such new data.



6. The total number of new marriages in the MRA less marriages in those states not included in the MRA unmarried population for the period 1957-1988. These data are not updated.
7. The total number of new marriages in the United States for the period 1989-2014. Normally, each year, the NCHS publishes the total number of marriages for one more year.
8. Number of new marriages in the MRA for years 1979 and 1981-1988 by age group (age groups include 14-19, 20-24, 25-29, 30-34, 35-44, 45-54, 55-64, and 65+), sex, and prior marital status (single, widowed, and divorced). These data are not available for years after 1988.
9. Number of unmarried people in the MRA for years 1979 and 1981-1988 by age group (age groups include 14-19, 20-24, 25-29, 30-34, 35-44, 45-54, 55-64, and 65+), sex, and prior marital status (single, widowed, and divorced). These data are not available for years after 1988.

*U.S. Census Bureau Data -*

10. Estimates of new marriages by age-group-of-husband crossed with age-group-of-wife from the American Community Survey (ACS) public use microdata sample (PUMS) files occurring, on average, at the end of years 2007 – 2015. An additional year of data is available each year. However, only years through the last available NCHS data are used.

*Other Input Data -*

11. From the vital statistics offices in various states, number of same-sex marriages from 2004 – 2012. These data are updated as they become available.

**1.6.c. *Development of Output***

*Equation 1.6.1 – Age-Specific Marriage Rates*

Age-specific marriage rates are determined for a given age-of-husband crossed with age-of-wife, where ages range from 14 through 100+. The historical period includes years of complete NCHS data on the number of marriages and the unmarried population in the MRA for the period 1978 through 1988, excluding 1980. Data for a subset of the MRA, available by age group only, are used for the period 1989 through 1995, and ACS new-married grids by age group are used for the period 2008 through 2014. The marriage grids by age group for the years 1996 through 2007 are linearly interpolated. The total number of marriages from NCHS are also used in the age-specific marriage rate calculations for the period 1989 – 2014. The projection period of the MARRIAGE subprocess begins in 2015.

The historical age-specific marriage rates are calculated for each year in the historical period based on NCHS data of the number of new marriages by age-of-husband crossed with age-of-wife and the number of unmarried persons by age and sex. The formula used in the calculations is given below:

$$\hat{m}_{x,y}^z = \frac{\hat{M}_{x,y}^z}{P_{x,y}^z}, \text{ where}$$

- $x$  refers to the age of males and  $y$  refers to the age of females;
- $\hat{M}_{x,y}^z$  is the number of marriages in year  $z$ ; and
- $P_{x,y}^z$  is the geometric mean of the midyear unmarried males and unmarried females in year  $z$ .

The rates for the period 1978 through 1988<sup>16</sup> are then averaged, graduated, and loaded into an 87 by 87 matrix (age-of-husband crossed with age-of-wife for ages 14 through 100+), denoted as MarGrid. This matrix is used in the calculation of the age-specific marriage rates for all later historical years and the years in the projection period.

For the period 1989-2014, the NCHS and ACS provided data on the number of marriages by age-group-of-husband crossed with age-group-of-wife (age groups include 15-19, 20-24, 25-29, 30-34, 35-44, 45-54, 55-64, and 65+). These data are used to change the distribution of MarGrid by these age groups. For each age-group-of-husband crossed with age-group-of-wife, the more detailed marriage rates in MarGrid that are contained within this group are adjusted so that the number of marriages obtained by using the rates in MarGrid match the number implied in the subset.

For each year of the entire 1989 – 2014 period, an expected total number of marriages is calculated by multiplying the rates in the MarGrid (or the adjusted MarGrid) by the corresponding geometric mean of the unmarried males and unmarried females in the Social Security area population. All rates in MarGrid (or the adjusted MarGrid) are then proportionally adjusted to correspond to the total number of marriages estimated in the year for the Social Security area population. This estimate is obtained by increasing the number of marriages reported in the U.S. to reflect the difference between the Social Security area population and the U.S. population. In addition, we also subtract out same-sex marriages from the NCHS data, as we handle those in a later step. The age-specific rates are then graduated using the Whittaker-Henderson method and are used to calculate the age-adjusted rates for each year.

The age-adjusted marriage rates are expected to reach their ultimate value in the 25<sup>th</sup> year of the 75-year projection period. Rather than use the last year of data to calculate the starting rate, we calculate the weighted average of the rates for the past five historical data years to derive the starting value. The annual rate of change decreases in absolute value as the ultimate year approaches.

To obtain the age-of-husband-age-of-wife-specific rates for a particular year from the age-adjusted rate projected for that year, the age-of-husband-age-of-wife-specific rates in MarGrid

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<sup>16</sup> Data for 1980 is not available and is excluded from the calculations.

are proportionally scaled so as to produce the age-adjusted rate for the particular year. The MarGrid rates are then adjusted to produce two sets of marriage rates: opposite-sex marriage rates and same-sex marriage rates.

A complete projection of age-of-husband-age-of-wife-specific marriage rates was not done separately for each previous marital status. However, data indicate that the differential in marriage rates by prior marital status is significant. Thus, future relative differences in marriage rates by prior marital status are assumed to be the same as the average of those experienced during 1979 and 1981-1988.

## 1.7. DIVORCE

### 1.7.a. Overview

For the period 1979 through 1988, the National Center for Health Statistics (NCHS) collected data on the annual number of divorces in the Divorce Registration Area (DRA), by age-group-of-husband crossed with age-group-of-wife. In 1988, the DRA consisted of 31 States and accounted for about 48 percent of all divorces in the U.S. These data are then inflated to represent an estimate of the total number of divorces in the Social Security area. This estimate for the Social Security area is based on the total number of divorces in the 50 States, the District of Columbia, Puerto Rico, and the Virgin Islands. Divorce rates for this period are calculated using this adjusted data on number of divorces and estimates of the married population by age and sex in the Social Security area.

An age-of-husband ( $x$ ) crossed with age-of-wife ( $y$ ) specific divorce rate ( $\hat{d}_{x,y}^z$ ) for a given year ( $z$ ) is defined as the ratio of (1) the number of divorces in the Social Security area for the given age of husband and wife ( $\hat{D}_{x,y}^z$ ) to (2) the corresponding number of married couples in the Social Security area ( $P_{x,y}^z$ ) with the given age of husband and wife. An age-adjusted central divorce rate ( $A\hat{D}R_{x,y}^z$ ) summarizes the  $\hat{d}_{x,y}^z$  for a given year.

The  $A\hat{D}R^z$  is calculated by determining the expected number of divorces by applying:

- The age-of-husband crossed with age-of-wife specific divorce rates to
- The July 1, 2010, population of married couples in the Social Security area by corresponding age-of-husband and age-of-wife.

The DIVORCE subprocess projects annual  $\hat{d}_{x,y}^z$  by age-of-husband crossed with age-of-wife.

The primary equations are given below:

$$\hat{d}_{x,y}^z = \hat{d}_{x,y}^z (\cdot) \quad (1.7.1)$$

$$A\hat{D}R^z = \frac{\sum_{x,y} P_{x,y}^S * \hat{d}_{x,y}^z}{\sum_{x,y} P_{x,y}^S} \quad (1.7.2)$$

where  $x$  and  $y$  refer to the age of husband and age of wife, respectively, and  $P_{x,y}^S$  is the number of married couples in the Social Security area population as of July 1, 2010.

## 1.7.b. *Input Data*

### *Long-Range OASDI Projection Data -*

#### Demography

1. Social Security area population of married couples by age-of-husband crossed with age-of-wife as of December 31 for years 1978-2015. These data are updated each year from the HISTORICAL POPULATION subprocess.
2. The total July 1 population in the Social Security area for years 1979-2014. An additional year of data is added for each additional year of divorce data from the NCHS.
3. The total July 1 population in the U.S. resident population plus armed forces overseas for years 1979-2014. An additional year of data is added for each additional year of divorce data from the NCHS.
4. The total July 1 population in Puerto Rico and the Virgin Islands for years 1979-2014. An additional year of data is added for each additional year of divorce data from the NCHS. However, only years 1988, 1998, 1999, and 2000 are used.

### *Assumptions -*

5. Each year, the assumed ultimate value for the age-adjusted divorce rate is established. The rate reaches its ultimate value in the 25th year of the 75-year projection period. For the 2018 report, the assumed ultimate  $ADR^z$  is 1,700 per 100,000 married couples.

### *NCHS Data -*

6. The number of divorces in the DRA, by age-of-husband crossed with age-of-wife, for calendar years 1979 through 1988. These data are not available for years after 1988. The data are broken out by single year age-of-husband crossed with single year age-of-wife for many ages (particularly younger ages).
7. The total number of divorces in the United States for the period for 1989-2014. For years 1992+, the number of divorces are derived by multiplying the rate times the population. Data is updated when it becomes available.
8. The total number of divorces in Puerto Rico and the Virgin Islands for years 1988, 1998, 1999, and 2000. New data are incorporated as they become available and resources are sufficient to validate their use.

### *State Divorce Data -*

9. Since NCHS stopped collecting state-specific divorce data by age of husband crossed with age of wife, we directly contacted various state health departments for their most recent data. We were able to get this data from 18 states. The years and age groups available vary by state. In general, the years were from 2009 – 2012. These 18 states that had these data available online, or that sent us the data via email, are Alabama, Alaska, Idaho, Kansas, Kentucky, Michigan, Missouri, Montana, Nebraska, New Hampshire, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, and Wyoming.

*Census Bureau Data –*

10. The number of Divorces for years 2008 – 2015 in Puerto Rico, estimated using the 2008 – 2016 American Community Survey (ACS) public use microdata sample (PUMS) files. A new year of data is generally available each year. However, only years through the last available NCHS data are used.

**1.7.c. Development of Output**

*Equation 1.7.1 -*

Age-specific divorce rates are calculated for ages 14 through 100+. Detailed NCHS data on the number of divorces by age-group-of-husband crossed with age-group-of-wife are available for the period 1979 through 1988. Data on the total number of divorces in the United States are used for the period 1989 through 2014. With the data from the various states, we developed an age-group-of-husband crossed with age-group-of-wife grid for 2011.

First, the detailed NCHS data on divorces by age group is disaggregated into single year of age of husband ( $x$ ) and age of wife ( $y$ ), for ages 14-100+, using the H.S. Beers method of interpolation. Then, the age-specific divorce rates ( $\hat{d}_{x,y}^z$ ), for each year ( $z$ ) are calculated for the period 1979-1988 by taking the number of divorces (inflated to represent the Social Security area,  $\hat{D}_{x,y}^z$ ) and dividing by the married population in the Social Security area at that age-of-husband and age-of-wife ( $P_{x,y}^z$ ). The formula for this calculation is given below:

$$\hat{d}_{x,y}^z = \frac{\hat{D}_{x,y}^z}{P_{x,y}^z} \quad (1.7.3)$$

These rates are then averaged, graduated,<sup>17</sup> and loaded into an 87 by 87 matrix (age-of-husband crossed with age-of-wife for ages 14 through 100+), denoted as DivGrid. DivGrid is then adjusted using the state data grid developed for 2011. DivGrid for years after 1988 is a weighted average of the 1988 DivGrid and the 2011 state data single year grid. This state data single year of age grid is derived by ratioing the 1988 DivGrid cells using the original state age-group data. DivGrid is used in the calculation of the age-specific divorce rates for all later years including the projection period.

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<sup>17</sup> Using the Whittaker-Henderson method of graduation.

For each year in the 1989-2014 period, an expected number of total divorces in the Social Security area is obtained by applying the age-of-husband crossed with age-of-wife rates in DivGrid to the corresponding married population in the Social Security area. The rates in DivGrid are then proportionally adjusted so that they would yield an estimate of the total number of divorces in the Social Security area. The estimate of total divorces is obtained by adjusting the reported number of divorces in the U.S. for (1) the differences between the total divorces in the U.S. and in the combined U.S., Puerto Rico, and Virgin Islands area, and (2) the difference between the population in the combined U.S., Puerto Rico, and Virgin Islands area and in the Social Security area.

The starting age-adjusted divorce rate is set to a weighted average of the past five years of data. This age-adjusted rate is assumed to reach its ultimate value in the 25<sup>th</sup> year of the 75-year projection period. The annual rate of change decreases in absolute value as the ultimate year approaches.

To obtain age-specific rates for use in the projections, the age-of-husband-age-of-wife-specific rates in DivGrid are adjusted proportionally so as to produce the age-adjusted rate assumed for that particular year.

## 1.8. PROJECTED POPULATION

### 1.8.a. Overview

For the 2018 Trustees Report, the starting population for the population projections is the December 31, 2015, Social Security area population, by age, sex, and marital status, produced by the HISTORICAL POPULATION subprocess. (For this section, section 1.8, the term “starting year” refers to the year 2016.) The Social Security area population is then projected using a component method. The components of change include births, deaths, net LPR immigration, and net other-than-LPR immigration. The components of change are applied to the starting population by age and sex to prepare estimated populations as of December 31, 2016 and 2017, and to project the population through the 75-year projection period (years 2018-2092).

Beginning with December 31, 2013, the historical and projected populations are modeled using the following population statuses: heterosexual, gay, and lesbian. The gay and lesbian populations in the HISTORICAL POPULATION program are broken out assuming 3.0% of the male population and 4.0% of the female population is gay or lesbian, and the same is true for cohorts born in the PROJECTED POPULATION program.

There is a separate equation for each of the components of change as follows:

$$B_{s,p}^z = B_{s,p}^z(\cdot) \quad (1.8.1)$$

where  $B_{s,p}^z$  is the number of births of each sex (s) by population status (p) born in year z;

$$D_{x,s,p}^z = D_{x,s,p}^z(\cdot) \quad (1.8.2)$$

where  $D_{x,s,p}^z$  is the number of deaths by age (x), sex (s), and population status (p) that occurs in year z; and

$$NI_{x,s}^z = NL_{x,s}^z + NO_{x,s}^z \quad (1.8.3)$$

where  $NI_{x,s}^z$  is the total net immigration (both LPR and other-than-LPR) by age (x), sex (s), and population status (p),  $NL_{x,s}^z$  is the net LPR immigration (produced by the LPR IMMIGRATION subprocess), and  $NO_{x,s}^z$  is the net other-than-LPR immigration (produced by the OTHER-TAN-LPR IMMIGRATION subprocess). The population program further disaggregates the new immigration,  $NI_{x,s}^z$ , by population status into  $NI_{x,s,p}^z$ .



Once the components of change are calculated, the following equation is used to calculate the Social Security area population by age, sex, and population status:

$$\begin{aligned}
 P_{0,s,p}^z &= B_{s,p}^z - D_{0,s,p}^z + NI_{0,s,p}^z && \text{for age} = 0 \\
 P_{x,s,p}^z &= P_{x-1,s,p}^{z-1} - D_{x,s,p}^z + NI_{x,s,p}^z && \text{for ages} > 0
 \end{aligned}
 \tag{1.8.4}$$

where  $P_{x,s,p}^z$  is the population, by age (x), sex (s), and population status (p), as of December 31<sup>st</sup> of each year (z).

The population is further disaggregated into the following four marital statuses: single (never married), married, widowed, and divorced. The following equation shows the population by age (x), sex (s), population status (p), and marital status (m) for each year (z):

$$P_{x,s,p,m}^z = P_{x,s,p,m}^z(\cdot)
 \tag{1.8.5}$$

The children (ages 0-18) population is further disaggregated into the following four parent statuses (i.e., fates): both parents are alive, only father is alive, only mother is alive, and both parents deceased. The following equation shows the children population by age of child (x), sex of parent (s), age group of parent (g), and fate of parent (f) for each year (z):

$$C_{x,s,g,f}^z = C_{x,s,g,f}^z(\cdot)
 \tag{1.8.6}$$

### 1.8.b. *Input Data*

#### *Long-Range OASDI Projection Data -*

##### Demography

##### FERTILITY

1. Historical birth rates by single year of age of mother (14-49) for the years beginning with 1941 and ending with the year prior to the starting year. These data are updated each year.
2. Projected birth rates by single year of age of mother (14-49) for the years beginning with the starting year and ending with 2100. These data are updated each year.

##### MORTALITY

3. Historical probabilities of death by age last birthday (including neonatal mortality factor, single year of age for ages 0-99, and age group 100+) and sex for years beginning with 1941 and ending with the year prior to the starting year. These data are updated each year.

4. Projected probabilities of death by age last birthday (including neonatal mortality factor, single year of age for ages 0-99, and age group 100+) and sex for the years beginning with the starting year and ending with 2100. These data are updated each year.
5. Factors to distribute probabilities of death by marital status. They are dimensioned by sex, single year of age (ages 14-100+), and marital status. These data are updated each year.

#### LPR IMMIGRATION

6. Projected numbers of LPR immigrants who are new arrivals, by single year of age (-1-100) and sex for years beginning with the starting year and ending with 2100. These data are updated each year. Note that age -1 represents births that occur during the year.
7. Projected numbers of legal emigrants by single year of age (-1-100) and sex for years beginning with the starting year and ending with 2100. These data are updated each year. Note that age -1 represents births that occur during the year.
8. Projected numbers of LPR immigrants who are adjustments of status, by single year of age (-1-100) and sex for years beginning with the starting year and ending with 2100. These data are updated each year. Note that age -1 represents births that occur during the year.

#### HISTORICAL POPULATION

9. Social Security area population by single year of age (0-99 and 100+), sex, and marital status for the years beginning with 1940 and ending with the year prior to the starting year in total and broken down by population status. These data are updated each year.
10. Married couples by single year of age of husband (ages 14-100+) crossed with single year of age of wife (ages 14-100+) for the years beginning with 1940 and ending with the year prior to the starting year in total and by marriage type (opposite-sex, same-sex male, and same-sex female). These data are updated each year.
11. Other-than-LPR population by age and sex for the years beginning with 1963 and ending with the year prior to the starting year. These data are updated each year.

#### OTHER-THAN-LPR IMMIGRATION

12. Projected numbers of other-than-LPR immigrants entering the country by age (-1-100) and sex for years beginning with the starting year and ending with 2100. These data are updated each year.
13. Projected numbers of other-than-LPR immigrants leaving the country by age (-1-100) and sex for years beginning with the starting year and ending with 2100. These data are updated each year.
14. Other-than-LPR population by age and sex for the years beginning with the starting year and ending with 2100. These data are updated each year.

## MARRIAGE

15. Projected central marriage rates by single year of age of husband (ages 14-100+) crossed with single year of age of wife (ages 14-100+) for each year of the projection period. These data are updated each year.
16. Projected central same-sex marriage rates by single year of age of spouse 1 (ages 14-100+) crossed with single year of age of spouse 2 (ages 14-100+) for each year of the projection period. These data are updated each year.
17. Averaged and graduated marriage rates for the period 1979 and 1981-1988 by single year of age (ages 14-100+), sex, and prior marital status (single, divorced, and widowed). These data are updated each year.
18. Total number of marriages for the years beginning with 1989 and ending with 2 years prior to the starting year. These data are updated each year.

## DIVORCE

19. Projected central divorce rates by single year of age of husband (14-100+) crossed with single year of age of wife (14-100+) for each year of the projection period. These data are updated each year.

### *U.S. Census Bureau Data -*

20. CPS data on the average number of children per married couple with children by age group of householder (age groups 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, and 55-64) for 1960-2016. (Note that the program splits the last age group, which is a 10-year age group, into two 5-year age groups.) An additional year of data is added each year.

### **1.8.c. Development of Output**

#### *Equation 1.8.1 - Births*

The number of births in the Social Security area,  $B_x^z$ , is computed for each year,  $z$ , of the projection period by applying the age-specific birth rate to the midyear female population aged 14 to 49 as follows:

$$B_x^z = b_x^z \left( \frac{FP_x^z + FP_x^{z+1}}{2} \right)$$

where,

$B_x^z$  = number of births to mothers age  $x$  in year  $z$ ;

$b_x^z$  = birth rate of mothers age  $x$  in year  $z$ ; and

$FP_x^z$  = female population age  $x$  at the beginning of year  $z$ .

The total number of births in a given year is the sum of the number of births to mothers at each age. This total number of births is disaggregated by sex by assuming a sex ratio of 1048 male births for every 1000 female births. The total number of births is also disaggregated by population status by assuming 3.0% of males born are gay and 4.0% of females born are lesbian.

*Equation 1.8.2 – Deaths*

The number of deaths for the Social Security area by age (x), sex (s), and population status (p),  $D_{x,s,p}^z$ , is computed for each projection year (z) by applying the death probabilities for each age and sex,  $q_{x,s}^z$ , to the exposed population at the beginning of the year.

$$D_{x,s,p}^z = q_{x,s}^z P_{x,s,p}^z$$

*Equation 1.8.5 – Disaggregating the population by marital status*

Once the population is projected by single year of age, sex, and population status, it is then disaggregated by population status into the following four marital states; single, married, widowed, and divorced. Estimates of the Social Security area population by single year of age (0-99 and 100+), sex, marital status, and population status as of the starting year of the population projection are obtained from the HISTORICAL POPULATION subprocess. In addition, the HISTORICAL POPULATION subprocess provides the number of married couples by single year of age of husband crossed with single year of age of wife and number of married male/male and female/female marriages, single year of age of spouse 1 crossed with single year of age of spouse 2, as of the starting year.

All births are assigned to the single marital status. For a given age, sex, and population status, deaths are assigned by marital status according to the relative differences in death rates by marital status observed for that age and sex during the calendar years 1995 and 1996, as determined in the MORTALITY subprocess. For a given age, sex, and population status, immigrants are assigned by marital status according to the beginning of year marital distribution of the Social Security area population for that age and sex.

Once the number of marriages, divorces, and widowings during a year are determined, the population by age, sex, population status, and marital status is updated to represent end of year. The unmarried population at the end of the year is estimated from the unmarried population at the beginning of the year by factoring in deaths, marriages, new unmarried immigrants, widowings, and divorces during the year. The married population at the end of the year is estimated from the married population at the beginning of the year by factoring in divorces, widowings, dissolutions of marriages when both husband and wife dies, new married immigrants, and marriages during the year.

Numbers of new marriages are determined for each projection year. The annual number of opposite-sex marriages occurring at each age of husband crossed with each age of wife is obtained by multiplying the age-of-husband-specific and age-of-wife-specific marriage rates

with the geometric mean of the midyear unmarried male population and the midyear unmarried female population.

The age-specific midyear unmarried male population<sup>18</sup> is estimated from the beginning of the year unmarried population. It is calculated by adjusting the number of unmarried males at the beginning of the year to represent midyear using the relationship between the prior beginning of year and the current beginning of year unmarried male populations. The midyear female unmarried population is approximated similarly.

The numbers of marriages are then distributed by previous marital status (single, widowed, divorced) in the same proportions as would have been produced by applying the previous marital-status-specific marriage rates from the MARRIAGE subprocess to the population by marital status at the beginning of the year.

Numbers of new divorces are determined for each projection year. The number of divorces during a year, occurring at each age of husband crossed with each age of wife, is obtained by multiplying the age-of-husband crossed with age-of-wife divorce rates for that year with the midyear number of married couples in that age crossing.

The number of age-of-husband crossed with age-of-wife midyear married couples is estimated from the beginning of the year married couples. It is calculated by adjusting the number of married couples at the beginning of the year to represent midyear using the relationship between the number of married couples at the beginning of the prior year and the beginning of the current year.

Marriages and divorces for same-sex couples are calculated similarly.

Widowings are computed by applying general population probabilities of death to the marriage prevalence at the beginning of the year. Widowings and deaths by marital status are then reconciled for internal consistency.

#### *Equation 1.8.6 – Disaggregating the children by parent survival status*

Once the population is projected by single year of age, sex, population status, and marital status, the number of children are then categorized by age of father, age of mother, and orphan status. The HISTORICAL POPULATION subprocess provides the historical number of children (ages 0-18), number of women (ages 14-49), and the number of married couples by single year of age of husband crossed with single year of age of wife. The projected number of children (ages 0-18), number of women (ages 14-49), and marriage grid age of husband crossed with age of wife is calculated in the projected population.

For women aged 14-49, births are calculated by multiplying the age-specific birth rate, from the FERTILITY subprocess, with the number of women at the corresponding age. The births are

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<sup>18</sup> The midyear population exposed to marriage is the unmarried population (sum of those single, widowed, and divorced).

then distributed to the age of husband in the same proportions as the age of husband crossed with age of wife married couples grid.

Each year the number of children is then rolled forward a year to the next age of husband, age of wife, and child age. Parent survival is calculated based on the deaths rates from the MORTALITY subprocess. The number of orphans consists of children with at least one parent deceased. The calculated number of children by age of father and age of mother must match the number of children in the historical or projected population. To accomplish this, the calculated number of children is multiplied by the ratio of the number of children in the historical or projected population to the number of children by age of father and age of mother that was calculated using the fertility rates. For any remaining difference, an adjustment of one is made for each age of husband crossed with age of wife until the total number of children match.

Once the population is projected by single year of age, sex, population status, marital status, and children, the mean number of children per married couple with children is determined by year and age of householder. The historical mean number of children by year and age of householder in the population program is calculated from the number of children categorized by age of father, age of mother, and the number of married men by age group from the HISTORICAL POPULATION subprocess. Linear regression is used to model the relationship between the mean number of children in the population program to the mean number of children from the U.S. Census Bureau. The regression model is then used to project the mean number of children by age of householder in the population program.

# **Process 2:**

# **Economics**

## ***2. Economic***

The Office of the Chief Actuary uses the Economic process to project OASDI employment and earnings-related variables, such as the average wage for indexing and the effective taxable payroll. The Economic process receives input data from the Demography process and provides output data to the Beneficiaries and the Trust Fund Operations & Actuarial Status processes.

The Economic Process is composed of five subprocesses, U.S. EMPLOYMENT, U.S. EARNINGS, COVERED EMPLOYMENT AND EARNINGS, TAXABLE PAYROLL, and REVENUES. As a rough overview, U.S. EMPLOYMENT and U.S. EARNINGS project U.S. employment and earnings data, respectively, while COVERED EMPLOYMENT AND EARNINGS converts these employment and earnings variables to OASDI covered concepts. TAXABLE PAYROLL, in turn, converts OASDI covered earnings to taxable concepts, which are eventually used to estimate future payroll tax income. REVENUES converts taxable concepts into projected OASDI wage tax liabilities (WTL) and self-employment tax liabilities (SEL) for the short range period.

U.S. EMPLOYMENT and U.S. EARNINGS produce output by quarter, while the output from COVERED EMPLOYMENT AND EARNINGS and TAXABLE PAYROLL are calendar year amounts. REVENUES produces amounts of wages paid to employees during a quarter and tax liabilities owed on those wages, as well as taxes collected on those amounts by quarter and by fiscal and calendar year.

Two appendices are at the end of this documentation. The first appendix, 2-1, provides details for most of the equations given in the following descriptions of the Economic process. The second appendix, 2-2, provides a listing with explanations of acronyms used in this documentation.



## 2.1. U.S. EMPLOYMENT (USEMP)

### 2.1.a. Overview

The Bureau of Labor Statistics (BLS) publishes historical monthly estimates for civilian U.S. employment-related concepts from the Current Population Survey (CPS). The principal measures include the civilian labor force (LC) and its two components – employment (E) and unemployment (U), along with the civilian noninstitutional population (N). The BLS also publishes values for the civilian labor force participation rate (LFPR) and the civilian unemployment rate (RU). The LFPR is defined as the ratio of LC to N, while the RU is the ratio of U to LC, expressed to a base of 100. For many of these concepts, the BLS publishes historical data disaggregated by age, gender, marital status, and presence of children.

For various disaggregated groups<sup>1</sup>, USEMP projects quarterly and annual values for these principal measures of U.S. employment and population. Equations 2.1.1 through 2.1.6 outline the subprocess' overall structure and solution sequence for the total economy. We project that the military population (M) will remain constant over the projection horizon. We also project that the sum of N and M will grow at the same annual rate projected for the Social Security area population (P) (see Demography Process input).

$$M^t = M^{2016} \quad (2.1.1)$$

$$N^t = [(N^{t-1} + M^{t-1}) * (P^t / P^{t-1})] - M^t \quad (2.1.2)$$

$$RU = RU(\cdot) \quad (2.1.3)$$

$$LFPR = LFPR(\cdot) \quad (2.1.4)$$

$$LC = LFPR * N \quad (2.1.5)$$

$$E = LC * (1 - RU / 100) \quad (2.1.6)$$

Note: the superscript t represents the projection year.

The Demography Process estimates historical values for the total Social Security area population (P) and an important component, the other-than-lawful-permanent-resident, or other-than-LPR, population (OP). OP is further disaggregated into components by visa status: those temporarily authorized to reside or work in the US (OP\_A), those who have overstayed their authorization (OP\_NA), and those who were never authorized to reside or work in the US (OP\_NO). Similarly, USEMP projects annual values for E and employed OP (EO), including its visa-status components (EO\_A, EO\_NA, EO\_NO). USEMP also separates EO to those whose earnings are reported and posted to the Master Earnings File (EO\_MEF), those whose earnings are reported

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<sup>1</sup> Group disaggregation includes age and gender. Some groups are additionally disaggregated by marital status and by presence of children.

posted to the Earnings Suspense File (EO\_ESF), those in the underground economy (EO\_UND). A further subgroup of EO\_MEF is also calculated: those who are OASDI covered (EO\_MEFC). Equations 2.1.7 through 2.1.14 outline the overall structure of the subprocess used to estimate EO and its sub-components.

$$EO\_A = EO\_A(\cdot) \quad (2.1.7)$$

$$EO\_NA = E * OP\_NA / N \quad (2.1.8)$$

$$EO\_NO = E * OP\_NO / N \quad (2.1.9)$$

$$EO = EO\_A + EO\_NA + EO\_NO \quad (2.1.10)$$

$$EO\_MEF = EO\_MEF(\cdot) \quad (2.1.11)$$

$$EO\_MEFC = EO\_MEFC(\cdot) \quad (2.1.12)$$

$$EO\_ESF = EO\_ESF(\cdot) \quad (2.1.13)$$

$$EO\_UND = EO - EO\_MEF - EO\_ESF \quad (2.1.14)$$

Finally, for each age/gender group, USEMP projects total “at-any-time” employed other-than-LPR population (TEO). EO represents the average weekly employment of the other-than-LPR population during a calendar year. TEO represents the total number of individuals in the other-than-LPR population who had any employment during the calendar year. (EO can be roughly viewed as the average number of jobs worked by OP during a calendar year, while TEO represents the total number of individuals who worked those jobs.) Effectively, Equations 2.1.15 through 2.1.19 convert every EO age-gender sub-component to an at-any-time TEO age-gender sub-component counterpart.

$$TEO\_MEF = TEO\_MEF(\cdot) \quad (2.1.15)$$

$$TEO\_MEFC = TEO\_MEFC(\cdot) \quad (2.1.16)$$

$$TEO\_ESF = TEO\_ESF(\cdot) \quad (2.1.17)$$

$$TEO\_UND = TEO\_UND(\cdot) \quad (2.1.18)$$

$$TEO = TEO\_MEF + TEO\_ESF + TEO\_UND \quad (2.1.19)$$

## 2.1.b. *Input Data*

### *Long-Range OASDI Projection Data*

These data are updated each year.

#### Demography

1. Social Security area population as of year-end (1941 – 2099) by age, marital status (single, married, widowed, divorced) and gender (M, F) (Econ Model workflow, sections 3.a.i & 3.a.viii)
2. “Other-than-LPR” population as of year-end (1964 – 2099) by age, gender (M, F), and visa status (OP\_A, OP\_NA, and OP\_NO) (Econ Model workflow, sections 3.a.iii, 3.a.v, 3.a.vi, 3.a.vii, 3.a.ix, 3.a.xii, 3.a.xiii, & 3.a.xiv)
3. Number of children by age of child and age of mother (1960-2099) (Econ Model workflow, section 3.a.ii)
4. Life expectancy by age and gender (1950-2099) (Econ Model workflow, section 3.a.x)
5. Exit rates (probability of leaving the “other-than-LPR” population by other than death) by age and gender. (Econ Model workflow, section 3.a.xi)
6. Mortality rates by age and gender (1941-2099) (Econ Model workflow, section 3.a.iv)

Trust Fund Operations and Actuarial Status – The Trust Fund Operations and Actuarial Status Process provides no input to the Economic Process sections. However, the LFPRs use input from the Outgo Process from the prior year’s Trustees Report. That is, the projected LFPRs for the 2018 Trustees Report use input from the 2017 Trustees Report that includes:

7. projections for the disability prevalence rates by age and gender (originally from the Beneficiaries subprocess) (Econ Model workflow, sections 3.b.i.1 & 3.b.i.2)
8. projections for the disability-insured population (originally from the Beneficiaries subprocess) (Econ Model workflow, section 3.b.i.3)
9. primary insurance amount (PIA) replacement rates by age and gender. (Econ Model workflow, section 3.c.i)

The disability prevalence rate is defined as the ratio of the number of disabled worker beneficiaries to the disability-insured population. The PIA replacement rate is defined as the ratio of a hypothetical medium-scaled worker’s PIA to his/her career-average indexed earnings level.

#### *Trustees’ Assumptions*

Each year the Board of Trustees of the OASDI Trust Funds sets the ultimate average annual growth rate values for key economic variables:

10. Real wage (Econ Model workflow, section 1.c.i)
11. Total economy productivity (Econ Model workflow, section 1.a.i)

12. Average hours worked (Econ Model workflow, section 1.a.i)
13. Ratio of wages to compensation (RWSD) (Econ Model workflow, section 1.c.i)
14. Ratio of compensation to GDP (RWSSY) (Econ Model workflow, section 1.c.i)
15. GDP deflator (PGDP) (Econ Model workflow, section 1.c.i)
16. Consumer Price Index (CPI) (Econ Model workflow, section 1.a.i)

The Board also sets ultimate values for:

17. Annual trust fund real interest rate (Eco Interest Workflow, section 1.a.1)
18. Unemployment rate (Econ Model workflow, section 1.a.i)

These ultimate values are typically reached during the last half of the short-range (first 10 years) of the projection horizon. Earlier projected values are set to provide a smooth transition from the latest actual historical values to the assumed long-range ultimate ones. As a by-product of this process, values for real GDP and potential GDP are set. The ratio (RTP) of real to potential GDP is an important summary measure of the economic cycle.

The Trustees also agree on the assumed short-range values for the listed variables.

#### *Addfactors*

19. Addfactors are adjustments that move an estimate closer to an expected value. They may be used for a variety of reasons associated with data availability, structural changes in the data and/or model, and perceived temporary aberrations in recent historical data. Addfactors were included on male and female LFPRs starting around age 40 to reflect the effects of projected changes in life expectancy. (Econ Model workflow, section 3.m)

#### *Other input data*

20. U.S. armed forces (EDMIL) by age and gender, estimated by the Department of Defense and published by the Census Bureau on a monthly basis (1948-2000) by single year of age (17 to 64) and gender. These data are no longer produced by Census. (Econ Model workflow, section 3.d.iv.8.b)
21. EDMIL by age and gender, estimated by the Economic Process as the difference in monthly resident plus Armed Forces overseas population and the monthly civilian population. These two populations are available from the Census Bureau on a monthly basis (April 2000 to December 2017) by single year of age (16 to 69) and gender. These data are updated once a year. (Econ Model workflow, section 3.d.iv)
22. Data for the mobilized military reservist population, by branch of service (September 2001-September 2016) are reported by the US Department of Defense weekly. These data are no longer reported by the Department of Defense. (Econ Model workflow, section 3.d.iv.8.a.v)
23. Data from the March Supplement of the Joint BLS/Census Current Population Survey (CPS) by year (1968-2017), for levels of the civilian noninstitutional

- population, labor force, military, and unemployment. These data are available from the U.S. Census Bureau, via DataFerrett, by single year of age (16 to 85+), gender, marital status (never married, married with a spouse present, and married with no spouse present), and presence of children. These data are updated by the U.S. Census Bureau for the BLS annually. This subprocess updates the data every other year (or more often, based on time availability). (Econ Model workflow, section 3.g)
24. Data from the March Supplement of the CPS by year (1992-2017), for levels of the civilian noninstitutional population. These data are available from the U.S. Census Bureau, via DataFerrett, by single year of age (16 to 85+), gender, and educational attainment level. These data are updated by the U.S. Census Bureau for the BLS annually. This subprocess updates the data every year, if time availability allows. (Econ Model workflow, section 3.h)
  25. Data from the CPS (1948-2017) for levels of civilian employment, civilian labor force, civilian unemployment, and civilian noninstitutional population. These data are available from the BLS by age group and gender. These data are updated by the BLS monthly. This subprocess updates the data several times a year. (Econ Model workflow, sections 3.d.i & 3.f)
  26. Data from the CPS by year (1994-2016), for the civilian noninstitutional population. These data are available from the BLS by single year of age (16 to 85+), gender, marital status, labor force employment status, and (for those not in the labor force) reason for not being in the labor force. These data are updated by the BLS monthly. Monthly data are used to calculate annual averages. This subprocess updates the data every year, if time availability allows. (Econ Model workflow, section 3.i)
  27. Data from the Current Employment Statistics survey (CES) (1964 (varies) to October 2017) for establishment employment, average hourly earnings, average weekly earnings, and average weekly hours. These data are available from the BLS by sector. These data are updated by the BLS monthly. This subprocess updates the data several times a year. (Econ Model workflow, section 3.d.i)
  28. Unpublished data from the CPS (1965 - October 2017) for male and female civilian labor force participation rates for older workers. These data are available from the BLS by single year of age (ages 55-79) and by group (75 and over, and 80 and over). These data are updated by the BLS monthly. This subprocess updates the data several times a year. (Econ Model workflow, section 3.e)

### 2.1.c. *Development of Output*

#### *Equation 2.1.3 - Unemployment Rate (RU)*

The RU is disaggregated by age and gender. The age groups include 16-17, 18-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74, and 75 and over. Thus, USEMP contains 28 RU equations, 14 for males and 14 for females. Each disaggregated RU is specified using a first-difference model that depends on the distributed lag in the change in the ratio of real to potential GDP (RTP) and an adjustment to ensure that values converge to its estimated trend level. Coefficients are estimated by regression and constrained to an expected aggregate behavior whereby a 2.0 percentage point increase in the RTP elicits a 1.0 percentage point decrease in the RU. Furthermore, projections are constrained to the ultimate age-gender-adjusted RU set by the Trustees. The aggregate age-sex-adjusted RU is dependent on the projected distribution of the labor force by age and gender. See Appendix 2-1 for details on the equations.

#### *Equation 2.1.4 - Labor Force Participation Rate (LFPR)*

The LFPR is disaggregated by age and gender. Age groups include 16 to 17 (i.e., 16-17), 18-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55, 56, ... 99, 100 and over. For age groups between 20 and 54, male and female LFPRs are further disaggregated by marital status, categories of which include never married, ever married with spouse present, and ever married with spouse absent (which includes separated, widowed, and divorced). Female LFPRs disaggregated by age (between 20 and 44) and by marital status are further disaggregated by presence of own child. The groups for presence of own child include females with at least one child under the age of six and females without a child under the age of six. Thus, USEMP contains 153 LFPR equations, 69 for males and 84 for females. See Appendix 2-1 for details on the equations.

Given the level of demographic disaggregation, the aggregate LFPR is dependent on the projected distribution of the population by age, gender, marital status, and presence of own child. Each disaggregated LFPR, however, is dependent on the input variables that are most relevant to the demographic group. For example, only the LFPRs for relevant older workers are dependent on changes to the normal retirement age (NRA). Specific examples of the impact of input data on the disaggregated LFPRs are presented below.

- Disability prevalence ratio (RD) is defined as the ratio of disabled worker beneficiaries to the disability-insured population. An increase in RD lowers the LFPR. RD is adjusted with a multiplicative factor defined as the group's average historical LFPR over a 15-year period. This adjustment implicitly assumes that disability can strike any person in the population with equal probability. For ages 62 to NRA, RDs are not "pure" RDs in that they are subject to the confounding effect of the availability of retirement benefits. For example, at age 62, a marginally disabled individual may opt to begin receiving retirement benefits rather than go through an uncertain disability application/appeals process. For ages NRA and above, RDs are unavailable because at the NRA all disabled-worker beneficiaries become retired-worker beneficiaries. To avoid these problems, RDs for ages

62-74 are set to their cohort RD at age 61. For example, the RD for males age 62 in year (t) is set to the RD for males age 61 in year (t-1). For those ages 75 and older, the lagged cohort variable provides information on the influence of disability prevalence rates on labor force participation.

- The unemployment rate (RU) is a measure of the economic cycle. An increase in the lagged and current unemployment rate leads to a decrease in the LFPR. The RU affects most LFPRs.
- The normal retirement age (NRA) is assumed to affect the LFPRs for those age 62 through 69 through an earnings test and replacement rate. The replacement rate is defined as the ratio of a hypothetical worker's PIA to career-average wage level. This value is projected for hypothetical workers with medium-scaled earnings patterns<sup>2</sup> who retire at ages 62 through 69. The replacement rate is adjusted to include the reduction for early retirement and the delayed retirement credit. An increase in the NRA decreases the adjusted replacement rates, which, in turn, leads to increases in the LFPRs for those between the ages of 62 and 69. The potential earnings test tax rate (POT\_ET\_TXRT) is used in LFPRs between 62 and 69. It is defined as a tax rate on monthly retirement benefits faced by an individual who opts to collect Social Security benefits before reaching NRA while continuing to work and earn income. An increase in the NRA from 66 to 67 leads to an increase in the potential tax rate for those age 66, which, in turn, leads to a decrease in their LFPR.
- The education distribution of the workforce increases the LFPRs *if* the level of educational attainment increases.
- The proportion of females with children under age of 6 and their average number of children under age 6 are functions of the ratio of the number of children under age 6 to mothers in each 5-year age group for ages between 20 and 44. For females aged 20 to 44 with at least one own child, an increase in the average number of children lowers the LFPR.
- A LFPR increases with its lagged cohort. Lagged cohort variables affect female LFPRs age 55 and over, and male LFPRs age 75 and over.
- The LFPRs for males age 62 through 74 increase with spousal LFPRs.
- For those approximately age 40 and over, an increase in life expectancy leads to an increase in LFPRs.

*Equation 2.1.7 to 2.1.19 – Employed Other-than-LPR Population (EO) and At-Any-Time Employed Other-than-LPR Population (TEO)*

EO is estimated by gender and single-year of age from 16 to 100 based on OP and estimated employment-to-population ratios by visa-status component (OP\_A, OP\_NA, OP\_NO). For this purpose, OP\_A is further disaggregated into subgroups by visa type that differ in employment patterns or OASDI coverage status. The other two components are assumed to have equal employment-to-population ratio as the LPR population of the same age and gender. This portion of USEMP contains 4,250 equations, for 85 ages, 2 genders, and 25 components and subgroups. We separate EO\_NO into those who worked in 2001 and earlier

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<sup>2</sup> More details on the hypothetical scaled workers are provided in Actuarial Note #2017.3, located at the following internet address: [www.socialsecurity.gov/OACT/NOTES/ran3/index.html](http://www.socialsecurity.gov/OACT/NOTES/ran3/index.html).

and those who began working in 2002 and later, since we believe that those who worked in 2001 and earlier are more likely to have OASDI covered wages. Each component is then further separated into EO\_MEF, EO\_MEFC, EO\_ESF, and EO\_UND.

Every EO sub-component by age, gender, and visa status is converted to its age-gender TEO sub-component counterpart using an age-gender conversion weight. For example, if the sub-component of EO is for never authorized males age 20 to 24, the conversion weight is defined as the ratio of total economy-wide at-any-time employed males age 20 to 24 (TEM2024) to the sum of military and CPS civilian male employment age 20 to 24. For authorized workers and students on temporary visas, conversion weights take into account their partial presence in the year of arrival and the year of departure.



## 2.2. U.S. EARNINGS (MODSOL2)

### 2.2.a. Overview

In the CPS data, E is separated by class of worker. The broad categories include wage and salary workers (EW), the self-employed (ES), and unpaid family workers (EU). For the nonagricultural sector, the self-employed participation rate (SEPR) is defined as the ratio of ES to E, the proportion of employed persons who are self-employed. For the agricultural sector, the SEPR is defined as the ratio of ES to the civilian noninstitutional population.

MODSOL2 projects quarterly values for these principal classes of employment. Equations 2.2.1 through 2.2.4 outline the subprocess' overall structure and solution sequence.

$$SEPR = SEPR(\cdot) \quad (2.2.1)$$

$$ES = SEPR * E \quad (2.2.2)$$

$$EU = EU(\cdot) \quad (2.2.3)$$

$$EW = E - ES - EU \quad (2.2.4)$$

In the National Income and Product Accounts (NIPA), the Bureau of Economic Analysis (BEA) publishes historical quarterly estimates for gross domestic product (GDP), real GDP, and the GDP price deflator (PGDP). Real GDP is equal to the ratio of nominal GDP to PGDP. Potential (or full-employment) GDP is a related concept defined as the level of real GDP that is consistent with a full-employment aggregate RU.

MODSOL2 projects quarterly values for these output measures. Potential GDP is based on the change in full-employment values for: (1) E (including U.S. armed forces), (2) average hours worked per week, and (3) productivity. Full-employment values for E are derived by solving USEMP under full-employment conditions, while the full-employment values for the other variables (average hours worked and productivity) are set by assumption. RTP is the ratio of real GDP to potential GDP and is set by assumption. RTP reaches 1.0 in the short-range period and remains at 1.0 thereafter. Projected real GDP is set equal to the product of potential GDP and RTP. Nominal GDP is the product of real GDP and PGDP. The growth rate in PGDP is set by assumptions.

The BEA also publishes quarterly values for the principal components of U.S. earnings, including total wage worker compensation (WSS), total wage and salary disbursements (WSD), and total proprietor income (Y). These concepts can be aggregated and rearranged. Total compensation (WSSY) is defined as the sum of WSS and Y. The total compensation ratio (RWSSY) is defined as the ratio of WSSY to the GDP. The income ratio (RY) is defined as the ratio of Y to WSSY. The earnings ratio (RWSD) is defined as the ratio of WSD to WSS.

MODSOL2 projects quarterly values for these principal components of U.S. earnings using Equations 2.2.5 through 2.2.11.

$$RWSSY = RWSSY(\cdot) \quad (2.2.5)$$

$$WSSY = RWSSY * GDP \quad (2.2.6)$$

$$RY = RY(\cdot) \quad (2.2.7)$$

$$Y = RY * WSSY \quad (2.2.8)$$

$$WSS = WSSY - Y \quad (2.2.9)$$

$$RWSD = RWSD(\cdot) \quad (2.2.10)$$

$$WSD = RWSD * WSS \quad (2.2.11)$$

## **2.2.b. Input Data**

### *Long-Range OASDI Projection Data*

1. Demography- (See Section 2.1.b.) (Econ Model workflow, section 3.a)
2. Economics - Data from Section 2.1 include the total employed (E), E by age and gender, LFPRs by age and gender, the aggregate unemployment rate (RU), and the full-employment concepts for LC, RU, and E.
3. *Trustees Assumptions* - (See Section 2.1.b.) (Econ Model workflow, section 1)

### *Addfactors*

4. Addfactors were included on some employment and output variables to smooth the transition between the latest historical data and the projected values. The need for addfactors is reviewed each year and they are implemented if necessary. (Econ Model workflow, section 3.m)

### *Other input data*

5. Data from the NIPA (1929 (varies) to 2017) for GDP, income, wages, compensation, personal consumption expenditures, investment, employer contributions for employee pension and insurance funds, and employer contributions for government social insurance. They are published by the BEA quarterly and/or annually. This subprocess updates the data several times a year. (Econ Model workflow, section 3.d.i)
6. OASDI employee, employer, and self-employed tax rates from 1937 to 2099. These contribution rates are set according to the Social Security Act of 1935 as amended through 2015. The rates are updated when legislation mandates a change. (Econ Model workflow, section 3.k.ii.4)
7. The historical Consumer Price Index (CPI) is published monthly by the BLS. This subprocess updates the data several times a year. (Econ Model workflow, section 3.d.i)
8. The historical CPI for medical services is published monthly by the BLS. Quarterly values are projected based on the projected growth in the aggregate CPI and an additional amount defined as the growth rate differential in the two price measures that was assumed in the latest President's Fiscal Year Budget. The series is updated annually. (Econ Model workflow, section 3.d.i)
9. U.S. armed forces (EDMIL) by age and gender were estimated by the Department of Defense and published by the Census Bureau on a monthly basis (1948-2000) by single year of age (17 to 64) and gender. These data are no longer produced by Census. (Econ Model workflow, section 3.d.iv.8.b)
10. EDMIL by age and gender are estimated by the Economic process as the difference in the monthly resident plus Armed Forces overseas population and the monthly civilian population. These two populations are available from the Census Bureau on a monthly basis (April 2000 to June 2017) by single year of age (16 to 69) and gender. These data are updated once a year. (Econ Model workflow, section 3.d.iv)
11. Wages for railroad workers are wages covered by the Railroad Retirement Act. The annual data are for the period 1971 to 2015. An additional year of data from the Railroad Retirement Board is usually available for including in preparation of the next annual Trustees Report. (Econ Model workflow, section 3.d.vii)
12. Unpublished data from the CPS (1988-2017) on employment by class of worker (i.e., agricultural, nonagricultural, unpaid family, private industry, government, wage and salary, self-employed). These data are available from the BLS by age group and gender. These data are updated by the BLS annually. This subprocess updates the data annually. (Econ Model workflow,

section 3.d.ii)

13. Data from the NIPA (1947-2017) for wages and compensation of households and institutions are published by the BEA quarterly. This subprocess updates the data several times a year. (Econ Model workflow, section 3.d.iii)
14. Other program-related parameters, including the average indexing wage, the benefit increase, the taxable maximum, and the annual retirement earnings test exempt amounts, are obtained annually from the Short-Range section of OCACT. This subprocess updates the data annually. (Econ Model workflow, sections 3.d.v and 3.d.vi)
15. Unpublished data from the CES & CPS for total hours worked in the economy. These data are available from the BLS. These data are updated by the BLS quarterly (1948-2017) and annually (1948-2016). This subprocess updates the data several times a year. (Econ Model workflow, section 3.d.viii)
16. The Federal minimum hourly wage is based on the Fair Labor Standards Act from the Department of Labor for 1938 to 2016. The wage is updated when there is legislation mandating a change. (Econ Model workflow, section 3.d.i)
17. Time trends (set by Economic process) are used in the agriculture sector for employment, real output, and compensation in the short-range period. These short-range trends are extended for each year's Trustees Report, reflecting a new short-range period. (Econ Model workflow, section 3.k.ii.2)

### **2.2.c. *Development of Output***

#### *Equation 2.2.1 - Self-Employed Participation Rate (SEPR)*

The SEPR is disaggregated by age, gender, and industry. The age groups include 16-17, 18-19, 20-24, 25-34, 35-44, 45-54, 55-64, and 65 and over. The industry groups include agriculture and nonagriculture.

For the nonagriculture sector, the SEPRs by age and gender are defined as the ratio of the nonagriculture self-employment to total employment. Thus, the aggregate nonagriculture SEPR is dependent on the projected distribution of employment by age and gender. All nonagriculture SEPRs by age and gender are dependent on the RTP. Increases in the RTP lead to decreases in the SEPRs.

For the agriculture sector, the male SEPRs by age (as well as the female SEPR for ages 16-17) are defined as the ratio of agriculture self-employment to the civilian noninstitutional population. Thus, the aggregate agriculture SEPR for males is dependent on the projected distribution of the population by age. The agriculture SEPRs for males by age are dependent on the ratio of total agriculture employment (EA) to the total civilian population aged 16 and over. (EA is projected in a farm sub-program. Real farm output is projected to increase with

the population, while farm productivity, defined as output per worker, is projected to continue to follow its historical trend. EA is projected as the ratio of farm output to farm productivity.) An increase in the ratio of EA to the total civilian population aged 16 and over leads to an increase in the agriculture SEPRs for males.

The female SEPRs by age (for ages 18 and higher) for the agriculture sector are defined as the ratio of the female to male agriculture self-employment. Thus, the aggregate agriculture SEPR for females is dependent on the projected distribution of male agriculture employment by age. For female age groups age 18 and over, the SEPRs are dependent on the RTP and the corresponding ratio of total female to male employment. Generally, an increase in the RTP leads to increases in the SEPRs. An increase in the total employment ratio also leads to an increase in the SEPR.

#### *Equation 2.2.2 – Self-Employed Workers (ES)*

ES is disaggregated by age, gender, and industry. The age groups include 16-17, 18-19, 20-24, 25-34, 35-44, 45-54, 55-64, and 65 and over. The industry groups include agriculture and nonagriculture. For the nonagricultural sector, ES is derived from SEPR by scaling it to the total nonagricultural self-employed workers (ENAS), which is projected as a constant share of nonagricultural employment over the long range. For the agricultural sector, it is similarly scaled to the total agricultural self-employed workers (EAS), which is projected as the residual after subtracting projected wage workers and unpaid family workers from total agricultural employment.

#### *Equation 2.2.3 - Unpaid Family Workers (EU)*

EU is disaggregated by age, gender, and industry. The age groups include 16-17, 18-19, 20-24, 25-34, 35-44, 45-54, 55-64, and 65 and over. The industry groups include agriculture and nonagriculture.

From 1970 to 2014, the level of EU fell from about 0.5 to 0.02 million in the agriculture sector and from about 0.5 to 0.06 million in the nonagricultural sector. For projections, the levels of EU by age and gender in the agriculture sector are assumed constant at about five thousand or less. The EUs by age and gender in the nonagricultural sector are projected as a constant ratio to ES.

#### *Equation 2.2.4 - Wage Workers (EW)*

For the nonagricultural sector, the number of wage workers is the residual after subtracting self-employed workers and unpaid family workers from total workers. For the agricultural sector, we first project wage workers, and the number of self-employed workers is the residual after subtracting wage workers and unpaid family workers from total agricultural workers. Agricultural wage workers in each age/gender group are projected as a function of the business cycle and the age-gender-group's share of total US workers. The age groups include 16-17, 18-19, 20-24, 25-34, 35-44, 45-54, 55-64, and 65 and over. The nonagriculture sector is further disaggregated: private household workers are projected by

age and sex, while Federal Government (Civilian and Military, separately) and State & Local Government workers are projected in total.

*Equation 2.2.5 - Total Compensation Ratio (RWSSY)*

The Trustees set the ultimate annual growth rate for RWSSY. For the short-range period, total WSS, WSD, and Y are aggregated from sector components. Total GDP, WSS, and WSD are divided into the farm and nonfarm sectors. The nonfarm sector is further separated into the government and government enterprises, households, nonprofit institutions, and residual (private nonfarm business excluding government enterprises (PBNFXGE)) sectors. Total Y is divided into the farm and residual (i.e., PBNFXGE) sectors.

The methodology used to estimate GDP, WSS, WSD, and Y differs by sector.

Farm - Nominal GDP is the product of real GDP and the farm price deflator. Real farm GDP is projected from estimates of real farm per capita output. EA is projected from estimates of farm productivity. EAW is projected to continue its historical increase relative to EA. Farm compensation (WSSPF) is the product of estimates for average farm compensation (AWSSPF) and EAW, while farm proprietor income (YF) is the product of estimates of average farm proprietor income (AYF) and EAS. AYF is projected based, in part, on the growth in AWSSPF.

Government and Government Enterprises - This sector is further disaggregated to Federal Civilian, Federal Military, and State and Local. In each sector, WSD is the product of estimates for average wages and employment. WSS is the sum of WSD and estimates for non-wage components of compensation. GDP is the sum of WSS and estimates of consumption of fixed capital.

Household - WSS is the product of estimates for average compensation and employment. WSD is WSS less employer contributions for the OASDHI tax. GDP is the sum of WSS and the gross value added of owner-occupied housing.

Nonprofit Institutions - The Nonprofit Institutions sector is further disaggregated to Health, Education, and Social Services sectors. In each sector, WSS is the product of estimates for average compensation and employment. WSD is WSS less the estimates for non-wage components of compensation. GDP is WSS plus a residual component of output.

Private Nonfarm Business Excluding Government Enterprises (PBNFXGE) - GDP in the PBNFXGE sector is total economy-wide GDP less the sum of the other sector GDPs. WSS is projected as a ratio to GDP less Y. The ratio is projected to be mostly stable, varying only temporarily with changes in RTP. Y is projected to grow with GDP and the ratio of EAS to total employment in the sector.

Thus, total labor compensation (WSSY) is summed from sector components, while the total compensation ratio (RWSSY) is the ratio of total WSSY to total GDP. It is important to note that the pure program-generated estimate for the total RWSSY is adjusted to ensure a smooth

transition between the latest historical data and the Trustees' ultimate assumptions.

*Equation 2.2.7 - Income Ratio (RY)*

Y is disaggregated to the farm and PBNFXGE sectors. (see description for Equation 2.2.5)

*Equation 2.2.10 - Earnings Ratio (RWSD)*

In the NIPA, the difference between WSS and WSD is defined as employer contributions for employee pension and insurance funds (OLI) and employer contributions for government social insurance (SOC). OLI is mostly health and life insurance, and pension and profit sharing. SOC is composed of employer contributions to Federal and State & Local government social insurance funds. Federal government funds include OASDI, HI, UI, and other small groups. State and Local government funds mostly include workers' compensation.

RWSD is defined as the ratio of WSD to WSS. RWSD is projected to mostly decline on a year-by-year basis over the entire 75-year projection horizon due to projected increases in employer contributions to employee group health insurance premiums (ECEGHIP) and pensions. ECEGHIP is projected by the Center for Medicare and Medicaid Services (CMS). Employer contributions to employee pension funds are assumed to increase as life expectancy increases.

## 2.3. OASDI COVERED EMPLOYMENT AND EARNINGS (COV)

### 2.3.a. Overview

Total at-any-time employment (TE) is defined as the sum of total OASDI covered employment (TCE) and total noncovered employment (NCE). TCE can be decomposed to workers who only report OASDI covered self-employed earnings (SEO) and to wage and salary workers who report some OASDI covered wages (WSW). Combination workers (CMB\_TOT) are those who have both OASDI covered wages and self-employed income. Workers with some self-employment income (CSW) are the sum of SEO and CMB\_TOT.

COV projects annual values for TE and the principle measures of OASDI covered employment. Equations 2.3.1 through 2.3.9 outline the overall structure and solution sequence used to project these concepts. The combination employment ratio (RCMB) is defined as the ratio of CMB\_TOT to WSW.

$$\text{(Equation 2.3.1 not used in this version.)} \quad (2.3.1)$$

$$TE = TE(\cdot) \quad (2.3.2)$$

$$NCE = NCE(\cdot) \quad (2.3.3)$$

$$TCE = TE - NCE \quad (2.3.4)$$

$$SEO = SEO(\cdot) \quad (2.3.5)$$

$$WSW = TCE - SEO \quad (2.3.6)$$

$$RCMB = RCMB(\cdot) \quad (2.3.7)$$

$$CMB\_TOT = RCMB * WSW \quad (2.3.8)$$

$$CSW = SEO + CMB\_TOT \quad (2.3.9)$$



Total OASDI covered earnings is defined as the sum of OASDI covered wages (WSC) and total covered self-employed income (CSE\_TOT). Both components can be expressed as ratios to their U.S. earnings counterparts. The covered wage ratio (RWSC) is defined as the ratio of WSC to WSD, while the covered self-employed ratio (RCSE) is the ratio of CSE\_TOT to Y.

COV projects annual values for the principal measures of OASDI covered earnings using Equations 2.3.10 through 2.3.13.

$$RWSC = RWSC(\cdot) \quad (2.3.10)$$

$$WSC = RWSC * WSD \quad (2.3.11)$$

$$RCSE = RCSE(\cdot) \quad (2.3.12)$$

$$CSE\_TOT = RCSE * Y \quad (2.3.13)$$

COV projects various annual measures of average OASDI covered earnings, including the average covered wage (ACW), average covered self-employed income (ACSE), and average covered earnings (ACE).

$$ACW = WSC / WSW \quad (2.3.14)$$

$$ACSE = CSE\_TOT / CSW \quad (2.3.15)$$

$$ACE = (WSC + CSE\_TOT) / TCE \quad (2.3.16)$$

The average wage index (AWI) is based on the average wage of all workers with wages reported on Forms W-2 and posted to the Master Earnings File (MEF). By law, it is used to set the OASDI contribution and benefit base (TAXMAX).

COV projects annual values for the AWI and TAXMAX.

$$AWI = AWI(\cdot) \quad (2.3.17)$$

$$TAXMAX = TAXMAX(\cdot) \quad (2.3.18)$$

### **2.3.b. Input Data**

#### *Long-Range OASDI Projection Data*

1. Demography - (See Section 2.1.b.) (Econ Model workflow, section 3.a)
2. Economics- Employment and earnings-related data from Sections 2.1 and 2.2.

3. *Trustees Assumptions* - (See Section 2.1.b.) (Econ Model workflow, section 1)

#### *Addfactors*

4. Addfactors were included on some employment variables to smooth the transition from the latest historical data to program estimates. The need for addfactors is reviewed each year and they are implemented if necessary. (Econ Model workflow, section 3.m)

#### *Other input data*

5. Ratios of OASDI covered to NIPA wages by sector. NIPA wages by sector are available quarterly and annually from 1947 to 2017. They are published by the BEA and updated several times during the year. OASDI covered wages (1971 to 2015) are updated annually by the Economic process. Covered data for the latest historical year are estimated from tabulations of Form 941 and W-2 data. (Econ Model workflow, section 3.j.iii)
6. U.S. armed forces (EDMIL) by age and gender were estimated by the Department of Defense and published by the Census Bureau on a monthly basis (1948-2000) by single year of age (17 to 64) and gender. These data are no longer produced by Census. (Econ Model workflow, section 3.d.iv.8.b)
7. EDMIL by age and gender are estimated by the Economic process as the difference in the monthly resident plus Armed Forces overseas population and the monthly civilian population. These two populations are available from the Census Bureau on a monthly basis (April 2000 to October 2017) by single year of age (16 to 69) and gender. These data are updated once a year. (Econ Model workflow, section 3.d.iv)
8. Railroad employment is covered by the Railroad Retirement Act. The annual historical data are for the period 1971 to 2015. An additional new year of historical data from the Railroad Retirement Board is usually available for inclusion in preparation of the next annual Trustees Report. (Econ Model workflow, section 3.d.vi)
9. Data obtained from Office of Research, Evaluation, and Statistics (ORES) are tabulations of quarterly Form 941 data. Data currently used are the OASDI, HI, and income taxable wages by sector for the most recent five years. The data represent changes in reported wages since the prior quarterly report. The most recent data are appended to previously reported data. Annual totals are computed and used to derive estimates of OASDI covered wages by sector for the latest historical years. (Econ Model workflow, section 3.j.iii)

10. Data obtained from the most recently available 1.0% CWHS active file, maintained on Social Security's mainframe and made available by ORES. The years of data are 1951 to the third year prior to the current Trustees Report year. The data are used for comparison of OASDI covered earnings from other sources. (Econ Model workflow, section 3.j.i)
11. Data obtained from extracting information from the 1.0% Employee-Employer Files, maintained on Social Security's mainframe and made available by ORES. Each year two files are created: a Version 1 file for the third year prior to the current Trustees Report and a Version 3 file for the fifth year prior to the current Trustees Report. Data currently being used are government and farm sector OASDI, HI, and total wages and employment. Data from the latest files are used to estimate OASDI covered wages for the years available on each file. (Econ Model workflow, section 3.j.i)
12. Data obtained from quarterly IRS Form 941 files, provided by Office of Systems (OS). Data currently used are the OASDI and HI taxable wages for 1978 to the most recent year available. The data represent changes in reported wages since the prior quarterly report. The most recent data are appended to previously reported data. Annual totals are computed and used to derive estimates of HI taxable wages, which are then used to develop OASDI covered wages for the most recent historical years, as described in section 2.a of the 941 data workflow.
13. Data from the Quarterly EPOXY Report, received in hard copy and, more recently, electronic formats obtained from OS. The data currently used are the number of workers with OASDI taxable earnings, number of workers with HI taxable earnings, distribution of number of HI workers by wage intervals, distribution of number of OASDI workers by wage intervals, number of persons with OASDI taxable wages, number of persons with HI taxable wages, number of persons with OASDI taxable self-employment earnings, and number of persons with HI taxable self-employment earnings. Data are also available on an age-sex specific basis for number of persons with OASDI taxable wages, number of persons with HI taxable wages, number of persons with OASDI taxable self-employment earnings, and number of persons with HI taxable self-employment earnings. (Econ Model workflow, section 3.j.i.3)
14. Data obtained from the Quarterly Trust Fund Letter, received from Office of Financial Policy and Operations (OFPO). Data currently used are OASDI and HI taxable wages accumulated from all Forms 941 and W-2 to date, and changes in self-employment earnings and self-reported tips since the prior Letter. These data are for years 1978 to the most recent year available. (Revearn workflow, sections 2.q and 2.u)
15. Data obtained from OS on amounts of OASDI taxable wages on the Earnings Suspense File for 1937 through the second year prior to the current Trustees

Report year. The data are used in estimating total OASDI covered employment. (Econ Model workflow, section 3.j.ii)

16. Ratio of OASDI covered to NIPA wages, and ratio of OASDI taxable to covered wages. NIPA wages by sector are available quarterly and annually from 1947 to 2017. They are published by the BEA and updated several times during the year. OASDI covered and taxable wages (1971 to 2015) are updated annually by the Economic process. Covered and taxable data for more recent historical years are estimated from preliminary tabulations of Form 941 and W-2 data. Projected values for covered ratios are set to the latest historical year for the military, state and local, farm, and private household sectors. The projected value for the federal civilian sector covered ratio is projected to grow to 1.0 by 2030. The projected values for the private nonfarm business and the private sector vary with the relative size of the other-than-LPR population. (Econ Model workflow, section 3.j.iii.2)

### **2.3.c. Development of Output**

#### *Equation 2.3.2 - Total Employment (TE)*

Based on the CPS, BLS estimates the total number of persons with any work experience (WE) during a calendar year. Average weeks worked (AWW) during a calendar year is defined as  $AWW = E * 52 / WE$ . Based on a 100 percent count of earnings reports (i.e., Form W-2 and Schedule SE) tabulated by SSA, OCACT estimates the total number of persons employed at any time during a calendar year (TE). Compared to WE, TE is a broader measure of employment. WE is an estimate of the number of workers in the civilian noninstitutional US population age 16 and over. TE is an estimate of employment in the broader Social Security area population, which includes U.S. territories, the military, and institutions. TE also includes employment of workers who age 15 and younger.

AWW is disaggregated by gender and age and is projected as a function of a time trend and unemployment rate. WE is projected as  $(E * 52) / AWW$ . TE is projected as the product of its lagged value and the growth rate for WE. TE is adjusted by two multiplicative factors due to differences between E and TE over the recent historical period. The first factor accounts for the difference in growth between N and P between the last historical value for TE and the last historical value for E. The second factor adjusts the model estimate to the value of our most recent historical year, and our latest estimate based on partial quarterly data for that year.

#### *Equation 2.3.3 - Noncovered Employment (NCE)*

NCE is disaggregated by age and gender. Age groups include 14-15, 16-17, 18-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, and 70 and over. Employment may not be OASDI covered for a variety of reasons mostly related to the type of work. Consequently, NCE is further disaggregated to the type-of-work components listed

below.

Federal Civilian Government - All Federal civilian employees are HI (i.e., Medicare) covered. All Federal Civilian employees hired in January 1984 and later are covered under the Federal Employees Retirement System (FERS) and are OASDI covered. Employees hired before January 1984 are covered under the Civil Service Retirement System (CSRS) and are not OASDI covered. This “closed group” of relatively older CSRS employees is projected to fall to near zero by 2030.

State and Local Government - In 1983, about 70 percent of State and Local Government (S&L) employment and wages were covered under OASDI and HI. Beginning April 1986, all newly hired S&L employees were covered under HI. Beginning January 1990, all S&L employees not under an S&L retirement system were covered under OASDHI.

By 2013, about 28 and 4 percent of S&L employment (and wages) are still not covered under OASDI and HI respectively. The closed group of relatively older S&L employees not covered under HI is projected to fall to near zero by 2030. S&L employment not covered under OASDI is projected to grow at about the same rate as the labor force.

Students at Public Schools - Prior to 2000, students working at S&L public schools were covered under OASDI and HI if the other school employees were covered. In 2000, legislation offered an “open season” allowing schools to remove their students from coverage. Virtually all major schools opted for removal. Hence, almost no students working at their public schools are covered under OASDI or HI. Students at public schools are projected to grow at about the same rate as the population aged 18 to 24.

Election Workers - Most S&L election workers are subject to an earnings test and are not covered under OASDHI. The earnings test was raised from \$100 to \$1,000 beginning January 1995 and indexed beginning in 2000. Election workers are projected to grow at about the same rate as LC.

Private Household - The threshold for coverage of domestic employees’ earnings was raised from \$50 per calendar quarter to \$1,000 per calendar year (CY) per employee. Domestic workers are no longer covered if under age 18. Private household employment is projected to grow at about the same rate as E and vary with RTP.

Students at Private Schools - All students working in private schools are not covered under OASDHI. Students at private schools are projected to grow at about the same rate as the population aged 18 to 24.

Railroad - Employers do not submit payments for payroll taxes to the IRS for railroad employees. Railroad employees are projected by the Railroad Retirement Board.

Underground Economy Workers - Set to the at-any-time employed in the other-than-LPR population who have no reported earnings and therefore are part of the underground economy (i.e., TEO\_UND).

## Foreign Students and Exchange Visitors

### *Equation 2.3.5 - Self-Employed Only (SEO)*

SEO is projected to grow at the same rate as ES.

### *Equation 2.3.7 - Ratio of Combination Workers (RCMB)*

Total CMB\_TOT can be separated into two groups depending on whether they have OASDI covered wages under or over the TAXMAX. CMB\_TOT with covered wages under the TAXMAX have taxable wages and self-employed income. CMB\_TOT with covered wages over the TAXMAX have taxable wages only. CMB\_TOT with covered wages over the TAXMAX would have paid taxes on their self-employed income if the TAXMAX had been eliminated.

Total CMB\_TOT is projected as a ratio to WSW. This ratio is dependent on the RTP. If RTP rises, then the CMB\_TOT increases.

### *Equation 2.3.10 - Ratio of Covered Wages (RWSC)*

RWSC is disaggregated by the following sectors: Federal Civilian government, Federal Military, S&L government, and Private.

Federal Civilian government - Total Federal civilian employment and wages are split by retirement system. Those under FERS are OASDI covered, while those under CSRS are not. Hence, the RWSC for the Federal civilian employment is defined as the ratio of wages for employment under FERS to total Federal civilian wages. Employment and wages are projected for workers under each retirement system. Employment under CSRS is a closed group that is expected to fall to zero by about 2030. Employment under FERS is defined as total Federal employment less employment under CSRS. Total Federal civilian employment is projected to be constant over the short-range period, and about equal to the growth in the LC thereafter. The growth rates in the average wage for those under CSRS and FERS are projected based on, for the first five years, pay raises assumed under the most recent OMB FY Budget and on the growth rate in the CPI.

Federal Military - The RWSC for the Federal military sector is projected to remain constant at its latest actual historical level.

S&L government - The RWSC for the S&L government sector is projected to remain constant at its latest actual historical level.

Private - The private sector is separated into sub-sectors including private households, farm, railroad, tips, and a residual private “base”. The RWSCs for the private household and farm sub-sectors are projected to remain constant at their latest actual historical levels. By

definition, the RWSCs for the railroad and tips sub-sectors are projected to remain constant at 0.0 and 1.0, respectively. The projected RWSC for the private base sub-sector is dependent on the ratio of EO wage workers in the private base sub-sector who are covered under the OASDI program to all EO wage workers in the private base sub-sector. We assume that all of EO will be wage workers employed in the private residual base sub-sector of the economy and that the proportion of EO that is covered under the OASDI program will decrease. Therefore, we assume that the RWSC for the private residual base sector will also decrease.

*Equation 2.3.12 - Ratio of Covered Self-Employed Earnings (RCSE)*

The RCSE is projected to remain constant at its latest actual historical level.

*Equation 2.3.17 - Average Wage Index (AWI)*

The growth in the AWI is projected to be equal to the growth in the average wage for employees with any wages (covered and noncovered) posted to the MEF (AWS\_MEF). Total wages posted to the MEF (WS\_MEF) is equal to WSC less wages posted to the ESF plus any non-OASDI covered wages posted to the MEF. Similarly, the total number of employees with any wages posted to the MEF (WSW\_MEF) is equal to WSW less employees posted only to the ESF plus any employees with no OASDI covered wages posted to the MEF.

*Equation 2.3.18 - OASDI Taxable Maximum (TAXMAX)*

By law, the growth in the AWI is used to increase the TAXMAX.

## 2.4. Effective TAXABLE PAYROLL (TAXPAY)

### 2.4.a. Overview

TAXPAY estimates annual OASDI taxable earnings values including total employee taxable wages (WTEE), total employer taxable wages (WTER), and taxable self-employment income (SET). By law, each individual is required to pay the employee share of OASDI tax on wages from all covered jobs and the self-employment tax from self-employment income up to the TAXMAX. Each employer is required to withhold the employee share of the OASDI tax on the wages of each worker up to the TAXMAX, as well as paying the identical employer share. If an employee works more than one covered wage job and the sum of all covered wages exceeds the TAXMAX, the employee is due a refund. The employers involved are not due the refund. Hence, WTER is greater than WTEE. The difference (i.e., WTER less WTEE) is defined as multi-employer refund wages (MER). Individuals with covered wage employment who are also self-employed only owe taxes on their self-employment income to the extent that it does not exceed the TAXMAX after being added to the individual's covered wages.

TAXPAY estimates the annual OASDI effective taxable payroll (ETP) using the components discussed above. ETP is the amount of earnings in a year which, when multiplied by the combined employee-employer tax rate, yields the total amount of taxes due from wages and self-employment income in the year. ETP is used in estimating OASDI income and in determining income and cost rates and the actuarial balance. ETP is defined as WTER plus SET less one-half of MER.

The components of ETP are estimated by a collection of ratios. The employee taxable ratio (RWTEE) is defined as the ratio of WTEE to WSC. The multi-employer refund wage ratio (RMER) is defined as the ratio of MER to WSC. The self-employment income taxable ratio (RSET) is defined as the ratio of SET to CSE\_TOT. Equations 2.4.1 through 2.4.8 outline the projection methodology.

$$RWTEE = RWTEE(\cdot) \quad (2.4.1)$$

$$WTEE = RWTEE * WSC \quad (2.4.2)$$

$$RMER = RMER(\cdot) \quad (2.4.3)$$

$$MER = RMER * WSC \quad (2.4.4)$$

$$WTER = WTEE + MER \quad (2.4.5)$$

$$RSET = RSET(\cdot) \quad (2.4.6)$$

$$SET = RSET * CSE\_TOT \quad (2.4.7)$$

$$ETP = WTER + SET - 0.5 * MER \quad (2.4.8)$$



In order to conform to the Trustees' assumption that the ratio of ETP to the sum of WSC and CSE\_TOT is 0.825 in the final short range year (see below), TAXPAY solves equations 2.4.1 through 2.4.8 iteratively, altering the trend adjustment on RWTEE until the assumed ratio is reached.

#### **2.4.b. Input Data**

##### *1. Trustees Assumptions (Econ Model workflow, section 1.d)*

The Board of Trustees of the OASDI Trust Funds assumes that the ratio of effective OASDI taxable payroll to covered earnings for the final calendar year of the short-range period (2027) is 0.825 and remains approximately constant in subsequent years.

##### *Data used to obtain values input directly to model*

2. Data obtained from ORES by email for the amounts of single and multi-employer refunds for the latest 5 years. Each year, data are updated. (Revearn workflow, sections 2.d.i,2.e.i)
3. Data obtained from the most recently available 1.0% CWHS active file, maintained on Social Security's mainframe and made available by ORES. The years of data are 1951 to the third year prior to the current Trustees Report year. The data are used in estimating OASDI taxable wages for 1951 through 1977. (Revearn workflow, section 2.g)
4. Data for taxable wages and self-employment income for 1978 on and total OASDI taxable earnings for 1951 on from the quarterly EPOXY Report, provided by OS. The data currently used in subprocess 2.4 are the amounts of OASDI taxable earnings, wages, and self-employment income and amounts of multi-employer excess wages. (Revearn workflow, section 2.c, 2.d,2.g)
5. Data obtained from the Quarterly Trust Fund Letter (QTFL), received from OFPO. Data currently used are OASDI and HI taxable wages accumulated from all Forms 941 and W-2 to date, and changes in self-employment income and self-reported tips since the prior QTFL. The wage data are for years 1978 to the most recent year available and the self-employment income data for years 1951 to the most recent year available. (Revearn workflow, section 2.b,2.c,2.f,2.g)

##### *Long-Range OASDI Projection Data*

Historical and projected data from Section 2.3 are used as inputs.

#### **2.4.c. Development of Output**

##### *Equation 2.4.1 - Employee Taxable Ratio (RWTEE)*

Over the short-range projection horizon, the projected value for RWTEE is the sum of the model's "raw" estimate and an addfactor consisting of four components. The raw estimate for RWTEE is dependent on the distribution of workers by wage interval, the RELMAX, RTP, the age-gender distribution of wage workers, a time trend adjustment, and a base-year error adjustment. The projected distribution of workers by wage interval is an average (or amalgam) distribution over the 2000 through 2015 period. Holding other factors constant, a distribution with relatively more workers with wages over the TAXMAX leads to a lower RWTEE. The RELMAX is defined as the ratio of the TAXMAX to the ACW. A higher RELMAX leads to a higher RWTEE.

An increase in the RTP leads to a lower RWTEE. The change in the projected RWTEE due to the change in the age-gender distribution of wage workers is calculated by allowing employment by age and gender to change while holding taxable ratios (and average covered wages) by age and gender constant to levels in 1996. The time trend adjustment reduces the level of RWTEE by about 0.6 percentage point over the short-range projection horizon. The base-year error adjustment starts with the value obtained by subtracting the estimated value of RWTEE for the latest historical (or base) year from the actual value and phases this amount out linearly over the ten years of the short-range projection period.

*Equation 2.4.2 - Employee Taxable Wages (WTEE)*

WTEE is computed by multiplying the ratio of taxable employee wages to covered wages by the level of covered wages.

*Equation 2.4.3 - Multi-Employer Refund Wage Ratio (RMER)*

The RMER is functionally related to the RWTEE. As RWTEE approaches one, RMER approaches zero. In between the limit values, RMER is positive. Given the present position of RWTEE and RMER on the function, a projected decline in RWTEE leads to an increase in RMER.

The projected RMER is also dependent on RU. An increase in RU leads to a decrease in RMER.

RMER is assumed to remain constant in years after the short-range projection period.

*Equation 2.4.4 - Multi-Employer Refund Wages (MER)*

MER is computed by multiplying the ratio of multi-employer refund wages to covered wages by the level of covered wages.

*Equation 2.4.5 - Employer Taxable Wages (WTER)*

WTER is computed by adding employer taxable wages to multi-employer refund wages.

*Equation 2.4.6 - Self-Employed Net Income Taxable Ratio (RSET)*

The RSET is disaggregated by type of self-employed worker, SEO and CMB\_TOT.

SEO - The RSET is dependent on the distribution of self-employed workers by income interval and a RELMAX. The projected distribution of self-employed workers by income interval is set to the 2014 distribution. The RELMAX is defined here as the ratio of the TAXMAX to the average income for SEO. A higher RELMAX leads to a higher RSET.

CMB\_TOT - Taxable self-employed net income for CMB\_TOT is projected in two steps. First, a taxable earnings (wages and self-employment income) ratio for CMB\_TOT is projected based on the 2014 distribution and a RELMAX defined as the ratio of the TAXMAX to the average covered earnings. The projected level of taxable earnings for CMB\_TOT is the product of the estimated taxable earnings ratio for CMB\_TOT and their covered earnings. Second, a taxable wage ratio for CMB\_TOT is projected based on a RELMAX defined as the ratio of the TAXMAX to the average covered wage for CMB\_TOT. The projected level of taxable wages for CMB\_TOT is the product of the estimated taxable wage ratio for CMB\_TOT and their covered wages.

Taxable self-employed net income for CMB\_TOT is obtained by subtracting taxable wages from taxable earnings for CMB\_TOT.

A “combined” RSET is calculated as the ratio of the sum of taxable self-employment income for SEO and CMB\_TOT to CSE\_TOT. As with the RWTEE, the combined RSET is adjusted over the short-range period due to other factors (i.e., RTP, the age-gender distribution of workers, and a trend). The effect of the other factors are taken from RWTEE and “scaled.” That is, RSET is adjusted by a percent effect (as opposed to percentage point) that is equal to the percent change in RWTEE due to changes in these other factors.

It is important to note that while the RWTEE is held constant after the short-range period, the RSETs for self-employed workers are not. After the short-range period, the projected RSETs for SEO and CMB\_TOT continue to be dependent on their respective RELMAXs. Since by law the TAXMAX grows at the rate of the AWI and since ACSE is assumed to grow faster than the ACW (since only ACW declines with the growth in fringe benefits), the RELMAXs for self-employed workers decline over the long-range period while the RELMAX for wage workers is approximately constant. Hence, the RSETs for SEO and CMB\_TOT are projected to decline over the long-range period while the RWTEE is held constant.

#### *Equation 2.4.7 - Taxable Self-Employment Income (SET)*

SET is computed by multiplying the self-employment income taxable ratio by the level of covered self-employment income.

#### *Equation 2.4.8 – Effective Taxable Payroll (ETP)*

ETP is computed by adding employer taxable wages and taxable self-employment income and subtracting from that total one-half of multi-employer refund wages. (Only employees

can obtain refunds of excess taxes withheld in multi-employer refund wage cases.)

As noted above, in order to meet the Trustees' assumption that the ratio of ETP to total covered earnings is 0.825 in the last year of the short-range period, equations 2.4.1 through 2.4.8 are solved repeatedly with changes to the time-trend adjustment in equation 2.4.1 until the ratio is obtained.

## 2.5. REVENUES

### 2.5.a. Overview

Over the short-range projection horizon (i.e., first 10 years), REVENUES computes tax liabilities from wages and self-employment income, as well as the amount of taxes to be transferred from the trust funds to the general fund of the Treasury due to multi-employer refund wages. In Equation 2.5.1, WTL is the product of taxable wages and the combined OASDI employee-employer tax rate (TRW). In Equation 2.5.2, SEL is the product of SET and the OASDI self-employed tax rate (TRSE). In Equation 2.5.3, MERL is the product of MER and the OASDI employee tax rate (TRWEE).

$$WTL = WTER * TRW \quad (2.5.1)$$

$$SEL = SET * TRSE \quad (2.5.2)$$

$$MERL = MER * TRWEE \quad (2.5.3)$$

Also over the short-range horizon, REVENUES decomposes WTL into quarterly wage tax liabilities (WTLQ), then to quarterly wage tax collections (WTLQC). REVENUES also decomposes SEL into quarterly self-employment income tax collections (SELQC).

$$WTLQ = WTLQ(\cdot) \quad (2.5.4)$$

$$WTLQC = WTLQC(\cdot) \quad (2.5.5)$$

$$SELQC = SELQC(\cdot) \quad (2.5.6)$$

When determining the amount of payroll tax collections for the year, REVENUES subtracts the amount MERL from the sum of the WTLQC amounts.

Finally, over the first two projected quarters, REVENUES estimates of WTLQC and SELQC are replaced with ones from the most recent OMB FY Budget.

### 2.5.b. Input Data

*Data used to obtain values input directly to model*

1. Data obtained from ORES as tabulations of quarterly Form 941 data. Data currently used are the OASDI, HI, and income taxable wages by sector (Federal Civilian, military, farm, and State and Local) for the most recent five years. The data represent changes in reported wages since the prior quarterly report. The most recent data are appended to previously reported data. Annual totals are computed and used to derive estimates of OASDI taxable wages by sector for the latest historical years. (Revearn workflow, sections 2.i.ii, 2.k.i, 2.m.i, and 2.o.ii)

2. Data obtained from quarterly IRS Form 941 files, provided by OS. Data currently used are the OASDI and HI taxable wages for 1978 to the most recent year available. The OASDI data include a separate amount for agricultural wages. The data represent changes in reported wages since the prior quarterly report. The most recent data are appended to previously reported data. Annual totals are computed and used to derive estimates of OASDI total and farm taxable wages for the most recent historical years. (Revearn workflow, sections 2.g, 2.k, and 2.q)

*Values input directly to model*

Historical and projected data from Sections 2.1, 2.2, and 2.3 are used as input. Data for the following variables have final year of 2099. Each variable is shown with the starting year of the data. (Revearn Model workflow, section 3.a)

3.	<b>ADDSETREEOD</b>	<b>Total add factor to OASDI taxable to covered self-employment income ratio, 2016</b>
4.	<b>ADDWSTREEOD</b>	<b>Total add factor to OASDI taxable to covered wage ratio, 2016</b>
5.	<b>ADDWSTREEODTREND</b>	<b>Component of total add factor to OASDI taxable to covered wage ratio due to trend in ratio, 2016</b>
6.	<b>AIW</b>	<b>Average wage for indexing (\$), 1971</b>
7.	<b>AWSCFM</b>	<b>Average covered wage for farm workers (\$), 1971</b>
8.	<b>AWSCML</b>	<b>Average covered wage for military (\$), 1971</b>
9.	<b>DMWCHI</b>	<b>Deemed military wage credits for HI (\$ millions), 1983</b>
10.	<b>DMWCOD</b>	<b>Deemed military wage credits for OASDI (\$ millions), 1983</b>
11.	<b>ECFCHO</b>	<b>Number of HI-only covered Federal Civilian workers (millions), 1983</b>
12.	<b>ECFCOD</b>	<b>Number of OASDI covered Federal Civilian workers (millions), 1983</b>
13.	<b>ECHITOT</b>	<b>Number of HI covered workers (millions), 1987</b>
14.	<b>ECSEHI</b>	<b>Number of HI covered self-employed workers (millions), 1988</b>
15.	<b>ECSENO MAX</b>	<b>Number of covered self-employed workers if no taxable maximum (millions), 1988</b>
16.	<b>ECSEO</b>	<b>Number of OASDI covered self-employed only workers (millions), 1981</b>
17.	<b>ECSEOD</b>	<b>Number of OASDI covered self-employed workers (millions), 1981</b>
18.	<b>ECSLNOIS</b>	<b>Number of non-OASDI covered State and Local workers including students (millions), 1983</b>
19.	<b>ECSLP91</b>	<b>Number of State and Local workers covered under OASDI under pre-1991 law (millions), 1983</b>

20.	<b>ECSLNRP</b>	<b>Number of OASDI covered State and Local workers with no retirement plan (millions), 1983</b>
21.	<b>ECSLOD</b>	<b>Number of OASDI covered State and Local workers (millions), 1983</b>
22.	<b>ECWSHI</b>	<b>Number of HI covered wage workers (millions), 1981</b>
23.	<b>ECWSOD</b>	<b>Number of OASDI covered wage workers (millions), 1981</b>
24.	<b>ECWSOD_MEF</b>	<b>Number of OASDI covered wage workers on the Master Earnings File (MEF) in millions, 1981</b>
25.	<b>ECWSOD(sex, age)_MEF</b>	<b>Number of OASDI covered wage workers on the Master Earnings File (MEF) in millions by sex (M/F) and age group (Under 16, 16-19, 20-24, 25-29, ..., 60-64, 65-69, 70 and over (millions), 1981</b>
26.	<b>ESLCG</b>	<b>Number of State and Local workers not covered under HI (millions), 1983</b>
27.	<b>ESLSTUD</b>	<b>Number of noncovered students at public schools employed by their school (millions), 1983</b>
28.	<b>GAPLAG</b>	<b>Ratio of real to potential GDP (units), 1971</b>
29.	<b>RTP</b>	<b>Ratio of real to potential GDP (units), 1971</b>
30.	<b>RU</b>	<b>Civilian unemployment rate (percent), 1971</b>
31.	<b>SEECMB</b>	<b>Self-employed earnings of all SE workers who also earned wages in same year (\$ millions), 1991</b>
32.	<b>SEECHI</b>	<b>HI covered self-employed earnings (\$ millions), 1991</b>
33.	<b>SEECNOMAX</b>	<b>Covered self-employed earnings if no taxable maximum (\$ millions), 1991</b>
34.	<b>SEECOD</b>	<b>OASDI covered self-employed earnings (\$ millions), 1991</b>
35.	<b>SEECOD_OLD</b>	<b>OASDI covered self-employed earnings excluding self-employed earnings of workers with covered wages greater than or equal to the OASDI taxable maximum (\$ millions), 1971</b>
36.	<b>SEETODCMB</b>	<b>OASDI taxable self-employment earnings of combination workers (\$ billions), 1995</b>
37.	<b>SEETODEXOG</b>	<b>Total OASDI taxable self-employment earnings (\$ millions), 1995</b>
38.	<b>SEETODSEO</b>	<b>OASDI taxable self-employment earnings of self-employed only workers (\$ billions), 1995</b>
39.	<b>TAXMAXHI</b>	<b>HI taxable maximum (\$) – 0 indicates no maximum, 1971</b>
40.	<b>TAXMAXOD</b>	<b>OASDI taxable maximum (\$), 1971</b>
41.	<b>TCFCD</b>	<b>Proportion of annual Federal Civilian wages earned in each quarter (units), 1971</b>
42.	<b>TCMD</b>	<b>Proportion of annual military wages earned in</b>

43.	<b>TCPD</b>	<b>each quarter (units), 1971 Proportion of annual private sector wages earned in each quarter (units), 1971</b>
44.	<b>TCSLD</b>	<b>Proportion of annual State and Local wages earned in each quarter (units), 1971</b>
45.	<b>TETODCMB</b>	<b>Total OASDI taxable earnings of combination workers (\$ millions), 1995</b>
46.	<b>WSCCMB</b>	<b>Wages earned in same year by all SE workers with both types of earnings (\$ millions), 1991</b>
47.	<b>WSCFCHO</b>	<b>HI Covered wages of Federal Civilian HI-only workers (\$ millions), 1983</b>
48.	<b>WSCFCOD</b>	<b>OASDI Covered wages of Federal Civilian workers (\$ millions), 1971</b>
49.	<b>WSCFM</b>	<b>Covered wages of farm workers (\$ millions), 1971</b>
50.	<b>WSCHI</b>	<b>HI covered wages (\$ millions), 1971</b>
51.	<b>WSCML</b>	<b>Covered wages of members of the Armed Forces (\$ millions), 1971</b>
52.	<b>WSCOD</b>	<b>OASDI covered wages (\$ millions), 1971</b>
53.	<b>WSCOD_SF</b>	<b>OASDI covered wages on the Suspense File (\$ millions), 1971</b>
54.	<b>WSCP HH</b>	<b>Covered wages of private household workers (\$ millions), 1971</b>
55.	<b>WSCP NF</b>	<b>Covered wages of private nonfarm workers (\$ millions), 1971</b>
56.	<b>WCSLHI</b>	<b>HI covered State and Local wages (\$ millions), 1971</b>
57.	<b>WCSL NRP</b>	<b>Covered wages of State and Local workers with no retirement plan (\$ millions), 1991</b>
58.	<b>WCSL OD</b>	<b>OASDI covered State and Local wages (\$ millions), 1971</b>
59.	<b>WCSL P91</b>	<b>Wages of State and Local workers covered under OASDI under pre-1991 law (\$ millions), 1971</b>
60.	<b>WSD</b>	<b>Total NIPA wages (\$ millions), 1971</b>
61.	<b>WSP</b>	<b>Total NIPA private sector wages (\$ millions), 1971</b>
62.	<b>WSS</b>	<b>Total NIPA compensation (\$ millions), 1971</b>
63.	<b>WSSL CG</b>	<b>Wages of State and Local workers not covered under HI (\$ millions), 1983</b>
64.	<b>WSSL NOIS</b>	<b>Wages of non-OASDI covered State and Local workers including students (\$ millions), 1983</b>
65.	<b>WSSL STUD</b>	<b>Wages of noncovered students at public schools employed by their school (\$ millions), 1983</b>
66.	<b>WSMERE FODEXOG</b>	<b>OASDI multi-employer refund wages (\$ millions), 2015</b>
67.	<b>WSTEE ODEXOG</b>	<b>Total OASDI taxable wages (\$ millions), 2016</b>
68.	<b>WSTR RTPHI</b>	<b>Wages of railroad workers taxable under HI</b>



69. **WSTTIPSSR** (\$ millions), 1971  
Taxable tips reported by tip earner instead of employer (\$ millions), 1978
70. **WTWPO** Proportion of annual Postal Service wages earned in each quarter (units), 1971

*Other direct input data*

71. FICA, SECA, and Federal Employer tax transfers by month from the Department of the Treasury for years 1984 to 2017. (Revearn workflow, section 1.a)
72. FICA, SECA, and Federal Employer tax transfers by month from the Department of the Treasury for January and February 2018. (Revearn workflow, section 1.a)
73. FICA and SECA tax transfers by month split by liability period from the Department of the Treasury for January 1984 to February 2018. (Revearn workflow, section 1.b)
74. Historical annual HI taxable self-employment earnings for 1983 to 1993. (Values from 1994 on are equal to HI covered earnings and are obtained from subprocess COV.) (Revearn workflow, section 2.b) **does not affect SOSI**
75. Historical annual OASDI taxable self-employment earnings for 1971 to 2016. (Revearn workflow, section 2.c)
76. Historical annual HI multi-employer refund wages for 1983 to 1993 (Values for 1994 on are zero because of the elimination of the HI taxable maximum.) **does not affect SOSI**
77. Historical annual OASDI multi-employer refund wages for 1971 to 2016. (Revearn workflow, section 2.d)
78. Historical annual HI taxable wages for 1983 to 1993. (Values from 1994 on are equal to HI covered wages and are obtained from subprocess COV.) (Revearn workflow, section 2.f) **does not affect SOSI**
79. Historical annual OASDI taxable wages for 1971 to 2016. (Revearn workflow, section 2.g)
- 80.** Historical annual HI-only taxable Federal Civilian wages for 1983 to 1993. (Values from 1994 on are equal to HI-only covered wages and are obtained from subprocess COV.) (Revearn workflow, section 2.h) **does not affect SOSI**
81. Historical annual OASDI taxable Federal Civilian wages for 1983 to 2016. (Revearn workflow, section 2.i)

82. Historical annual HI taxable Federal Civilian wages for 1983 to 1993. (Values from 1994 on are equal to HI covered wages and are obtained from subprocess COV.) (Revearn workflow, section 2.j) **does not affect SOSI**
83. Historical annual OASDI taxable farm sector wages for 1971 to 2016. (Revearn workflow, section 2.k)
84. Historical annual HI taxable farm sector wages for 1991 to 1993. (Values from 1994 on are equal to HI covered wages and are obtained from subprocess COV.) (Revearn workflow, section 2.l) **does not affect SOSI**
85. Historical annual OASDI taxable military sector wages for 1971 to 2016. (Revearn workflow, section 2.m)
86. Historical annual HI taxable military sector wages for 1991 to 1993. (Values from 1994 on are equal to HI covered wages and are obtained from subprocess COV.) (Revearn workflow, section 2.n) **does not affect SOSI**
87. Historical annual OASDI taxable State and Local government sector wages for 1971 to 2016. (Revearn workflow, section 2.o)
88. Historical annual HI taxable State and Local government sector wages for 1983 to 1993. (Values from 1994 on are equal to HI covered wages and are obtained from subprocess COV.) (Revearn workflow, section 2.p) **does not affect SOSI**
89. Historical annual OASDI taxable tips for employees as reported by employers for 1971 to 2016. (Revearn workflow, section 2.q)
90. Historical and projected annual OASDI taxable tips for employers as reported by employers for 1980 to 1987. (No tips were taxable for employers prior to 1980. Employer taxable tips equal employee in 1988 and after.) (Revearn workflow, section 2.q)
91. Quarterly OASDI and **HI** taxable wages for calendar year 2017. (These values do not add up to the annual values as described above. These quarterly distributions are used to split the annual 2017 values.) (Revearn workflow, section 2.r) **HI values do not affect SOSI**
92. Historical FICA and SECA appropriation adjustments for OASI, DI, and **HI** by month for 1968 to 2017. (Revearn workflow, section 2.s) **HI values do not affect SOSI**
93. Estimated FICA and SECA appropriation adjustments for OASI, DI, and **HI** for March 2018 (Revearn workflow, section 2.t) **HI values do not affect SOSI**
94. Historical FICA revenues for OASI, DI, and **HI** by quarter for 1984 to 2017.

- (Revearn workflow, section 2.v) **HI values do not affect SOSI**
95. Historical SECA revenues for OASI, DI, and **HI** by quarter for 1984 to 2017. (Revearn workflow, section 2.v) **HI values do not affect SOSI**
  96. Historical Federal Employer revenues for OASI, DI, and **HI** by quarter for 1984 to 2017. (Revearn workflow, section 2.v) **HI values do not affect SOSI**
  97. Historical Deposits by States for OASI, DI, and **HI** by quarter for 1984 to 2017. (This is an obsolete type of revenue which has had no valid non-zero amount since 2002.) (Revearn workflow, section 2.v) **HI values do not affect SOSI**
  98. Historical single-employer refunds of excess taxes for OASI, DI, and **HI** by quarter for 1984 to 2017. (Revearn workflow, section 2.v) **HI values do not affect SOSI**
  99. Historical FICA credits for OASI and DI by quarter for 1984 to 2017. (Revearn workflow, section 2.v)
  100. Historical SECA credits for OASI, DI, and **HI** by quarter for 1984 to 2017. (Revearn workflow, section 2.v) **HI values do not affect SOSI**
  101. Historical multi-employer refunds of excess taxes for OASI, DI, and **HI** by month for 1968 to 2017. (Revearn workflow, section 2.w) **HI values do not affect SOSI**

Miscellaneous historical covered employment and earnings data:

102. HI Covered self-employed workers for 1986 to 1987 – variable ECSEHI. (Revearn workflow, section 2.x) **does not affect SOSI**
103. Number of OASDI covered wage workers for 1971 to 1980 – variable ECWSOD. (Revearn workflow, section 2.x)
104. HI covered self-employment earnings for 1971 to 1990 – variable SEECHI. (Revearn workflow, section 2.x) **does not affect SOSI**
105. Covered self-employment earnings if there were no taxable maximum for 1971 to 1990 – variable SEECNOMAX. (Revearn workflow, section 2.x)
106. OASDI covered self-employment earnings for 1971 to 1990 – variable SEECOD. (Revearn workflow, section 2.x)

Miscellaneous historical and fixed projected data:

107. Quarterly distribution of annual OASDI taxable farm wages for 1971 to 2100 – variable TTFMD. (Revearn workflow, section 2.y)

108. Quarterly OASDI covered private nonfarm sector wages for 1971 to 1975 – variable QWSCPNF. (Revearn workflow, section 2.y)
109. Quarterly OASDI covered State and Local government sector wages for 1971 to 1977 – variable QWSCSLOD. (Revearn workflow, section 2.y)
110. Quarterly OASDI covered military sector wages for 1971 to 1977 – variable QWSCML. (Revearn workflow, section 2.y)
111. Quarterly OASDI covered Federal Civilian sector wages for 1971 to 1977 – variable QWSCFCOD. (Revearn workflow, section 2.y)
112. Quarterly OASDI taxable private nonfarm sector wages for 1971 to 1977 – variable QWSTPNFEEOD. (Revearn workflow, section 2.y)
113. Quarterly OASDI taxable State and Local government sector wages for 1971 to 1980Q1 – variable QWSTSLEEOD. (Revearn workflow, section 2.y)
114. Quarterly OASDI taxable military sector wages for 1971 to 1977 – variable QWSTMLEEOD. (Revearn workflow, section 2.y)
115. Quarterly OASDI taxable Federal Civilian sector wages for 1971 to 1977 – variable QWSTFCEEOD. (Revearn workflow, section 2.y)
116. Quarterly OASDI taxable farm sector wages for 1971 to 1980 – variable QWSTFMEEOD. (Revearn workflow, section 2.y)
117. OASDI employee, employer, and self-employment tax rates from 1937 to 2100. These contribution rates are set according to the Social Security Act of 1935 and subsequent changes to the Act and to the Internal Revenue Code. The rates are updated when legislation mandates a change. The rates were unchanged from 2000 to 2015. The Bipartisan Budget Act of 2015 reallocated the OASI and DI employee-employer and self-employment tax rates for years 2016 through 2018. The OASDI rates remain the same and the rates revert to the ones in effect for 2000 to 2015 in 2019 and thereafter – variables RATEEO, RATEED, RATEEH, RATERO, RATERD, RATERH, RATSEO, RATSED, RATSEH. (Revearn workflow, section 2.y)
118. Annual OASDI employee credit tax rate for 1984 – variable CRATEEOD. (Revearn workflow, section 2.y)
119. Annual OASDI self-employment credit tax rates for 1984 to 1989 – variable CRATSEODH. (Revearn workflow, section 2.y)
120. Annual reductions in OASDI employee and self-employment tax rates due to the

payroll tax holiday for 2011 and 2012. (Revearn workflow, section 2.ee)

121. Annual trend variable for taxable to covered wage ratio calculation for 1971 to 2100 – variable TREND. (no longer used) (Revearn workflow, section 2.y)
122. Annual trend variable for taxable to covered self-employment earnings ratio calculation for 1971 to 2100 – variable SETRND. (no longer used) (Revearn workflow, section 2.y)
123. Average OASDI covered wages by age groups and gender for 1996. (Revearn workflow, section 2.aa)
124. Ratio of OASDI taxable to covered wages by age groups and gender for 1996. (Revearn workflow, section 2.bb)
125. Corrections to prior FICA appropriation adjustments made in March 2000. (Revearn workflow, section 2.cc)
126. Projected single-employer refund wages by calendar year for 2017 through 2028. (Revearn workflow, section 2.dd)
127. Projected ratio of OASDI taxable tips for the current year to the prior year for 2017 through 2028. (Revearn workflow, section 2.a)
128. FICA and SECA appropriation adjustments for OASI and DI related to HIRE Act of 2010. (Revearn workflow, section 2.u)
129. Estimated quarterly transfers provided to OTA for calendar years 2000 through 2018, 2nd quarter. (Revearn workflow, section 2.z)
130. Data needed to compute estimates of the ACA’s additional HI tax effective starting 2013. (Revearn workflow, section 2.ff) does not affect SOSI
131. Estimated tax transfers by liability period for the ACA’s additional HI tax for 2013Q1 through 2018Q2 used in computing adjustments. (Revearn workflow, section 2.gg) does not affect SOSI
132. Estimated tax transfers for the ACA’s additional HI tax for 2013Q1 through 2018Q2 used in computing adjustments. (Revearn workflow, section 2.hh) does not affect SOSI

### **2.5.c. Development of Output**

#### *Equation 2.5.1 – Annual Covered Wage Tax Liabilities (WTL)*

WTL is computed by multiplying the combined OASDI employee-employer tax rate by the OASDI taxable wages input from the PAYROLL subprocess. REVENUES estimates annual taxable wages for the Federal Civilian, Federal Military, S&L, Private Household, Farm, Self-reported Tips, and residual Private Nonfarm sectors. Liabilities by sector are computed by multiplying the combined OASDI employee-employer tax rate by OASDI taxable wages for each sector.

#### *Equation 2.5.2 – Annual Self-Employed Income Tax Collections (SEL)*

SEL is computed by multiplying the OASDI self-employment tax rate by the OASDI self-employment taxable income input from the PAYROLL subprocess.

#### *Equation 2.5.3 – Annual Multi-Employer Refund Wage Liabilities (MERL)*

MERL is computed by multiplying the OASDI employee tax rate by the OASDI multi-employer refund wages input from the PAYROLL subprocess.

#### *Equation 2.5.4 – Quarterly Covered Wage Tax Liabilities (WTLQ)*

Total WTLQ is summed from sector components that include Federal Civilian, Federal Military, S&L, Private Household, Farm, Self-reported Tips, and residual Private Nonfarm. Sector WTLQs are determined by computing ratios of quarterly to annual liabilities for each quarter. These are calculated for the Private Nonfarm, S&L, Federal Civilian and Military sectors. Each is dependent on the quarterly distribution of WSD and the RWTEE for the relevant sector, and on a payday adjustment that takes into account the actual number of paydays that fall into a particular calendar quarter. WTLQ ratios for the other sectors are assumed to be constants over the projection horizon.

#### *Equation 2.5.5 - Quarterly Wage Tax Collections (WTLQC)*

Employers incur tax liabilities when they pay wages to their employees. These liabilities are required to be deposited in the general fund of the U.S. Treasury by employers based on the amount of total payroll tax liability (income taxes plus Social Security and Medicare taxes withheld) accumulated. Some very large employers must deposit their tax liabilities the next banking day after paying their employees. Other levels of accumulated tax liabilities require depositing within three days and by the middle of the following month. If employers follow these deposit requirements, the result is that all tax liability for a particular quarter is deposited by the last day of the month following the end of the quarter. Thus, the WTLQC for any particular quarter are the sum of the tax liabilities deposited for wages paid in the same quarter and the liabilities deposited for wages paid in the prior quarter.

WTLQC are summed from sector components that include the Federal Civilian, Federal

Military, Farm, S&L, and residual Private Nonfarm (including Private Household and Self-Reported Tips). For the Federal Civilian and Military sectors, the WTLQC are set equal to their respective WTLQ since tax liabilities for the two sectors are considered collected immediately. The WTLQC for Farm is also set equal to its WTLQ, due in part to the fact that farms report tax liabilities annually. For the S&L and Private Nonfarm sectors, the WTLQC amount is computed by adding the product of WTLQ and the proportion of WTLQ that should be deposited in the same quarter in which the wages were paid to the WTLQ from the previous quarter which was not deposited in that quarter. Each quarter's proportion is based on the deposit requirements and estimates of accumulated tax liabilities, which in turn are based on firm size (or total wages paid). Separate proportions are estimated for the S&L and the Private Nonfarm sector because of the large difference in wage distributions between them.

*Equation 2.5.6 - Quarterly Self-Employed Income Tax Collections (SELQC)*

For wage workers, annual liabilities (WTL) are distributed to quarterly liabilities (WTLQ), which in turn are distributed to quarterly collections (WTLQC). However, for self-employed workers, annual liabilities (SEL) are distributed directly to SELQC, since self-employment income is only reported on an annual basis (on IRS Form 1040 Schedule SE).

SEL for a particular calendar year are distributed as collections to the four quarters of that year and to the first three quarters of the next year. This distribution uses quarterly proportions that are based on an historical pattern of the amount of SEL collected in each month, as estimated by the OTA. The OTA estimates reflect IRS regulations that require self-employed workers to deposit estimated tax liabilities four times a year (January, April, June, and September) and to make up any shortfall when filing Federal income tax returns in the following year. The program computes the collection distribution ratios based on the OTA estimates, which are input to the program. The ratios for projected years are determined by averaging the ratios for all years 1997 through the most recent year for which the OTA estimates are complete.

## *Appendix 2-1* *Equations*

### 2.1 U.S. Employment (USEMP)

#### UNEMPLOYMENT RATES, PRELIMINARY

##### MALES

$$RM1617\_P = RM1617\_P.1 + (-36.2076 * DIFF(RTP) - 14.2816 * DIFF(RTP.1) - 26.6756 * DIFF(RTP.2) - 16.9202 * DIFF(RTP.3)) * 50.00/44.72$$

RM1617

Ordinary Least Squares

QUARTERLY data for 132 periods from 1976Q1 to 2008Q4

Date: 23 OCT 2009

diff(rm1617)

$$\begin{aligned} = & - 36.2076 * \text{diff}(rtp) - 14.2816 * \text{diff}(rtp)[-1] \\ & (2.29349) \qquad (0.87160) \\ & - 26.6756 * \text{diff}(rtp)[-2] - 16.9202 * \text{diff}(rtp)[-3] \\ & (1.63426) \qquad (1.06303) \\ & + 1.64214 * \text{minw} - 0.90365 * \text{minw}[-1] + 0.06020 * \text{minw}[-2] \\ & (1.76311) \qquad (0.70381) \qquad (0.04365) \\ & - 0.77627 * \text{minw}[-3] - 0.12616 \\ & (0.72653) \qquad (0.26611) \end{aligned}$$

Sum Sq	198.967	Std Err	1.2719	LHS Mean	0.0553
R Sq	0.1483	R Bar Sq	0.0929	F	8,123
D.W.( 1)	2.5142	D.W.( 4)	2.3291		2.6769

$$RM1819\_P = RM1819\_P.1 + (-48.4227 * DIFF(RTP) - 25.8766 * DIFF(RTP.1) - 21.7466 * DIFF(RTP.2) + 1.1551 * DIFF(RTP.3)) * 50.00/44.72$$

RM1819

Ordinary Least Squares

QUARTERLY data for 132 periods from 1976Q1 to 2008Q4

Date: 23 OCT 2009

diff(rm1819)

$$\begin{aligned} = & - 48.4227 * \text{diff}(rtp) - 25.8766 * \text{diff}(rtp)[-1] \\ & (3.45103) \qquad (1.77685) \\ & - 21.7466 * \text{diff}(rtp)[-2] + 1.15512 * \text{diff}(rtp)[-3] \\ & (1.49900) \qquad (0.08165) \\ & + 0.62723 * \text{minw} - 0.48738 * \text{minw}[-1] + 0.67739 * \text{minw}[-2] \\ & (0.75770) \qquad (0.42710) \qquad (0.55270) \\ & - 0.79385 * \text{minw}[-3] - 0.11294 \\ & (0.83595) \qquad (0.26803) \end{aligned}$$

Sum Sq	157.172	Std Err	1.1304	LHS Mean	0.0235
R Sq	0.1890	R Bar Sq	0.1362	F	8,123
D.W.( 1)	2.6908	D.W.( 4)	2.4565		3.5828

$$RM2024\_P = RM2024\_P.1 + (-51.6518 * DIFF(RTP) - 16.6465 * DIFF(RTP.1) - 13.1350 * DIFF(RTP.2) - 10.9309 * DIFF(RTP.3)) * 50.00/44.72$$

RM2024

Ordinary Least Squares

QUARTERLY data for 132 periods from 1976Q1 to 2008Q4

Date: 23 OCT 2009



```
diff(rm2024)
= - 51.6518 * diff(rtp) - 16.6465 * diff(rtp)[-1]
  (7.75482)          (2.35721)
- 13.1350 * diff(rtp)[-2] - 10.9309 * diff(rtp)[-3] + 0.00093
  (1.86731)          (1.59404)          (0.01922)

Sum Sq    38.7297  Std Err    0.5522  LHS Mean  -0.0048
R Sq      0.4356   R Bar Sq   0.4178   F    4,127  24.5002
D.W.( 1)  2.4679   D.W.( 4)  2.2856
```

RM2529\_P = RM2529\_P.1 + (-37.9533 \* DIFF(RTP) - 17.3941 \* DIFF(RTP.1) - 14.9170 \* DIFF(RTP.2) - 7.0513 \* DIFF(RTP.3)) \* 50.00/44.72

```
RM2529
Ordinary Least Squares
QUARTERLY data for 129 periods from 1976Q4 to 2008Q4
Date: 23 OCT 2009
```

```
diff(rm2529)
= - 37.9533 * diff(rtp) - 17.3941 * diff(rtp)[-1]
  (7.06307)          (3.05222)
- 14.9170 * diff(rtp)[-2] - 7.05126 * diff(rtp)[-3] + 0.00609
  (2.61734)          (1.28703)          (0.15745)

Sum Sq    23.9433  Std Err    0.4394  LHS Mean   0.0095
R Sq      0.4417   R Bar Sq   0.4237   F    4,124  24.5278
D.W.( 1)  2.1341   D.W.( 4)  2.4166
```

RM3034\_P = RM3034\_P.1 + (-23.6417 \* DIFF(RTP) - 14.1284 \* DIFF(RTP.1) - 7.5008 \* DIFF(RTP.2) - 9.7232 \* DIFF(RTP.3)) \* 50.00/44.72

```
RM3034
Ordinary Least Squares
QUARTERLY data for 129 periods from 1976Q4 to 2008Q4
Date: 23 OCT 2009
```

```
diff(rm3034)
= - 23.6417 * diff(rtp) - 14.1286 * diff(rtp)[-1]
  (6.21241)          (3.50067)
- 7.50079 * diff(rtp)[-2] - 9.7232 * diff(rtp)[-3] + 0.01058
  (1.85832)          (2.50593)          (0.38580)

Sum Sq    12.0091  Std Err    0.3112  LHS Mean   0.0119
R Sq      0.4221   R Bar Sq   0.4034   F    4,124  22.6397
D.W.( 1)  2.1876   D.W.( 4)  1.8816
```

RM3539\_P = RM3539\_P.1 + (-27.6828 \* DIFF(RTP) - 5.4850 \* DIFF(RTP.1) - 10.8974 \* DIFF(RTP.2) - 9.8932 \* DIFF(RTP.3)) \* 50.00/44.72

```
RM3539
Ordinary Least Squares
QUARTERLY data for 129 periods from 1976Q4 to 2008Q4
Date: 23 OCT 2009
```

```
diff(rm3539)
= - 27.6828 * diff(rtp) - 5.48498 * diff(rtp)[-1]
  (6.57840)          (1.22901)
- 10.8974 * diff(rtp)[-2] - 9.8932 * diff(rtp)[-3] + 0.01127
  (2.44154)          (2.30580)          (0.37184)

Sum Sq    14.6843  Std Err    0.3441  LHS Mean   0.0130
R Sq      0.3795   R Bar Sq   0.3595   F    4,124  18.9589
D.W.( 1)  2.3381   D.W.( 4)  1.9092
```

RM4044\_P = RM4044\_P.1 + (-14.6558 \* DIFF(RTP) - 14.9735 \* DIFF(RTP.1) - 8.2594 \* DIFF(RTP.2) - 5.5023 \* DIFF(RTP.3)) \* 50.00/44.72

```
RM4044
Ordinary Least Squares
QUARTERLY data for 129 periods from 1976Q4 to 2008Q4
```

Date: 23 OCT 2009

diff(rm4044)

$$\begin{aligned} &= - 14.6558 * \text{diff}(rtp) - 14.9735 * \text{diff}(rtp)[-1] \\ &\quad (3.48851) \quad (3.36064) \\ &- 8.25944 * \text{diff}(rtp)[-2] - 5.50233 * \text{diff}(rtp)[-3] + 0.00570 \\ &\quad (1.85359) \quad (1.28455) \quad (0.18829) \end{aligned}$$

Sum Sq	14.6357	Std Err	0.3436	LHS Mean	0.0064
R Sq	0.2692	R Bar Sq	0.2456	F	4,124 11.4206
D.W.( 1)	2.6138	D.W.( 4)	2.0655		

RM4549\_P = RM4549\_P.1 + (-20.7806 \* DIFF(RTP) - 11.5121 \* DIFF(RTP.1) - 9.9409 \* DIFF(RTP.2) + 1.5480 \* DIFF(RTP.3)) \* 50.00/44.72

RM4549

Ordinary Least Squares

QUARTERLY data for 129 periods from 1976Q4 to 2008Q4

Date: 23 OCT 2009

diff(rm4549)

$$\begin{aligned} &= - 20.7806 * \text{diff}(rtp) - 11.5121 * \text{diff}(rtp)[-1] \\ &\quad (5.31669) \quad (2.77721) \\ &- 9.9409 * \text{diff}(rtp)[-2] + 1.54797 * \text{diff}(rtp)[-3] + 0.00874 \\ &\quad (2.39795) \quad (0.38844) \quad (0.31046) \end{aligned}$$

Sum Sq	12.6680	Std Err	0.3196	LHS Mean	0.0114
R Sq	0.3249	R Bar Sq	0.3031	F	4,124 14.9185
D.W.( 1)	2.2355	D.W.( 4)	1.7877		

RM5054\_P = RM5054\_P.1 + (-19.3341 \* DIFF(RTP) - 9.5336 \* DIFF(RTP.1) - 8.8784 \* DIFF(RTP.2) - 7.6218 \* DIFF(RTP.3)) \* 50.00/44.72

RM5054

Ordinary Least Squares

QUARTERLY data for 129 periods from 1976Q4 to 2008Q4

Date: 23 OCT 2009

diff(rm5054)

$$\begin{aligned} &= - 19.3341 * \text{diff}(rtp) - 9.5336 * \text{diff}(rtp)[-1] \\ &\quad (4.72314) \quad (2.19601) \\ &- 8.87840 * \text{diff}(rtp)[-2] - 7.62180 * \text{diff}(rtp)[-3] + 0.01083 \\ &\quad (2.04491) \quad (1.82617) \quad (0.36742) \end{aligned}$$

Sum Sq	13.8950	Std Err	0.3347	LHS Mean	0.0118
R Sq	0.2957	R Bar Sq	0.2730	F	4,124 13.0163
D.W.( 1)	2.1290	D.W.( 4)	1.7836		

RM5559\_P = RM5559\_P.1 + (-25.9031 \* DIFF(RTP) - 11.4442 \* DIFF(RTP.1) - 4.5421 \* DIFF(RTP.2) + 0.55815 \* DIFF(RTP.3)) \* 50.00/44.72

RM5559

Ordinary Least Squares

QUARTERLY data for 129 periods from 1976Q4 to 2008Q4

Date: 23 OCT 2009

diff(rm5559)

$$\begin{aligned} &= - 25.9031 * \text{diff}(rtp) - 11.4442 * \text{diff}(rtp)[-1] \\ &\quad (5.21572) \quad (2.17280) \\ &- 4.54211 * \text{diff}(rtp)[-2] + 0.55815 * \text{diff}(rtp)[-3] + 0.00326 \\ &\quad (0.86229) \quad (0.11023) \quad (0.09111) \end{aligned}$$

Sum Sq	20.4526	Std Err	0.4061	LHS Mean	0.0068
R Sq	0.2605	R Bar Sq	0.2366	F	4,124 10.9177
D.W.( 1)	2.2469	D.W.( 4)	1.7904		

RM6064\_P = RM6064\_P.1 + (1.3133 \* DIFF(RTP) - 12.9625 \* DIFF(RTP.1) - 2.4816 \* DIFF(RTP.2) - 14.4797 \* DIFF(RTP.3)) \* 50.00/44.72

RM6064

Ordinary Least Squares  
QUARTERLY data for 129 periods from 1976Q4 to 2008Q4  
Date: 23 OCT 2009

diff(rm6064)

$$= \begin{matrix} 1.31332 * \text{diff}(rtp) - 12.9625 * \text{diff}(rtp)[-1] \\ (0.25208) & (2.34596) \\ - 2.48164 * \text{diff}(rtp)[-2] - 14.4797 * \text{diff}(rtp)[-3] + 0.00491 \\ (0.44909) & (2.72583) & (0.13091) \end{matrix}$$

Sum Sq	22.5085	Std Err	0.4261	LHS Mean	0.0021	
R Sq	0.1187	R Bar Sq	0.0903	F	4,124	4.1768
D.W.( 1)	2.3485	D.W.( 4)	1.9007			

RM6569\_P = RM6569\_P.1 + (-19.5151 \* DIFF(RTP) + 4.9785 \* DIFF(RTP.1) - 13.3449 \* DIFF(RTP.2) + 2.4706 \* DIFF(RTP.3)) \* 50.00/44.72

RM6569

Ordinary Least Squares  
QUARTERLY data for 129 periods from 1976Q4 to 2008Q4  
Date: 23 OCT 2009

diff(rm6569)

$$= \begin{matrix} - 19.5151 * \text{diff}(rtp) + 4.97852 * \text{diff}(rtp)[-1] \\ (2.18595) & (0.52582) \\ - 13.3449 * \text{diff}(rtp)[-2] + 2.47056 * \text{diff}(rtp)[-3] - 0.01208 \\ (1.40935) & (0.27142) & (0.18783) \end{matrix}$$

Sum Sq	66.0895	Std Err	0.7301	LHS Mean	-0.0096	
R Sq	0.0551	R Bar Sq	0.0246	F	4,124	1.8065
D.W.( 1)	2.6235	D.W.( 4)	1.5080			

RM7074\_P = RM7074\_P.1 + (4.1938 \* DIFF(RTP) - 5.9012 \* DIFF(RTP.1) - 27.0406 \* DIFF(RTP.2) + 7.0400 \* DIFF(RTP.3)) \* 50.00/44.72

RM7074

Ordinary Least Squares  
QUARTERLY data for 111 periods from 1981Q2 to 2008Q4  
Date: 23 OCT 2009

diff(rm7074)

$$= \begin{matrix} 4.19384 * \text{diff}(rtp) - 5.90117 * \text{diff}(rtp)[-1] \\ (0.25776) & (0.34403) \\ - 27.0406 * \text{diff}(rtp)[-2] + 7.03995 * \text{diff}(rtp)[-3] + 0.02434 \\ (1.59539) & (0.43075) & (0.24587) \end{matrix}$$

Sum Sq	114.781	Std Err	1.0406	LHS Mean	0.0185	
R Sq	0.0282	R Bar Sq	-0.0085	F	4,106	0.7684
D.W.( 1)	2.8303	D.W.( 4)	1.7482			

RM750\_P = RM750\_P.1 + (-12.1042 \* DIFF(RTP) - 15.6142 \* DIFF(RTP.1) + 7.06185 \* DIFF(RTP.2) - 2.5738 \* DIFF(RTP.3)) \* 50.00/44.72

RM750

Ordinary Least Squares  
QUARTERLY data for 111 periods from 1981Q2 to 2008Q4  
Date: 23 OCT 2009

diff(rm750)

$$= \begin{matrix} - 12.1042 * \text{diff}(rtp) - 15.6142 * \text{diff}(rtp)[-1] \\ (0.80507) & (0.98509) \\ + 7.06185 * \text{diff}(rtp)[-2] - 2.57381 * \text{diff}(rtp)[-3] + 0.00860 \\ (0.45088) & (0.17042) & (0.09395) \end{matrix}$$

Sum Sq	98.0128	Std Err	0.9616	LHS Mean	0.0133	
R Sq	0.0212	R Bar Sq	-0.0157	F	4,106	0.5749
D.W.( 1)	2.6726	D.W.( 4)	1.8788			

**FEMALES**

$$RF1617\_P = RF1617\_P.1 + (-27.3243 * DIFF(RTP) + 13.4173 * DIFF(RTP.1) - 50.4583 * DIFF(RTP.2) - 0.3678 * DIFF(RTP.3)) * 50.00 / 44.72$$

RF1617

Ordinary Least Squares

QUARTERLY data for 132 periods from 1976Q1 to 2008Q4

Date: 23 OCT 2009

diff(rf1617)

$$= - 27.3243 * \text{diff}(rtp) + 13.4173 * \text{diff}(rtp)[-1]$$

$$(1.81297) \qquad (0.85773)$$

$$- 50.4583 * \text{diff}(rtp)[-2] - 0.36782 * \text{diff}(rtp)[-3]$$

$$(3.23806) \qquad (0.02421)$$

$$+ 0.33050 * \text{minw} + 0.19356 * \text{minw}[-1] + 0.18090 * \text{minw}[-2]$$

$$(0.37169) \qquad (0.15791) \qquad (0.13742)$$

$$- 0.68394 * \text{minw}[-3] - 0.13675$$

$$(0.67051) \qquad (0.30213)$$

Sum Sq	181.339	Std Err	1.2142	LHS Mean	-0.0136
R Sq	0.1227	R Bar Sq	0.0656	F	8,123 2.1501
D.W.( 1)	2.9150	D.W.( 4)	2.4862		

$$RF1819\_P = RF1819\_P.1 + (-42.6358 * DIFF(RTP) - 13.6261 * DIFF(RTP.1) + 9.5650 * DIFF(RTP.2) - 31.4798 * DIFF(RTP.3)) * 50.00 / 44.72$$

RF1819

Ordinary Least Squares

QUARTERLY data for 132 periods from 1976Q1 to 2008Q4

Date: 23 OCT 2009

diff(rf1819)

$$= - 42.6358 * \text{diff}(rtp) - 13.6261 * \text{diff}(rtp)[-1]$$

$$(3.54124) \qquad (1.09043)$$

$$+ 9.5650 * \text{diff}(rtp)[-2] - 31.4798 * \text{diff}(rtp)[-3]$$

$$(0.76838) \qquad (2.59333)$$

$$+ 0.27394 * \text{minw} - 0.95221 * \text{minw}[-1] + 1.01588 * \text{minw}[-2]$$

$$(0.38566) \qquad (0.97247) \qquad (0.96600)$$

$$- 0.32609 * \text{minw}[-3] - 0.05888$$

$$(0.40019) \qquad (0.16286)$$

Sum Sq	115.721	Std Err	0.9700	LHS Mean	-0.0217
R Sq	0.1706	R Bar Sq	0.1167	F	8,123 3.1631
D.W.( 1)	2.7048	D.W.( 4)	2.3991		

$$RF2024\_P = RF2024\_P.1 + (-16.9400 * DIFF(RTP) - 13.2669 * DIFF(RTP.1) - 7.8323 * DIFF(RTP.2) - 8.6887 * DIFF(RTP.3)) * 50.00 / 44.72$$

RF2024

Ordinary Least Squares

QUARTERLY data for 132 periods from 1976Q1 to 2008Q4

Date: 23 OCT 2009

diff(rf2024)

$$= - 16.9400 * \text{diff}(rtp) - 13.2669 * \text{diff}(rtp)[-1]$$

$$(3.09139) \qquad (2.28348)$$

$$- 7.83232 * \text{diff}(rtp)[-2] - 8.68870 * \text{diff}(rtp)[-3] - 0.02226$$

$$(1.35342) \qquad (1.54010) \qquad (0.56228)$$

Sum Sq	26.2142	Std Err	0.4543	LHS Mean	-0.0275
R Sq	0.1917	R Bar Sq	0.1663	F	4,127 7.5310
D.W.( 1)	2.5252	D.W.( 4)	2.1988		

$$RF2529\_P = RF2529\_P.1 + (-15.5798 * DIFF(RTP) - 11.9097 * DIFF(RTP.1) - 9.8424 * DIFF(RTP.2) - 2.7555 * DIFF(RTP.3)) * 50.00 / 44.72$$

RF2529

Ordinary Least Squares  
QUARTERLY data for 129 periods from 1976Q4 to 2008Q4  
Date: 23 OCT 2009

diff(rf2529)

$$\begin{aligned} &= - 15.5798 * \text{diff}(rtp) - 11.9097 * \text{diff}(rtp)[-1] \\ &\quad (3.32423) \quad (2.39607) \\ &- 9.8424 * \text{diff}(rtp)[-2] - 2.75548 * \text{diff}(rtp)[-3] - 0.01837 \\ &\quad (1.97999) \quad (0.57663) \quad (0.54398) \end{aligned}$$

Sum Sq	18.2145	Std Err	0.3833	LHS Mean	-0.0172
R Sq	0.2094	R Bar Sq	0.1839	F	4,124 8.2130
D.W.( 1)	2.3764	D.W.( 4)	2.0455		

RF3034\_P = RF3034\_P.1 + (-12.5396 \* DIFF(RTP) - 1.6601 \* DIFF(RTP.1) - 21.0289 \* DIFF(RTP.2) + 0.0881 \* DIFF(RTP.3))\*50.00/44.72

RF3034

Ordinary Least Squares  
QUARTERLY data for 129 periods from 1976Q4 to 2008Q4  
Date: 23 OCT 2009

diff(rf3034)

$$\begin{aligned} &= - 12.5396 * \text{diff}(rtp) - 1.66005 * \text{diff}(rtp)[-1] \\ &\quad (2.58233) \quad (0.32234) \\ &- 21.0289 * \text{diff}(rtp)[-2] + 0.08813 * \text{diff}(rtp)[-3] - 0.01851 \\ &\quad (4.08297) \quad (0.01780) \quad (0.52910) \end{aligned}$$

Sum Sq	19.5533	Std Err	0.3971	LHS Mean	-0.0179
R Sq	0.1929	R Bar Sq	0.1669	F	4,124 7.4100
D.W.( 1)	2.5217	D.W.( 4)	2.0509		

RF3539\_P = RF3539\_P.1 + (-21.9314 \* DIFF(RTP) - 3.0139 \* DIFF(RTP.1) - 7.8723 \* DIFF(RTP.2) - 6.4785 \* DIFF(RTP.3))\*50.00/44.72;

RF3539

Ordinary Least Squares  
QUARTERLY data for 129 periods from 1976Q4 to 2008Q4  
Date: 23 OCT 2009

diff(rf3539)

$$\begin{aligned} &= - 21.9314 * \text{diff}(rtp) - 3.01391 * \text{diff}(rtp)[-1] \\ &\quad (5.04991) \quad (0.65436) \\ &- 7.87232 * \text{diff}(rtp)[-2] - 6.47846 * \text{diff}(rtp)[-3] - 0.00217 \\ &\quad (1.70904) \quad (1.46307) \quad (0.06942) \end{aligned}$$

Sum Sq	15.6401	Std Err	0.3551	LHS Mean	-0.0005
R Sq	0.2453	R Bar Sq	0.2210	F	4,124 10.0778
D.W.( 1)	2.3835	D.W.( 4)	1.7499		

RF4044\_P = RF4044\_P.1 + (-7.7893 \* DIFF(RTP) - 7.7152 \* DIFF(RTP.1) - 5.7849 \* DIFF(RTP.2) - 2.7298 \* DIFF(RTP.3))\*50.00/44.72

RF4044

Ordinary Least Squares  
QUARTERLY data for 129 periods from 1976Q4 to 2008Q4  
Date: 23 OCT 2009

diff(rf4044)

$$\begin{aligned} &= - 7.78933 * \text{diff}(rtp) - 7.71518 * \text{diff}(rtp)[-1] \\ &\quad (1.61580) \quad (1.50905) \\ &- 5.78494 * \text{diff}(rtp)[-2] - 2.72977 * \text{diff}(rtp)[-3] - 0.00986 \\ &\quad (1.13141) \quad (0.55538) \quad (0.28389) \end{aligned}$$

Sum Sq	19.2707	Std Err	0.3942	LHS Mean	-0.0095
R Sq	0.0780	R Bar Sq	0.0483	F	4,124 2.6232
D.W.( 1)	2.2897	D.W.( 4)	2.2106		

RF4549\_P = RF4549\_P.1 + (-7.8747 \* DIFF(RTP) - 12.5212 \* DIFF(RTP.1) + 3.56675 \* DIFF(RTP.2) - 5.4812 \* DIFF(RTP.3)) \* 50.00 / 44.72  
RF4549

Ordinary Least Squares  
QUARTERLY data for 129 periods from 1976Q4 to 2008Q4  
Date: 23 OCT 2009

diff(rf4549)

$$\begin{aligned} &= - 7.87468 * \text{diff}(rtp) - 12.5212 * \text{diff}(rtp)[-1] \\ &\quad (1.73362) \qquad\qquad\qquad (2.59919) \\ &+ 3.56675 * \text{diff}(rtp)[-2] - 5.48119 * \text{diff}(rtp)[-3] - 0.00968 \\ &\quad (0.74033) \qquad\qquad\qquad (1.18351) \qquad\qquad\qquad (0.29587) \end{aligned}$$

Sum Sq	17.1092	Std Err	0.3715	LHS Mean	-0.0093	
R Sq	0.1055	R Bar Sq	0.0767	F	4,124	3.6575
D.W.( 1)	2.5032	D.W.( 4)	2.1339			

RF5054\_P = RF5054\_P.1 + (-9.7818 \* DIFF(RTP) - 3.1242 \* DIFF(RTP.1) - 14.0327 \* DIFF(RTP.2) - 4.0364 \* DIFF(RTP.3)) \* 50.00 / 44.72  
RF5054

Ordinary Least Squares  
QUARTERLY data for 129 periods from 1976Q4 to 2008Q4  
Date: 23 OCT 2009

diff(rf5054)

$$\begin{aligned} &= - 9.7818 * \text{diff}(rtp) - 3.12420 * \text{diff}(rtp)[-1] \\ &\quad (2.25978) \qquad\qquad\qquad (0.68055) \\ &- 14.0327 * \text{diff}(rtp)[-2] - 4.03638 * \text{diff}(rtp)[-3] - 0.00195 \\ &\quad (3.05649) \qquad\qquad\qquad (0.91457) \qquad\qquad\qquad (0.06247) \end{aligned}$$

Sum Sq	15.5373	Std Err	0.3540	LHS Mean	-0.0021	
R Sq	0.1556	R Bar Sq	0.1283	F	4,124	5.7111
D.W.( 1)	2.3211	D.W.( 4)	1.9891			

RF5559\_P = RF5559\_P.1 + (-2.4665 \* DIFF(RTP) - 4.8191 \* DIFF(RTP.1) - 11.4418 \* DIFF(RTP.2) - 3.5854 \* DIFF(RTP.3)) \* 50.00 / 44.72  
RF5559

Ordinary Least Squares  
QUARTERLY data for 129 periods from 1976Q4 to 2008Q4  
Date: 23 OCT 2009

diff(rf5559)

$$\begin{aligned} &= - 2.46651 * \text{diff}(rtp) - 4.81906 * \text{diff}(rtp)[-1] \\ &\quad (0.39811) \qquad\qquad\qquad (0.73342) \\ &- 11.4418 * \text{diff}(rtp)[-2] - 3.58538 * \text{diff}(rtp)[-3] - 0.00784 \\ &\quad (1.74120) \qquad\qquad\qquad (0.56759) \qquad\qquad\qquad (0.17561) \end{aligned}$$

Sum Sq	31.8294	Std Err	0.5066	LHS Mean	-0.0088	
R Sq	0.0474	R Bar Sq	0.0166	F	4,124	1.5416
D.W.( 1)	2.8260	D.W.( 4)	1.3743			

RF6064\_P = RF6064\_P.1 + (-22.1139 \* DIFF(RTP) + 4.5539 \* DIFF(RTP.1) - 6.2406 \* DIFF(RTP.2) - 7.0337 \* DIFF(RTP.3)) \* 50.00 / 44.72  
RF6064

Ordinary Least Squares  
QUARTERLY data for 129 periods from 1976Q4 to 2008Q4  
Date: 23 OCT 2009

diff(rf6064)

$$\begin{aligned} &= - 22.1139 * \text{diff}(rtp) + 4.55389 * \text{diff}(rtp)[-1] \\ &\quad (2.75662) \qquad\qquad\qquad (0.53526) \\ &- 6.24055 * \text{diff}(rtp)[-2] - 7.03372 * \text{diff}(rtp)[-3] - 0.00247 \\ &\quad (0.73345) \qquad\qquad\qquad (0.85995) \qquad\qquad\qquad (0.04266) \end{aligned}$$

Sum Sq	53.3640	Std Err	0.6560	LHS Mean	-0.0008
--------	---------	---------	--------	----------	---------

R Sq	0.0732	R Bar Sq	0.0433	F	4,124	2.4497
D.W.( 1)	3.0445	D.W.( 4)	1.3297			

$$RF6569\_P = RF6569\_P.1 + (9.2541 * DIFF(RTP) + 7.6281 * DIFF(RTP.1) - 22.5230 * DIFF(RTP.2) + 0.2738 * DIFF(RTP.3)) * 50.00 / 44.72$$

RF6569  
 Ordinary Least Squares  
 QUARTERLY data for 129 periods from 1976Q4 to 2008Q4  
 Date: 23 OCT 2009

```
diff(rf6569)
= 9.25410 * diff(rtp) + 7.62811 * diff(rtp)[-1]
(0.80440) (0.62521)
- 22.5230 * diff(rtp)[-2] + 0.27380 * diff(rtp)[-3] - 0.01724
(1.84584) (0.02334) (0.20808)
```

Sum Sq	109.749	Std Err	0.9408	LHS Mean	-0.0199	
R Sq	0.0329	R Bar Sq	0.0017	F	4,124	1.0547
D.W.( 1)	3.0050	D.W.( 4)	1.0241			

$$RF7074\_P = RF7074\_P.1 + (24.2237 * DIFF(RTP) + 8.3386 * DIFF(RTP.1) - 13.5317 * DIFF(RTP.2) - 8.1855 * DIFF(RTP.3)) * 50.00 / 44.72$$

RF7074  
 Ordinary Least Squares  
 QUARTERLY data for 111 periods from 1981Q2 to 2008Q4  
 Date: 23 OCT 2009

```
diff(rf7074)
= 24.2237 * diff(rtp) + 8.33858 * diff(rtp)[-1]
(1.28864) (0.42077)
- 13.5317 * diff(rtp)[-2] - 8.18546 * diff(rtp)[-3] + 0.01891
(0.69102) (0.43349) (0.16535)
```

Sum Sq	153.213	Std Err	1.2023	LHS Mean	0.0075	
R Sq	0.0218	R Bar Sq	-0.0151	F	4,106	0.5903
D.W.( 1)	2.6506	D.W.( 4)	1.6645			

$$RF750\_P = RF750\_P.1 + (-28.8294 * DIFF(RTP) + 55.5911 * DIFF(RTP.1) - 31.0676 * DIFF(RTP.2) - 15.8580 * DIFF(RTP.3)) * 50.00 / 44.72$$

RF750  
 Ordinary Least Squares  
 QUARTERLY data for 111 periods from 1981Q2 to 2008Q4  
 Date: 23 OCT 2009

```
diff(rf750)
= - 28.8294 * diff(rtp) + 55.5911 * diff(rtp)[-1]
(1.09028) (1.99419)
- 31.0676 * diff(rtp)[-2] - 15.8580 * diff(rtp)[-3] + 0.03090
(1.12786) (0.59703) (0.19206)
```

Sum Sq	303.162	Std Err	1.6912	LHS Mean	0.0324	
R Sq	0.0508	R Bar Sq	0.0149	F	4,106	1.4170
D.W.( 1)	2.6248	D.W.( 4)	1.5572			

**UNEMPLOYMENT RATES, AGE-GENDER ADJUSTED, PRELIMINARY**

$$RUM\_ASA\_P = (RM1617\_P * LM1617\_BY + RM1819\_P * LM1819\_BY + RM2024\_P * LM2024\_BY + RM2529\_P * LM2529\_BY + RM3034\_P * LM3034\_BY + RM3539\_P * LM3539\_BY + RM4044\_P * LM4044\_BY + RM4549\_P * LM4549\_BY + RM5054\_P * LM5054\_BY + RM5559\_P * LM5559\_BY + RM6064\_P * LM6064\_BY + RM6569\_P * LM6569\_BY + RM7074\_P * LM7074\_BY + RM750\_P * LM750\_BY) / LCM\_BY$$

$$\begin{aligned} \text{RUF\_ASA\_P} &= (\text{RF1617\_P} * \text{LF1617\_BY} + \text{RF1819\_P} * \text{LF1819\_BY} + \text{RF2024\_P} * \text{LF2024\_BY} + \text{RF2529\_P} * \text{LF2529\_BY} + \\ &\quad \text{RF3034\_P} * \text{LF3034\_BY} + \text{RF3539\_P} * \text{LF3539\_BY} + \text{RF4044\_P} * \text{LF4044\_BY} + \text{RF4549\_P} * \text{LF4549\_BY} + \\ &\quad \text{RF5054\_P} * \text{LF5054\_BY} + \text{RF5559\_P} * \text{LF5559\_BY} + \text{RF6064\_P} * \text{LF6064\_BY} + \text{RF6569\_P} * \text{LF6569\_BY} + \\ &\quad \text{RF7074\_P} * \text{LF7074\_BY} + \text{RF750\_P} * \text{LF750\_BY}) / \text{LCF\_BY} \\ \text{RU\_ASA\_P} &= (\text{RUM\_ASA\_P} * \text{LCM\_BY} + \text{RUF\_ASA\_P} * \text{LCF\_BY}) / \text{LC\_BY} \end{aligned}$$

## UNEMPLOYMENT RATES

### MALES

$$\begin{aligned} \text{RM1617} &= \text{RM1617\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RM1819} &= \text{RM1819\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RM2024} &= \text{RM2024\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RM2529} &= \text{RM2529\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RM3034} &= \text{RM3034\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RM3539} &= \text{RM3539\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RM4044} &= \text{RM4044\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RM4549} &= \text{RM4549\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RM5054} &= \text{RM5054\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RM5559} &= \text{RM5559\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RM6064} &= \text{RM6064\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RM6569} &= \text{RM6569\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RM7074} &= \text{RM7074\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RM750} &= \text{RM750\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \end{aligned}$$

### FEMALES

$$\begin{aligned} \text{RF1617} &= \text{RF1617\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RF1819} &= \text{RF1819\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RF2024} &= \text{RF2024\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RF2529} &= \text{RF2529\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RF3034} &= \text{RF3034\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RF3539} &= \text{RF3539\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RF4044} &= \text{RF4044\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RF4549} &= \text{RF4549\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RF5054} &= \text{RF5054\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RF5559} &= \text{RF5559\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RF6064} &= \text{RF6064\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RF6569} &= \text{RF6569\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RF7074} &= \text{RF7074\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \\ \text{RF750} &= \text{RF750\_P} * (1 + \text{RU\_ASA\_ADJ} / \text{RU\_ASA\_P}) \end{aligned}$$

## UNEMPLOYMENT RATES, AGE-GENDER ADJUSTED

$$\begin{aligned} \text{RUM\_ASA} &= (\text{RM1617} * \text{LM1617\_BY} + \text{RM1819} * \text{LM1819\_BY} + \text{RM2024} * \text{LM2024\_BY} + \text{RM2529} * \text{LM2529\_BY} + \\ &\quad \text{RM3034} * \text{LM3034\_BY} + \text{RM3539} * \text{LM3539\_BY} + \text{RM4044} * \text{LM4044\_BY} + \text{RM4549} * \text{LM4549\_BY} + \\ &\quad \text{RM5054} * \text{LM5054\_BY} + \text{RM5559} * \text{LM5559\_BY} + \text{RM6064} * \text{LM6064\_BY} + \text{RM6569} * \text{LM6569\_BY} + \\ &\quad \text{RM7074} * \text{LM7074\_BY} + \text{RM750} * \text{LM750\_BY}) / \text{LCM\_BY} \end{aligned}$$

$$\begin{aligned} \text{RUF\_ASA} &= (\text{RF1617} * \text{LF1617\_BY} + \text{RF1819} * \text{LF1819\_BY} + \text{RF2024} * \text{LF2024\_BY} + \text{RF2529} * \text{LF2529\_BY} + \\ &\quad \text{RF3034} * \text{LF3034\_BY} + \text{RF3539} * \text{LF3539\_BY} + \text{RF4044} * \text{LF4044\_BY} + \text{RF4549} * \text{LF4549\_BY} + \\ &\quad \text{RF5054} * \text{LF5054\_BY} + \text{RF5559} * \text{LF5559\_BY} + \text{RF6064} * \text{LF6064\_BY} + \text{RF6569} * \text{LF6569\_BY} + \\ &\quad \text{RF7074} * \text{LF7074\_BY} + \text{RF750} * \text{LF750\_BY}) / \text{LCF\_BY} \end{aligned}$$

$$\text{RU\_ASA} = (\text{RUM\_ASA} * \text{LCM\_BY} + \text{RUF\_ASA} * \text{LCF\_BY}) / \text{LC\_BY}$$



## UNEMPLOYMENT RATES, FULL EMPLOYMENT DIFFERENTIALS

### MALES

DRM1617\_FE = (-36.2076 \* (1 - RTP) - 14.2816 \* (1 - RTP.1) - 26.6756 \* (1 - RTP.2) - 16.9202 \* (1 - RTP.3))\*50.00/44.72  
DRM1819\_FE = (-48.4227 \* (1 - RTP) - 25.8766 \* (1 - RTP.1) - 21.7466 \* (1 - RTP.2) + 1.1551 \* (1 - RTP.3))\*50.00/44.72  
DRM2024\_FE = (-51.6518 \* (1 - RTP) - 16.6465 \* (1 - RTP.1) - 13.1350 \* (1 - RTP.2) - 10.9309 \* (1 - RTP.3))\*50.00/44.72  
DRM2529\_FE = (-37.9533 \* (1 - RTP) - 17.3941 \* (1 - RTP.1) - 14.9170 \* (1 - RTP.2) - 7.0513 \* (1 - RTP.3))\*50.00/44.72  
DRM3034\_FE = (-23.6417 \* (1 - RTP) - 14.1284 \* (1 - RTP.1) - 7.5008 \* (1 - RTP.2) - 9.7232 \* (1 - RTP.3))\*50.00/44.72  
DRM3539\_FE = (-27.6828 \* (1 - RTP) - 5.4850 \* (1 - RTP.1) - 10.8974 \* (1 - RTP.2) - 9.8932 \* (1 - RTP.3))\*50.00/44.72  
DRM4044\_FE = (-14.6558 \* (1 - RTP) - 14.9735 \* (1 - RTP.1) - 8.2594 \* (1 - RTP.2) - 5.5023 \* (1 - RTP.3))\*50.00/44.72  
DRM4549\_FE = (-20.7806 \* (1 - RTP) - 11.5121 \* (1 - RTP.1) - 9.9409 \* (1 - RTP.2) + 1.5480 \* (1 - RTP.3))\*50.00/44.72  
DRM5054\_FE = (-19.3341 \* (1 - RTP) - 9.5336 \* (1 - RTP.1) - 8.8784 \* (1 - RTP.2) - 7.6218 \* (1 - RTP.3))\*50.00/44.72  
DRM5559\_FE = (-25.9031 \* (1 - RTP) - 11.4442 \* (1 - RTP.1) - 4.5421 \* (1 - RTP.2) + 0.55815 \* (1 - RTP.3))\*50.00/44.72  
DRM6064\_FE = (1.3133 \* (1 - RTP) - 12.9625 \* (1 - RTP.1) - 2.4816 \* (1 - RTP.2) - 14.4797 \* (1 - RTP.3))\*50.00/44.72  
DRM6569\_FE = (-19.5151 \* (1 - RTP) + 4.9785 \* (1 - RTP.1) - 13.3449 \* (1 - RTP.2) + 2.4706 \* (1 - RTP.3))\*50.00/44.72  
DRM7074\_FE = 4.1938 \* (1 - RTP) - 5.9012 \* (1 - RTP.1) - 27.0406 \* (1 - RTP.2) + 7.0400 \* (1 - RTP.3))\*50.00/44.72  
DRM750\_FE = (-12.1042 \* (1 - RTP) - 15.6142 \* (1 - RTP.1) + 7.06185 \* (1 - RTP.2) - 2.5738 \* (1 - RTP.3))\*50.00/44.72

### FEMALES

DRF1617\_FE = (-27.3243 \* (1 - RTP) + 13.4173 \* (1 - RTP.1) - 50.4583 \* (1 - RTP.2) - 0.3678 \* (1 - RTP.3))\*50.00/44.72  
DRF1819\_FE = (-42.6358 \* (1 - RTP) - 13.6261 \* (1 - RTP.1) + 9.5650 \* (1 - RTP.2) - 31.4798 \* (1 - RTP.3))\*50.00/44.72  
DRF2024\_FE = (-16.9400 \* (1 - RTP) - 13.2669 \* (1 - RTP.1) - 7.8323 \* (1 - RTP.2) - 8.6887 \* (1 - RTP.3))\*50.00/44.72  
DRF2529\_FE = (-15.5798 \* (1 - RTP) - 11.9097 \* (1 - RTP.1) - 9.8424 \* (1 - RTP.2) - 2.7555 \* (1 - RTP.3))\*50.00/44.72  
DRF3034\_FE = (-12.5396 \* (1 - RTP) - 1.6601 \* (1 - RTP.1) - 21.0289 \* (1 - RTP.2) + 0.0881 \* (1 - RTP.3))\*50.00/44.72  
DRF3539\_FE = (-21.9314 \* (1 - RTP) - 3.0139 \* (1 - RTP.1) - 7.8723 \* (1 - RTP.2) - 6.4785 \* (1 - RTP.3))\*50.00/44.72  
DRF4044\_FE = (-7.7893 \* (1 - RTP) - 7.7152 \* (1 - RTP.1) - 5.7849 \* (1 - RTP.2) - 2.7298 \* (1 - RTP.3))\*50.00/44.72  
DRF4549\_FE = (-7.8747 \* (1 - RTP) - 12.5212 \* (1 - RTP.1) + 3.56675 \* (1 - RTP.2) - 5.4812 \* (1 - RTP.3))\*50.00/44.72  
DRF5054\_FE = (-9.7818 \* (1 - RTP) - 3.1242 \* (1 - RTP.1) - 14.0327 \* (1 - RTP.2) - 4.0364 \* (1 - RTP.3))\*50.00/44.72  
DRF5559\_FE = (-2.4665 \* (1 - RTP) - 4.8191 \* (1 - RTP.1) - 11.4418 \* (1 - RTP.2) - 3.5854 \* (1 - RTP.3))\*50.00/44.72  
DRF6064\_FE = (-22.1139 \* (1 - RTP) + 4.5539 \* (1 - RTP.1) - 6.2406 \* (1 - RTP.2) - 7.0337 \* (1 - RTP.3))\*50.00/44.72  
DRF6569\_FE = (9.2541 \* (1 - RTP) + 7.6281 \* (1 - RTP.1) - 22.5230 \* (1 - RTP.2) + 0.2738 \* (1 - RTP.3))\*50.00/44.72  
DRF7074\_FE = (24.2237 \* (1 - RTP) + 8.3386 \* (1 - RTP.1) - 13.5317 \* (1 - RTP.2) - 8.1855 \* (1 - RTP.3))\*50.00/44.72  
DRF750\_FE = (-28.8294 \* (1 - RTP) + 55.5911 \* (1 - RTP.1) - 31.0676 \* (1 - RTP.2) - 15.8580 \* (1 - RTP.3))\*50.00/44.72

## UNEMPLOYMENT RATES, FULL EMPLOYMENT DIFFERENTIALS

### TOTALS

#### MALES

RM1617\_FE = RM1617 + DRM1617\_FE  
RM1819\_FE = RM1819 + DRM1819\_FE  
RM2024\_FE = RM2024 + DRM2024\_FE  
RM2529\_FE = RM2529 + DRM2529\_FE  
RM3034\_FE = RM3034 + DRM3034\_FE  
RM3539\_FE = RM3539 + DRM3539\_FE  
RM4044\_FE = RM4044 + DRM4044\_FE  
RM4549\_FE = RM4549 + DRM4549\_FE  
RM5054\_FE = RM5054 + DRM5054\_FE  
RM5559\_FE = RM5559 + DRM5559\_FE  
RM6064\_FE = RM6064 + DRM6064\_FE  
RM6569\_FE = RM6569 + DRM6569\_FE  
RM7074\_FE = RM7074 + DRM7074\_FE  
RM750\_FE = RM750 + DRM750\_FE

RF1617\_FE = RF1617 + DRF1617\_FE  
RF1819\_FE = RF1819 + DRF1819\_FE  
RF2024\_FE = RF2024 + DRF2024\_FE  
RF2529\_FE = RF2529 + DRF2529\_FE

RF3034\_FE = RF3034 + DRF3034\_FE  
 RF3539\_FE = RF3539 + DRF3539\_FE  
 RF4044\_FE = RF4044 + DRF4044\_FE  
 RF4549\_FE = RF4549 + DRF4549\_FE  
 RF5054\_FE = RF5054 + DRF5054\_FE  
 RF5559\_FE = RF5559 + DRF5559\_FE  
 RF6064\_FE = RF6064 + DRF6064\_FE  
 RF6569\_FE = RF6569 + DRF6569\_FE  
 RF7074\_FE = RF7074 + DRF7074\_FE  
 RF75O\_FE = RF75O + DRF75O\_FE

## LABOR FORCE PARTICIPATION RATES (LFPR)

### MALE LFPR EQUATIONS

AGE 16 TO 19

$PM1617\_P = 0.98298 - 0.000026$   
 $- 0.368046 * RM1617DI$   
 $- (-0.78720 + 0.01330 * TR\_PM1617 + 0.00158 * RM1617 + 0.00180 * RM1617.1 + 0.00115 * RM1617.2 + 0.00014 * RM1617.3 -$   
 $0.00072 * RM1617.4 - 0.00094 * RM1617.5);$

$PM1819\_P = 0.97979 - 0.000070$   
 $- 0.614469 * RM1819DI$   
 $- (-0.50476 + 0.00764 * TR\_PM1819 + 0.00626 * MOVAVG(5, RM1819));$

$PM1617 = PM1617\_P;$   
 $PM1819 = PM1819\_P;$

AGE 20 TO 54

NEVER MARRIED

$PM2024NM\_P = 1.04005 - 0.00523 - 0.000143 - 0.00225 * TR\_PM2024$   
 $- 0.00063 * RM2024 - 0.00077 * RM2024.1 - 0.00059 * RM2024.2 - 0.00027 * RM2024.3 + 0.00005 * RM2024.4 + 0.00020 * RM2024.5$   
 $- 0.788895 * RM2024DI;$

$PM2529NM\_P = 0.97919 - 0.00809 + 0.000424 - 0.00070 * TR\_PM2529$   
 $- 0.00028 * RM2529 - 0.00044 * RM2529.1 - 0.00050 * RM2529.2 - 0.00047 * RM2529.3 - 0.00037 * RM2529.4 - 0.00021 * RM2529.5$   
 $- 0.887239 * RM2529DI;$

$PM3034NM\_P = 0.90427 + 0.000567$   
 $- 0.00046 * RM3034 - 0.00061 * RM3034.1 - 0.00054 * RM3034.2 - 0.00036 * RM3034.3 - 0.00014 * RM3034.4 + 0.00001 * RM3034.5$   
 $- 0.883076 * RM3034DI;$

$PM3539NM\_P = 0.86825 - 0.000105$   
 $- 0.00004 * RM3539 - 0.00010 * RM3539.1 - 0.00016 * RM3539.2 - 0.00021 * RM3539.3 - 0.00021 * RM3539.4 - 0.00015 * RM3539.5$   
 $- 0.846107 * RM3539DI;$

$PM4044NM\_P = 0.83977 - 0.001481$   
 $- 0.00057 * RM4044 - 0.00066 * RM4044.1 - 0.00044 * RM4044.2 - 0.00009 * RM4044.3 + 0.00022 * RM4044.4 + 0.00031 * RM4044.5$   
 $- 0.807518 * RM4044DI;$

$PM4549NM\_P = 0.81116 - 0.004005$   
 $- 0.00002 * RM4549 - 0.00016 * RM4549.1 - 0.00034 * RM4549.2 - 0.00049 * RM4549.3 - 0.00054 * RM4549.4 - 0.00040 * RM4549.5$

- 0.765856 \* RM4549DI;

PM5054NM\_P = 0.77540 - 0.010316  
+ 0.00112 \* RM5054 + 0.00103 \* RM5054.1 + 0.00023 \* RM5054.2 - 0.00078 \* RM5054.3 - 0.00149 \* RM5054.4 - 0.00139 \*  
RM5054.5  
- 0.715161 \* RM5054DI;

AGE 20 TO 54

MARRIED, SPOUSE PRESENT

PM2024MS\_P = 1.03184 - 0.00733 + 0.000543 - 0.00069 \* TR\_PM2024  
- 0.00063 \* RM2024 - 0.00077 \* RM2024.1 - 0.00059 \* RM2024.2 - 0.00027 \* RM2024.3 + 0.00005 \* RM2024.4 + 0.00020 \*  
RM2024.5  
- 0.937270 \* RM2024DI;

PM2529MS\_P = 1.00110 - 0.00498 + 0.001239 - 0.00025 \* TR\_PM2529  
- 0.00028 \* RM2529 - 0.00044 \* RM2529.1 - 0.00050 \* RM2529.2 - 0.00047 \* RM2529.3 - 0.00037 \* RM2529.4 - 0.00021 \*  
RM2529.5  
- 0.956095 \* RM2529DI;

PM3034MS\_P = 0.97120 + 0.001964 + 0.16457 \* 1/(TR\_PM3034 - 85)  
- 0.00046 \* RM3034 - 0.00061 \* RM3034.1 - 0.00054 \* RM3034.2 - 0.00036 \* RM3034.3 - 0.00014 \* RM3034.4 + 0.00001 \*  
RM3034.5  
- 0.961197 \* RM3034DI;

PM3539MS\_P = 0.98068 + 0.002566  
- 0.00004 \* RM3539 - 0.00010 \* RM3539.1 - 0.00016 \* RM3539.2 - 0.00021 \* RM3539.3 - 0.00021 \* RM3539.4 - 0.00015 \*  
RM3539.5  
- 0.958567 \* RM3539DI;

PM4044MS\_P = 0.98250 + 0.003434  
- 0.00057 \* RM4044 - 0.00066 \* RM4044.1 - 0.00044 \* RM4044.2 - 0.00009 \* RM4044.3 + 0.00022 \* RM4044.4 + 0.00031 \*  
RM4044.5  
- 0.950227 \* RM4044DI;

PM4549MS\_P = 0.98115 + 0.004829  
- 0.00002 \* RM4549 - 0.00016 \* RM4549.1 - 0.00034 \* RM4549.2 - 0.00049 \* RM4549.3 - 0.00054 \* RM4549.4 - 0.00040 \*  
RM4549.5  
- 0.935691 \* RM4549DI;

PM5054MS\_P = 0.94484 + 0.004732  
+ 0.00112 \* RM5054 + 0.00103 \* RM5054.1 + 0.00023 \* RM5054.2 - 0.00078 \* RM5054.3 - 0.00149 \* RM5054.4 - 0.00139 \*  
RM5054.5  
+ 0.09796 \* (RF5054CU6+RF5054C6O) - 0.901430 \* RM5054DI;

AGE 20 TO 54

MARRIED, SPOUSE ABSENT

PM2024MA\_P = 1.14087 - 0.01412 + 0.000270 - 0.00232 \* TR\_PM2024  
- 0.00063 \* RM2024 - 0.00077 \* RM2024.1 - 0.00059 \* RM2024.2 - 0.00027 \* RM2024.3 + 0.00005 \* RM2024.4 + 0.00020 \*  
RM2024.5  
- 0.878382 \* RM2024DI;

PM2529MA\_P = 0.98602 - 0.00788 + 0.000733 - 0.00051 \* TR\_PM2529  
- 0.00028 \* RM2529 - 0.00044 \* RM2529.1 - 0.00050 \* RM2529.2 - 0.00047 \* RM2529.3 - 0.00037 \* RM2529.4 - 0.00021 \*  
RM2529.5  
- 0.913332 \* RM2529DI;

PM3034MA\_P = 0.93933 + 0.001197  
- 0.00046 \* RM3034 - 0.00061 \* RM3034.1 - 0.00054 \* RM3034.2 - 0.00036 \* RM3034.3 - 0.00014 \* RM3034.4 + 0.00001 \*  
RM3034.5  
- 0.918267 \* RM3034DI;

$$\begin{aligned} \text{PM3539MA\_P} &= 0.92354 + 0.001209 \\ &- 0.00004 * \text{RM3539} - 0.00010 * \text{RM3539.1} - 0.00016 * \text{RM3539.2} - 0.00021 * \text{RM3539.3} - 0.00021 * \text{RM3539.4} - 0.00015 * \\ &\text{RM3539.5} \\ &- 0.901443 * \text{RM3539DI}; \end{aligned}$$

$$\begin{aligned} \text{PM4044MA\_P} &= 0.91512 + 0.001111 \\ &- 0.00057 * \text{RM4044} - 0.00066 * \text{RM4044.1} - 0.00044 * \text{RM4044.2} - 0.00009 * \text{RM4044.3} + 0.00022 * \text{RM4044.4} + 0.00031 * \\ &\text{RM4044.5} \\ &- 0.882777 * \text{RM4044DI}; \end{aligned}$$

$$\begin{aligned} \text{PM4549MA\_P} &= 0.89473 + 0.000334 \\ &- 0.00002 * \text{RM4549} - 0.00016 * \text{RM4549.1} - 0.00034 * \text{RM4549.2} - 0.00049 * \text{RM4549.3} - 0.00054 * \text{RM4549.4} - 0.00040 * \\ &\text{RM4549.5} \\ &- 0.849283 * \text{RM4549DI}; \end{aligned}$$

$$\begin{aligned} \text{PM5054MA\_P} &= 0.84912 - 0.004345 \\ &+ 0.00112 * \text{RM5054} + 0.00103 * \text{RM5054.1} + 0.00023 * \text{RM5054.2} - 0.00078 * \text{RM5054.3} - 0.00149 * \text{RM5054.4} - 0.00139 * \\ &\text{RM5054.5} \\ &- 0.789075 * \text{RM5054DI}; \end{aligned}$$

#### AGE 20 TO 54

$$\begin{aligned} \text{PM2024\_P} &= (\text{PM2024NM\_P} * \text{NM2024NM} + \text{PM2024MS\_P} * \text{NM2024MS} + \text{PM2024MA\_P} * \text{NM2024MA}) / \text{NM2024}; \\ \text{PM2529\_P} &= (\text{PM2529NM\_P} * \text{NM2529NM} + \text{PM2529MS\_P} * \text{NM2529MS} + \text{PM2529MA\_P} * \text{NM2529MA}) / \text{NM2529}; \\ \text{PM3034\_P} &= (\text{PM3034NM\_P} * \text{NM3034NM} + \text{PM3034MS\_P} * \text{NM3034MS} + \text{PM3034MA\_P} * \text{NM3034MA}) / \text{NM3034}; \\ \text{PM3539\_P} &= (\text{PM3539NM\_P} * \text{NM3539NM} + \text{PM3539MS\_P} * \text{NM3539MS} + \text{PM3539MA\_P} * \text{NM3539MA}) / \text{NM3539}; \\ \text{PM4044\_P} &= (\text{PM4044NM\_P} * \text{NM4044NM} + \text{PM4044MS\_P} * \text{NM4044MS} + \text{PM4044MA\_P} * \text{NM4044MA}) / \text{NM4044}; \\ \text{PM4549\_P} &= (\text{PM4549NM\_P} * \text{NM4549NM} + \text{PM4549MS\_P} * \text{NM4549MS} + \text{PM4549MA\_P} * \text{NM4549MA}) / \text{NM4549}; \\ \text{PM5054\_P} &= (\text{PM5054NM\_P} * \text{NM5054NM} + \text{PM5054MS\_P} * \text{NM5054MS} + \text{PM5054MA\_P} * \text{NM5054MA}) / \text{NM5054}; \end{aligned}$$

$$\begin{aligned} \text{PM2024} &= \text{PM2024\_P}; \\ \text{PM2529} &= \text{PM2529\_P}; \\ \text{PM3034} &= \text{PM3034\_P}; \\ \text{PM3539} &= \text{PM3539\_P}; \\ \text{PM4044} &= \text{PM4044\_P}; \\ \text{PM4549} &= \text{PM4549\_P}; \\ \text{PM5054} &= \text{PM5054\_P}; \end{aligned}$$

$$\begin{aligned} \text{PM2024NM} &= \text{PM2024NM\_P} * \text{PM2024} / \text{PM2024\_P}; \\ \text{PM2529NM} &= \text{PM2529NM\_P} * \text{PM2529} / \text{PM2529\_P}; \\ \text{PM3034NM} &= \text{PM3034NM\_P} * \text{PM3034} / \text{PM3034\_P}; \\ \text{PM3539NM} &= \text{PM3539NM\_P} * \text{PM3539} / \text{PM3539\_P}; \\ \text{PM4044NM} &= \text{PM4044NM\_P} * \text{PM4044} / \text{PM4044\_P}; \\ \text{PM4549NM} &= \text{PM4549NM\_P} * \text{PM4549} / \text{PM4549\_P}; \\ \text{PM5054NM} &= \text{PM5054NM\_P} * \text{PM5054} / \text{PM5054\_P}; \end{aligned}$$

$$\begin{aligned} \text{PM2024MS} &= \text{PM2024MS\_P} * \text{PM2024} / \text{PM2024\_P}; \\ \text{PM2529MS} &= \text{PM2529MS\_P} * \text{PM2529} / \text{PM2529\_P}; \\ \text{PM3034MS} &= \text{PM3034MS\_P} * \text{PM3034} / \text{PM3034\_P}; \\ \text{PM3539MS} &= \text{PM3539MS\_P} * \text{PM3539} / \text{PM3539\_P}; \\ \text{PM4044MS} &= \text{PM4044MS\_P} * \text{PM4044} / \text{PM4044\_P}; \\ \text{PM4549MS} &= \text{PM4549MS\_P} * \text{PM4549} / \text{PM4549\_P}; \\ \text{PM5054MS} &= \text{PM5054MS\_P} * \text{PM5054} / \text{PM5054\_P}; \end{aligned}$$

$$\begin{aligned} \text{PM2024MA} &= \text{PM2024MA\_P} * \text{PM2024} / \text{PM2024\_P}; \\ \text{PM2529MA} &= \text{PM2529MA\_P} * \text{PM2529} / \text{PM2529\_P}; \\ \text{PM3034MA} &= \text{PM3034MA\_P} * \text{PM3034} / \text{PM3034\_P}; \\ \text{PM3539MA} &= \text{PM3539MA\_P} * \text{PM3539} / \text{PM3539\_P}; \\ \text{PM4044MA} &= \text{PM4044MA\_P} * \text{PM4044} / \text{PM4044\_P}; \\ \text{PM4549MA} &= \text{PM4549MA\_P} * \text{PM4549} / \text{PM4549\_P}; \\ \text{PM5054MA} &= \text{PM5054MA\_P} * \text{PM5054} / \text{PM5054\_P}; \end{aligned}$$

#### AGE 55 TO 61

$$\begin{aligned} \text{PM55\_P} = & -0.76902 + 0.000142 - 0.818694 * \text{RM55DI} + \text{PM55E\_DE} + \text{PM55\_DM} \\ & + 0.00062 * \text{RM5559} + 0.00041 * \text{RM5559.1} - 0.00026 * \text{RM5559.2} - 0.00101 * \text{RM5559.3} - 0.00147 * \text{RM5559.4} - 0.00126 * \\ & \text{RM5559.5}; \end{aligned}$$

$$\begin{aligned} \text{PM56\_P} = & -0.76098 - 0.002143 - 0.798138 * \text{RM56DI} + \text{PM56E\_DE} + \text{PM56\_DM} \\ & + 0.00062 * \text{RM5559} + 0.00041 * \text{RM5559.1} - 0.00026 * \text{RM5559.2} - 0.00101 * \text{RM5559.3} - 0.00147 * \text{RM5559.4} - 0.00126 * \\ & \text{RM5559.5}; \end{aligned}$$

$$\begin{aligned} \text{PM57\_P} = & -0.71065 - 0.004979 - 0.776220 * \text{RM57DI} + \text{PM57E\_DE} + \text{PM57\_DM} \\ & + 0.00062 * \text{RM5559} + 0.00041 * \text{RM5559.1} - 0.00026 * \text{RM5559.2} - 0.00101 * \text{RM5559.3} - 0.00147 * \text{RM5559.4} - 0.00126 * \\ & \text{RM5559.5}; \end{aligned}$$

$$\begin{aligned} \text{PM58\_P} = & -0.69412 - 0.007970 - 0.755977 * \text{RM58DI} + \text{PM58E\_DE} + \text{PM58\_DM} \\ & + 0.00062 * \text{RM5559} + 0.00041 * \text{RM5559.1} - 0.00026 * \text{RM5559.2} - 0.00101 * \text{RM5559.3} - 0.00147 * \text{RM5559.4} - 0.00126 * \\ & \text{RM5559.5}; \end{aligned}$$

$$\begin{aligned} \text{PM59\_P} = & -0.60153 - 0.012123 - 0.730720 * \text{RM59DI} + \text{PM59E\_DE} + \text{PM59\_DM} \\ & + 0.00062 * \text{RM5559} + 0.00041 * \text{RM5559.1} - 0.00026 * \text{RM5559.2} - 0.00101 * \text{RM5559.3} - 0.00147 * \text{RM5559.4} - 0.00126 * \\ & \text{RM5559.5}; \end{aligned}$$

$$\begin{aligned} \text{PM60\_P} = & -0.58858 - 0.011072 + 0.000362 - 0.682175 * \text{RM60DI} + \text{PM60E\_DE} + \text{PM60\_DM} \\ & + 0.00203 * \text{RM6064} + 0.00160 * \text{RM6064.1} - 0.00021 * \text{RM6064.2} - 0.00235 * \text{RM6064.3} - 0.00374 * \text{RM6064.4} - 0.00331 * \\ & \text{RM6064.5} \\ & + 0.01566 * \text{PF58}; \end{aligned}$$

$$\begin{aligned} \text{PM61\_P} = & -0.55646 - 0.019672 + 0.002517 - 0.647667 * \text{RM61DI} + \text{PM61E\_DE} + \text{PM61\_DM} \\ & + 0.00203 * \text{RM6064} + 0.00160 * \text{RM6064.1} - 0.00021 * \text{RM6064.2} - 0.00235 * \text{RM6064.3} - 0.00374 * \text{RM6064.4} - 0.00331 * \\ & \text{RM6064.5} \\ & + 0.08544 * \text{PF59}; \end{aligned}$$

#### AGE 62 TO 74

$$\begin{aligned} \text{PM62\_P} = & 0.26329 * \text{PF60} - 0.29161 - 0.544582 * \text{RM61DI.4} + \text{PM62E\_DE} + \text{PM62\_DM} - 0.056836 + 0.008814 \\ & + 0.00203 * \text{RM6064} + 0.00160 * \text{RM6064.1} - 0.00021 * \text{RM6064.2} - 0.00235 * \text{RM6064.3} - 0.00374 * \text{RM6064.4} - 0.00331 * \\ & \text{RM6064.5} \\ & - 0.60 * \text{RRADJ\_M62} - 0.02 * \text{POT\_ET\_TXRT\_62}; \end{aligned}$$

$$\begin{aligned} \text{PM63\_P} = & 0.40940 * \text{PF61} - 0.29495 - 0.480592 * \text{RM61DI.8} + \text{PM63E\_DE} + \text{PM63\_DM} - 0.085295 + 0.017121 \\ & + 0.00203 * \text{RM6064} + 0.00160 * \text{RM6064.1} - 0.00021 * \text{RM6064.2} - 0.00235 * \text{RM6064.3} - 0.00374 * \text{RM6064.4} - 0.00331 * \\ & \text{RM6064.5} \\ & - 0.55 * \text{RRADJ\_M63} - 0.02 * \text{POT\_ET\_TXRT\_63}; \end{aligned}$$

$$\begin{aligned} \text{PM64\_P} = & 0.47933 * \text{PF62} - 0.22665 - 0.435189 * \text{RM61DI.12} + \text{PM64E\_DE} + \text{PM64\_DM} - 0.113466 + 0.030849 \\ & + 0.00203 * \text{RM6064} + 0.00160 * \text{RM6064.1} - 0.00021 * \text{RM6064.2} - 0.00235 * \text{RM6064.3} - 0.00374 * \text{RM6064.4} - 0.00331 * \\ & \text{RM6064.5} \\ & - 0.50 * \text{RRADJ\_M64} - 0.02 * \text{POT\_ET\_TXRT\_64}; \end{aligned}$$

$$\begin{aligned} \text{PM65\_P} = & 0.72722 * \text{PF63} - 0.35819 - 0.368105 * \text{RM61DI.16} + \text{PM65E\_DE} + \text{PM65\_DM} - 0.016932 + 0.059764 \\ & + 0.00067 * \text{RM6569} + 0.00040 * \text{RM6569.1} - 0.00040 * \text{RM6569.2} - 0.00127 * \text{RM6569.3} - 0.00178 * \text{RM6569.4} - 0.00151 * \\ & \text{RM6569.5} \\ & - 0.45 * \text{RRADJ\_M65} - 0.02 * \text{POT\_ET\_TXRT\_65}; \end{aligned}$$

$$\begin{aligned} \text{PM66\_P} = & 0.38684 * \text{PF64} - 0.20883 - 0.330352 * \text{RM61DI.20} + \text{PM66E\_DE} + \text{PM66\_DM} + 0.000194 + 0.036539 \\ & + 0.00067 * \text{RM6569} + 0.00040 * \text{RM6569.1} - 0.00040 * \text{RM6569.2} - 0.00127 * \text{RM6569.3} - 0.00178 * \text{RM6569.4} - 0.00151 * \\ & \text{RM6569.5} \\ & - 0.40 * \text{RRADJ\_M66} - 0.02 * \text{POT\_ET\_TXRT\_66}; \end{aligned}$$

$$\begin{aligned} \text{PM67\_P} = & 0.35012 * \text{PF65} - 0.15975 - 0.294277 * \text{RM61DI.24} + \text{PM67E\_DE} + \text{PM67\_DM} + 0.042362 - 0.012475 \\ & + 0.00067 * \text{RM6569} + 0.00040 * \text{RM6569.1} - 0.00040 * \text{RM6569.2} - 0.00127 * \text{RM6569.3} - 0.00178 * \text{RM6569.4} - 0.00151 * \\ & \text{RM6569.5} \\ & - 0.35 * \text{RRADJ\_M67} - 0.02 * \text{POT\_ET\_TXRT\_67}; \end{aligned}$$

$$\begin{aligned} \text{PM68\_P} = & 0.95984 * \text{PF66} - 0.26305 - 0.269452 * \text{RM61DI.28} + \text{PM68E\_DE} + \text{PM68\_DM} + 0.057835 - 0.027492 \\ & + 0.00067 * \text{RM6569} + 0.00040 * \text{RM6569.1} - 0.00040 * \text{RM6569.2} - 0.00127 * \text{RM6569.3} - 0.00178 * \text{RM6569.4} - 0.00151 * \\ & \text{RM6569.5} \\ & - 0.30 * \text{RRADJ\_M68} - 0.02 * \text{POT\_ET\_TXRT\_68}; \end{aligned}$$

$$\begin{aligned} \text{PM69\_P} = & 0.74113 * \text{PF67} - 0.22589 - 0.246975 * \text{RM61DI.32} + \text{PM69E\_DE} + \text{PM69\_DM} + 0.047260 - 0.018867 \\ & + 0.00067 * \text{RM6569} + 0.00040 * \text{RM6569.1} - 0.00040 * \text{RM6569.2} - 0.00127 * \text{RM6569.3} - 0.00178 * \text{RM6569.4} - 0.00151 * \\ & \text{RM6569.5} \\ & - 0.30 * \text{RRADJ\_M69} - 0.02 * \text{POT\_ET\_TXRT\_69}; \end{aligned}$$

$$\begin{aligned} \text{PM70\_P} = & 0.46445 * \text{PF68} - 0.23451 - 0.220464 * \text{RM61DI.36} + \text{PM70E\_DE} + \text{PM70\_DM} + 0.037323 - 0.010528 \\ & - 0.00013 * \text{RM7074} - 0.00016 * \text{RM7074.1} - 0.00013 * \text{RM7074.2} - 0.00006 * \text{RM7074.3} + 0.00000 * \text{RM7074.4} + 0.00003 * \\ & \text{RM7074.5}; \end{aligned}$$

$$\begin{aligned} \text{PM71\_P} = & 0.27684 * \text{PF69} - 0.20679 - 0.202537 * \text{RM61DI.40} + \text{PM71E\_DE} + \text{PM71\_DM} + 0.030867 - 0.005653 \\ & - 0.00013 * \text{RM7074} - 0.00016 * \text{RM7074.1} - 0.00013 * \text{RM7074.2} - 0.00006 * \text{RM7074.3} + 0.00000 * \text{RM7074.4} + 0.00003 * \\ & \text{RM7074.5}; \end{aligned}$$

$$\begin{aligned} \text{PM72\_P} = & 0.77240 * \text{PF70} - 0.25289 - 0.186071 * \text{RM61DI.44} + \text{PM72E\_DE} + \text{PM72\_DM} + 0.040290 - 0.012330 \\ & - 0.00013 * \text{RM7074} - 0.00016 * \text{RM7074.1} - 0.00013 * \text{RM7074.2} - 0.00006 * \text{RM7074.3} + 0.00000 * \text{RM7074.4} + 0.00003 * \\ & \text{RM7074.5}; \end{aligned}$$

$$\begin{aligned} \text{PM73\_P} = & 0.65971 * \text{PF71} - 0.19394 - 0.167545 * \text{RM61DI.48} + \text{PM73E\_DE} + \text{PM73\_DM} + 0.036021 - 0.009631 \\ & - 0.00013 * \text{RM7074} - 0.00016 * \text{RM7074.1} - 0.00013 * \text{RM7074.2} - 0.00006 * \text{RM7074.3} + 0.00000 * \text{RM7074.4} + 0.00003 * \\ & \text{RM7074.5}; \end{aligned}$$

$$\begin{aligned} \text{PM74\_P} = & 0.78464 * \text{PF72} - 0.17649 - 0.147134 * \text{RM61DI.52} + \text{PM74E\_DE} + \text{PM74\_DM} + 0.033451 - 0.010839 \\ & - 0.00013 * \text{RM7074} - 0.00016 * \text{RM7074.1} - 0.00013 * \text{RM7074.2} - 0.00006 * \text{RM7074.3} + 0.00000 * \text{RM7074.4} + 0.00003 * \\ & \text{RM7074.5}; \end{aligned}$$

#### AGE 75 TO 79

$$\begin{aligned} \text{PM75\_P} &= \text{PM74.4} * 0.920 + \text{DPM75O\_FE}; \\ \text{PM76\_P} &= \text{PM75.4} * 0.920 + \text{DPM75O\_FE}; \\ \text{PM77\_P} &= \text{PM76.4} * 0.920 + \text{DPM75O\_FE}; \\ \text{PM78\_P} &= \text{PM77.4} * 0.920 + \text{DPM75O\_FE}; \\ \text{PM79\_P} &= \text{PM78.4} * 0.920 + \text{DPM75O\_FE}; \end{aligned}$$

#### AGE 55 TO 79

$$\begin{aligned} \text{PM55} &= \text{PM55\_P}; \\ \text{PM56} &= \text{PM56\_P}; \\ \text{PM57} &= \text{PM57\_P}; \\ \text{PM58} &= \text{PM58\_P}; \\ \text{PM59} &= \text{PM59\_P}; \\ \text{PM60} &= \text{PM60\_P}; \\ \text{PM61} &= \text{PM61\_P}; \\ \text{PM62} &= \text{PM62\_P}; \\ \text{PM63} &= \text{PM63\_P}; \\ \text{PM64} &= \text{PM64\_P}; \\ \text{PM65} &= \text{PM65\_P}; \\ \text{PM66} &= \text{PM66\_P}; \\ \text{PM67} &= \text{PM67\_P}; \\ \text{PM68} &= \text{PM68\_P}; \\ \text{PM69} &= \text{PM69\_P}; \\ \text{PM70} &= \text{PM70\_P}; \\ \text{PM71} &= \text{PM71\_P}; \\ \text{PM72} &= \text{PM72\_P}; \\ \text{PM73} &= \text{PM73\_P}; \\ \text{PM74} &= \text{PM74\_P}; \\ \text{PM75} &= \text{PM75\_P}; \\ \text{PM76} &= \text{PM76\_P}; \\ \text{PM77} &= \text{PM77\_P}; \\ \text{PM78} &= \text{PM78\_P}; \\ \text{PM79} &= \text{PM79\_P}; \end{aligned}$$

AGE 80 AND OVER

$$\begin{aligned}
 PM80\_P &= PM79.4 * 0.965^{**}(1) + DPM75O\_FE; \\
 PM81\_P &= PM79.8 * 0.965^{**}(2) + DPM75O\_FE; \\
 PM82\_P &= PM79.12 * 0.965^{**}(3) + DPM75O\_FE; \\
 PM83\_P &= PM79.16 * 0.965^{**}(4) + DPM75O\_FE; \\
 PM84\_P &= PM79.20 * 0.965^{**}(5) + DPM75O\_FE; \\
 PM85\_P &= MOVAVG(8,PM79.24) * 0.965^{**}(6) + DPM75O\_FE; \\
 PM86\_P &= MOVAVG(8,PM79.28) * 0.965^{**}(7) + DPM75O\_FE; \\
 PM87\_P &= MOVAVG(8,PM79.32) * 0.965^{**}(8) + DPM75O\_FE; \\
 PM88\_P &= MOVAVG(8,PM79.36) * 0.965^{**}(9) + DPM75O\_FE; \\
 PM89\_P &= MOVAVG(8,PM79.40) * 0.965^{**}(10) + DPM75O\_FE; \\
 PM90\_P &= MOVAVG(8,PM79.44) * 0.965^{**}(11) + DPM75O\_FE; \\
 PM91\_P &= MOVAVG(8,PM79.48) * 0.965^{**}(12) + DPM75O\_FE; \\
 PM92\_P &= MOVAVG(8,PM79.52) * 0.965^{**}(13) + DPM75O\_FE; \\
 PM93\_P &= MOVAVG(8,PM79.56) * 0.965^{**}(14) + DPM75O\_FE; \\
 PM94\_P &= MOVAVG(8,PM79.60) * 0.965^{**}(15) + DPM75O\_FE;
 \end{aligned}$$

$$\begin{aligned}
 PM95\_P &= PM94\_P * 0.965 + DPM75O\_FE; \\
 PM96\_P &= PM95\_P * 0.965 + DPM75O\_FE; \\
 PM97\_P &= PM96\_P * 0.965 + DPM75O\_FE; \\
 PM98\_P &= PM97\_P * 0.965 + DPM75O\_FE; \\
 PM99\_P &= PM98\_P * 0.965 + DPM75O\_FE; \\
 PM100\_P &= PM99\_P * 0.965 + DPM75O\_FE;
 \end{aligned}$$

$$\begin{aligned}
 PM80O\_P &= (PM80\_P * NM80 + PM81\_P * NM81 + PM82\_P * NM82 + PM83\_P * NM83 + PM84\_P * NM84 + PM85\_P * NM85 + \\
 &PM86\_P * NM86 + PM87\_P * NM87 + PM88\_P * NM88 + PM89\_P * NM89 + \\
 &PM90\_P * NM90 + PM91\_P * NM91 + PM92\_P * NM92 + PM93\_P * NM93 + PM94\_P * NM94 + PM95\_P * NM95 + PM96\_P * NM96 + \\
 &PM97\_P * NM97 + PM98\_P * NM98 + PM99\_P * NM99 + \\
 &PM100\_P * NM100) / NM80O;
 \end{aligned}$$

$$PM80O = PM80O\_P;$$

$$\begin{aligned}
 PM80 &= PM80\_P * PM80O / PM80O\_P; \\
 PM81 &= PM81\_P * PM80O / PM80O\_P; \\
 PM82 &= PM82\_P * PM80O / PM80O\_P; \\
 PM83 &= PM83\_P * PM80O / PM80O\_P; \\
 PM84 &= PM84\_P * PM80O / PM80O\_P; \\
 PM85 &= PM85\_P * PM80O / PM80O\_P; \\
 PM86 &= PM86\_P * PM80O / PM80O\_P; \\
 PM87 &= PM87\_P * PM80O / PM80O\_P; \\
 PM88 &= PM88\_P * PM80O / PM80O\_P; \\
 PM89 &= PM89\_P * PM80O / PM80O\_P; \\
 PM90 &= PM90\_P * PM80O / PM80O\_P; \\
 PM91 &= PM91\_P * PM80O / PM80O\_P; \\
 PM92 &= PM92\_P * PM80O / PM80O\_P; \\
 PM93 &= PM93\_P * PM80O / PM80O\_P; \\
 PM94 &= PM94\_P * PM80O / PM80O\_P; \\
 PM95 &= PM95\_P * PM80O / PM80O\_P;
 \end{aligned}$$

$$\begin{aligned}
 PM96 &= PM96\_P * PM80O / PM80O\_P; \\
 PM97 &= PM97\_P * PM80O / PM80O\_P; \\
 PM98 &= PM98\_P * PM80O / PM80O\_P; \\
 PM99 &= PM99\_P * PM80O / PM80O\_P; \\
 PM100 &= PM100\_P * PM80O / PM80O\_P;
 \end{aligned}$$

**FEMALE LFPR EQUATIONS**

AGE 16 TO 19

$$\begin{aligned}
 PF1617\_P &= 0.98681 - 0.000047 - (0.377204 * RF1617DI) \\
 &- (-0.00741 + 0.23393 * RF1617CU6 + 0.00051 * MOVAVG(5,RF1617)) \\
 &- (-0.69608 + 0.01166 * TR\_PF1617 + 0.00616 * MOVAVG(5,RF1617));
 \end{aligned}$$

$$PF1819\_P = 0.98200 - 0.000069$$

-(0.584930 \* RF1819DI)  
-(-0.00080 + 0.22814 \* RF1819CU6 + 0.00318 \* MOVAVG(5,RF1819))  
-(- 0.53433+ 0.00764 \* TR\_PF1819 + 0.00667 \* MOVAVG(5,RF1819));

PF1617 = PF1617\_P;  
PF1819 = PF1819\_P;

AGE 20 TO 44

FEMALES - NEVER MARRIED WITH AT LEAST 1 OWN CHILD UNDER AGE 6

PF2024NMC6U\_P = ( 0.70868 - 0.000477  
- 0.00087 \* RF2024 - 0.00099 \* RF2024.1 - 0.00063 \* RF2024.2 - 0.00007 \* RF2024.3 + 0.00041 \* RF2024.4 + 0.00052 \*  
RF2024.5  
- 0.661872 \* RF2024DI)  
\* 1.0160;

PF2529NMC6U\_P = ( 0.74861 - 0.000966  
- 0.00056 \* RF2529 - 0.00070 \* RF2529.1 - 0.00057 \* RF2529.2 - 0.00029 \* RF2529.3 - 0.00002 \* RF2529.4 + 0.00013 \*  
RF2529.5  
- 0.700572 \* RF2529DI)  
\* 0.9981;

PF3034NMC6U\_P = ( 0.73944 - 0.001998  
- 0.00081 \* RF3034 - 0.00065 \* RF3034.1 + 0.00005 \* RF3034.2 + 0.00089 \* RF3034.3 + 0.00143 \* RF3034.4 + 0.00128 \*  
RF3034.5  
- 0.690741 \* RF3034DI)  
\* 0.9980;

PF3539NMC6U\_P = ( 0.75363 - 0.003230  
- 0.00195 \* RF3539 - 0.00216 \* RF3539.1 - 0.00128 \* RF3539.2 + 0.00002 \* RF3539.3 + 0.00111 \* RF3539.4 + 0.00132 \*  
RF3539.5  
- 0.701148 \* RF3539DI)  
\* 0.9989;

PF4044NMC6U\_P = ( 0.73920 - 0.005589  
- 0.00026 \* RF4044 - 0.00050 \* RF4044.1 - 0.00068 \* RF4044.2 - 0.00076 \* RF4044.3 - 0.00070 \* RF4044.4 - 0.00046 \*  
RF4044.5  
- 0.677955 \* RF4044DI)  
\* 0.9989;

FEMALES - NEVER MARRIED NO OWN CHILDREN UNDER AGE 6

PF2024NMNC6\_P = ( 1.13654 - 0.000206 - 0.00366 \* TR\_PF2024NMNC6  
- 0.00087 \* RF2024 - 0.00099 \* RF2024.1 - 0.00063 \* RF2024.2 - 0.00007 \* RF2024.3 + 0.00041 \* RF2024.4 + 0.00052 \*  
RF2024.5  
- 0.742995 \* RF2024DI)  
\* 1.0160;

PF2529NMNC6\_P = ( 0.98148 + 0.000457 - 0.00111 \* TR\_PF2529NMNC6  
- 0.00056 \* RF2529 - 0.00070 \* RF2529.1 - 0.00057 \* RF2529.2 - 0.00029 \* RF2529.3 - 0.00002 \* RF2529.4 + 0.00013 \*  
RF2529.5  
- 0.853721 \* RF2529DI)  
\* 0.9981;

PF3034NMNC6\_P = ( 0.84901 + 0.000598  
- 0.00081 \* RF3034 - 0.00065 \* RF3034.1 + 0.00005 \* RF3034.2 + 0.00089 \* RF3034.3 + 0.00143 \* RF3034.4 + 0.00128 \*  
RF3034.5  
- 0.838634 \* RF3034DI)  
\* 0.9980;

PF3539NMNC6\_P = ( 0.84953 + 0.000015  
- 0.00195 \* RF3539 - 0.00216 \* RF3539.1 - 0.00128 \* RF3539.2 + 0.00002 \* RF3539.3 + 0.00111 \* RF3539.4 + 0.00132 \*  
RF3539.5



- 0.822121 \* RF3539DI)  
\* 0.9989;

PF4044NMNC6\_P = ( 0.83790 - 0.000878  
- 0.00026 \* RF4044 - 0.00050 \* RF4044.1 - 0.00068 \* RF4044.2 - 0.00076 \* RF4044.3 - 0.00070 \* RF4044.4 - 0.00046 \*  
RF4044.5  
- 0.799021 \* RF4044DI)  
\* 0.9989;

FEMALES - MARRIED SPOUSE PRESENT WITH AT LEAST 1 OWN CHILD UNDER AGE 6

PF2024MSC6U\_P = ( 0.69043 - 0.000935 + 0.000015  
- 0.00087 \* RF2024 - 0.00099 \* RF2024.1 - 0.00063 \* RF2024.2 - 0.00007 \* RF2024.3 + 0.00041 \* RF2024.4 + 0.00052 \*  
RF2024.5  
- 0.524765 \* RF2024DI - 0.1\*IF2024MSC6U)  
\* 1.0160;

PF2529MSC6U\_P = ( 0.76218 - 0.001821 - 0.000004  
- 0.00056 \* RF2529 - 0.00070 \* RF2529.1 - 0.00057 \* RF2529.2 - 0.00029 \* RF2529.3 - 0.00002 \* RF2529.4 + 0.00013 \*  
RF2529.5  
- 0.608428 \* RF2529DI - 0.1\*IF2529MSC6U)  
\* 0.9981;

PF3034MSC6U\_P = ( 0.78186 - 0.002891 - 0.000006  
- 0.00081 \* RF3034 - 0.00065 \* RF3034.1 + 0.00005 \* RF3034.2 + 0.00089 \* RF3034.3 + 0.00143 \* RF3034.4 + 0.00128 \*  
RF3034.5  
- 0.639819 \* RF3034DI - 0.1\*IF3034MSC6U)  
\* 0.9980;

PF3539MSC6U\_P = ( 0.79072 - 0.004987 - 0.000005  
- 0.00195 \* RF3539 - 0.00216 \* RF3539.1 - 0.00128 \* RF3539.2 + 0.00002 \* RF3539.3 + 0.00111 \* RF3539.4 + 0.00132 \*  
RF3539.5  
- 0.635646 \* RF3539DI - 0.1\*IF3539MSC6U)  
\* 0.9989;

PF4044MSC6U\_P = ( 0.79356 - 0.007041 - 0.000008  
- 0.00026 \* RF4044 - 0.00050 \* RF4044.1 - 0.00068 \* RF4044.2 - 0.00076 \* RF4044.3 - 0.00070 \* RF4044.4 - 0.00046 \*  
RF4044.5  
- 0.640644 \* RF4044DI - 0.1\*IF4044MSC6U)  
\* 0.9989;

FEMALES - MARRIED SPOUSE PRESENT NO OWN CHILDREN UNDER AGE 6

PF2024MSNC6\_P = ( 0.79421 - 0.000075  
- 0.00087 \* RF2024 - 0.00099 \* RF2024.1 - 0.00063 \* RF2024.2 - 0.00007 \* RF2024.3 + 0.00041 \* RF2024.4 + 0.00052 \*  
RF2024.5  
- 0.781956 \* RF2024DI)  
\* 1.0160;

PF2529MSNC6\_P = ( 0.83502 + 0.000186  
- 0.00056 \* RF2529 - 0.00070 \* RF2529.1 - 0.00057 \* RF2529.2 - 0.00029 \* RF2529.3 - 0.00002 \* RF2529.4 + 0.00013 \*  
RF2529.5  
- 0.824520 \* RF2529DI)  
\* 0.9981;

PF3034MSNC6\_P = ( 0.80379 - 0.000056  
- 0.00081 \* RF3034 - 0.00065 \* RF3034.1 + 0.00005 \* RF3034.2 + 0.00089 \* RF3034.3 + 0.00143 \* RF3034.4 + 0.00128 \*  
RF3034.5  
- 0.801357 \* RF3034DI)  
\* 0.9980;

PF3539MSNC6\_P = ( 0.80906 - 0.000984  
- 0.00195 \* RF3539 - 0.00216 \* RF3539.1 - 0.00128 \* RF3539.2 + 0.00002 \* RF3539.3 + 0.00111 \* RF3539.4 + 0.00132 \*  
RF3539.5

- 0.784868 \* RF3539DI)  
\* 0.9989;

PF4044MSNC6\_P = ( 0.82602 - 0.001249  
- 0.00026 \* RF4044 - 0.00050 \* RF4044.1 - 0.00068 \* RF4044.2 - 0.00076 \* RF4044.3 - 0.00070 \* RF4044.4 - 0.00046 \*  
RF4044.5  
- 0.789470 \* RF4044DI)  
\* 0.9989;

FEMALES - MARRIED SPOUSE ABSENT WITH AT LEAST 1 OWN CHILD UNDER AGE 6

PF2024MAC6U\_P = ( 0.95787 - 0.000403 + 0.000007  
- 0.00087 \* RF2024 - 0.00099 \* RF2024.1 - 0.00063 \* RF2024.2 - 0.00007 \* RF2024.3 + 0.00041 \* RF2024.4 + 0.00052 \*  
RF2024.5  
- 0.683999 \* RF2024DI - 0.16722 \* IF2024MAC6U)  
\* 1.0160;

PF2529MAC6U\_P = ( 0.90653 - 0.000676  
- 0.00056 \* RF2529 - 0.00070 \* RF2529.1 - 0.00057 \* RF2529.2 - 0.00029 \* RF2529.3 - 0.00002 \* RF2529.4 + 0.00013 \*  
RF2529.5  
- 0.731798 \* RF2529DI - 0.10000 \* IF2529MAC6U)  
\* 0.9981;

PF3034MAC6U\_P = ( 0.88071 - 0.001042  
- 0.00081 \* RF3034 - 0.00065 \* RF3034.1 + 0.00005 \* RF3034.2 + 0.00089 \* RF3034.3 + 0.00143 \* RF3034.4 + 0.00128 \*  
RF3034.5  
- 0.745172 \* RF3034DI - 0.10000 \* IF3034MAC6U)  
\* 0.9980;

PF3539MAC6U\_P = ( 0.90258 - 0.002058  
- 0.00195 \* RF3539 - 0.00216 \* RF3539.1 - 0.00128 \* RF3539.2 + 0.00002 \* RF3539.3 + 0.00111 \* RF3539.4 + 0.00132 \*  
RF3539.5  
- 0.744846 \* RF3539DI - 0.10000 \* IF3539MAC6U)  
\* 0.9989;

PF4044MAC6U\_P = ( 0.89876 - 0.003975 - 0.000005  
- 0.00026 \* RF4044 - 0.00050 \* RF4044.1 - 0.00068 \* RF4044.2 - 0.00076 \* RF4044.3 - 0.00070 \* RF4044.4 - 0.00046 \*  
RF4044.5  
- 0.719419 \* RF4044DI - 0.10000 \* IF4044MAC6U)  
\* 0.9989;

FEMALES - MARRIED SPOUSE ABSENT NO OWN CHILDREN UNDER AGE 6

PF2024MANC6\_P = ( 0.75174 - 0.000258 + 0.000005  
- 0.00087 \* RF2024 - 0.00099 \* RF2024.1 - 0.00063 \* RF2024.2 - 0.00007 \* RF2024.3 + 0.00041 \* RF2024.4 + 0.00052 \*  
RF2024.5  
- 0.727427 \* RF2024DI)  
\* 1.0160;

PF2529MANC6\_P = ( 0.82060 - 0.000015  
- 0.00056 \* RF2529 - 0.00070 \* RF2529.1 - 0.00057 \* RF2529.2 - 0.00029 \* RF2529.3 - 0.00002 \* RF2529.4 + 0.00013 \*  
RF2529.5  
- 0.802962 \* RF2529DI)  
\* 0.9981;

PF3034MANC6\_P = ( 0.83806 + 0.000442  
- 0.00081 \* RF3034 - 0.00065 \* RF3034.1 + 0.00005 \* RF3034.2 + 0.00089 \* RF3034.3 + 0.00143 \* RF3034.4 + 0.00128 \*  
RF3034.5  
- 0.829717 \* RF3034DI)  
\* 0.9980;

PF3539MANC6\_P = ( 0.86613 + 0.000458  
- 0.00195 \* RF3539 - 0.00216 \* RF3539.1 - 0.00128 \* RF3539.2 + 0.00002 \* RF3539.3 + 0.00111 \* RF3539.4 + 0.00132 \*  
RF3539.5

- 0.838637 \* RF3539DI)  
\* 0.9989;

PF4044MANC6\_P = ( 0.85937 + 0.000112  
- 0.00026 \* RF4044 - 0.00050 \* RF4044.1 - 0.00068 \* RF4044.2 - 0.00076 \* RF4044.3 - 0.00070 \* RF4044.4 - 0.00046 \*  
RF4044.5  
- 0.824438 \* RF4044DI)  
\* 0.9989;

PF2024NM\_P = (PF2024NMC6U\_P \* NF2024NMC6U + PF2024NMNC6\_P \* NF2024NMNC6) / NF2024NM;  
PF2024MS\_P = (PF2024MSC6U\_P \* NF2024MSC6U + PF2024MSNC6\_P \* NF2024MSNC6) / NF2024MS;  
PF2024MA\_P = (PF2024MAC6U\_P \* NF2024MAC6U + PF2024MANC6\_P \* NF2024MANC6) / NF2024MA;

PF2529NM\_P = (PF2529NMC6U\_P \* NF2529NMC6U + PF2529NMNC6\_P \* NF2529NMNC6) / NF2529NM;  
PF2529MS\_P = (PF2529MSC6U\_P \* NF2529MSC6U + PF2529MSNC6\_P \* NF2529MSNC6) / NF2529MS;  
PF2529MA\_P = (PF2529MAC6U\_P \* NF2529MAC6U + PF2529MANC6\_P \* NF2529MANC6) / NF2529MA;

PF3034NM\_P = (PF3034NMC6U\_P \* NF3034NMC6U + PF3034NMNC6\_P \* NF3034NMNC6) / NF3034NM;  
PF3034MS\_P = (PF3034MSC6U\_P \* NF3034MSC6U + PF3034MSNC6\_P \* NF3034MSNC6) / NF3034MS;  
PF3034MA\_P = (PF3034MAC6U\_P \* NF3034MAC6U + PF3034MANC6\_P \* NF3034MANC6) / NF3034MA;

PF3539NM\_P = (PF3539NMC6U\_P \* NF3539NMC6U + PF3539NMNC6\_P \* NF3539NMNC6) / NF3539NM;  
PF3539MS\_P = (PF3539MSC6U\_P \* NF3539MSC6U + PF3539MSNC6\_P \* NF3539MSNC6) / NF3539MS;  
PF3539MA\_P = (PF3539MAC6U\_P \* NF3539MAC6U + PF3539MANC6\_P \* NF3539MANC6) / NF3539MA;

PF4044NM\_P = (PF4044NMC6U\_P \* NF4044NMC6U + PF4044NMNC6\_P \* NF4044NMNC6) / NF4044NM;  
PF4044MS\_P = (PF4044MSC6U\_P \* NF4044MSC6U + PF4044MSNC6\_P \* NF4044MSNC6) / NF4044MS;  
PF4044MA\_P = (PF4044MAC6U\_P \* NF4044MAC6U + PF4044MANC6\_P \* NF4044MANC6) / NF4044MA;

AGE 45 TO 54

FEMALES - NEVER MARRIED 45 TO 54

PF4549NM\_P = 0.03650 - 0.003349 + PF4549E\_DE  
- 0.00076 \* RF4549 - 0.00070 \* RF4549.1 - 0.00018 \* RF4549.2 + 0.00049 \* RF4549.3 + 0.00096 \* RF4549.4 + 0.00091 \* RF4549.5  
- 0.774819 \* RF4549DI;

PF5054NM\_P = 0.05788 - 0.008250 + PF5054E\_DE  
+ 0.00003 \* RF5054 - 0.00011 \* RF5054.1 - 0.00032 \* RF5054.2 - 0.00051 \* RF5054.3 - 0.00059 \* RF5054.4 - 0.00045 \* RF5054.5  
- 0.732696 \* RF5054DI;

FEMALES - MARRIED SPOUSE PRESENT 45 TO 54

PF4549MS\_P = 0.03842 - 0.003545 + PF4549E\_DE  
- 0.00076 \* RF4549 - 0.00070 \* RF4549.1 - 0.00018 \* RF4549.2 + 0.00049 \* RF4549.3 + 0.00096 \* RF4549.4 + 0.00091 \*  
RF4549.5  
- 0.771341 \* RF4549DI - 0.15 \* RF4549MSCU6;

PF5054MS\_P = - 0.40180 - 0.008735 + PF5054E\_DE  
+ 0.00003 \* RF5054 - 0.00011 \* RF5054.1 - 0.00032 \* RF5054.2 - 0.00051 \* RF5054.3 - 0.00059 \* RF5054.4 - 0.00045 \* RF5054.5  
+ 0.00454 \* TR\_PF5054MS - 0.726715 \* RF5054DI - 0.12 \* RF5054MSCU6;

FEMALES - MARRIED SPOUSE ABSENT 45 TO 54

PF4549MA\_P = 0.06830 - 0.001541 + PF4549E\_DE  
- 0.00076 \* RF4549 - 0.00070 \* RF4549.1 - 0.00018 \* RF4549.2 + 0.00049 \* RF4549.3 + 0.00096 \* RF4549.4 + 0.00091 \*  
RF4549.5  
- 0.806961 \* RF4549DI - 0.1 \* RF4549MACU6;

PF5054MA\_P = 0.08983 - 0.006021 + PF5054E\_DE  
+ 0.00003 \* RF5054 - 0.00011 \* RF5054.1 - 0.00032 \* RF5054.2 - 0.00051 \* RF5054.3 - 0.00059 \* RF5054.4 - 0.00045 \* RF5054.5  
- 0.760157 \* RF5054DI - 0.2 \* RF5054MACU6;

AGE 20 TO 54

PF2024\_P = (PF2024NM\_P \* NF2024NM + PF2024MS\_P \* NF2024MS + PF2024MA\_P \* NF2024MA) / NF2024;  
PF2529\_P = (PF2529NM\_P \* NF2529NM + PF2529MS\_P \* NF2529MS + PF2529MA\_P \* NF2529MA) / NF2529;  
PF3034\_P = (PF3034NM\_P \* NF3034NM + PF3034MS\_P \* NF3034MS + PF3034MA\_P \* NF3034MA) / NF3034;  
PF3539\_P = (PF3539NM\_P \* NF3539NM + PF3539MS\_P \* NF3539MS + PF3539MA\_P \* NF3539MA) / NF3539;  
PF4044\_P = (PF4044NM\_P \* NF4044NM + PF4044MS\_P \* NF4044MS + PF4044MA\_P \* NF4044MA) / NF4044;  
PF4549\_P = (PF4549NM\_P \* NF4549NM + PF4549MS\_P \* NF4549MS + PF4549MA\_P \* NF4549MA) / NF4549;  
PF5054\_P = (PF5054NM\_P \* NF5054NM + PF5054MS\_P \* NF5054MS + PF5054MA\_P \* NF5054MA) / NF5054;

PF2024 = PF2024\_P;  
PF2529 = PF2529\_P;  
PF3034 = PF3034\_P;  
PF3539 = PF3539\_P;  
PF4044 = PF4044\_P;  
PF4549 = PF4549\_P;  
PF5054 = PF5054\_P;

PF2024NM = PF2024NM\_P \* PF2024 / PF2024\_P;  
PF2529NM = PF2529NM\_P \* PF2529 / PF2529\_P;  
PF3034NM = PF3034NM\_P \* PF3034 / PF3034\_P;  
PF3539NM = PF3539NM\_P \* PF3539 / PF3539\_P;  
PF4044NM = PF4044NM\_P \* PF4044 / PF4044\_P;  
PF4549NM = PF4549NM\_P \* PF4549 / PF4549\_P;  
PF5054NM = PF5054NM\_P \* PF5054 / PF5054\_P;

PF2024MS = PF2024MS\_P \* PF2024 / PF2024\_P;  
PF2529MS = PF2529MS\_P \* PF2529 / PF2529\_P;  
PF3034MS = PF3034MS\_P \* PF3034 / PF3034\_P;  
PF3539MS = PF3539MS\_P \* PF3539 / PF3539\_P;  
PF4044MS = PF4044MS\_P \* PF4044 / PF4044\_P;  
PF4549MS = PF4549MS\_P \* PF4549 / PF4549\_P;  
PF5054MS = PF5054MS\_P \* PF5054 / PF5054\_P;

PF2024MA = PF2024MA\_P \* PF2024 / PF2024\_P;  
PF2529MA = PF2529MA\_P \* PF2529 / PF2529\_P;  
PF3034MA = PF3034MA\_P \* PF3034 / PF3034\_P;  
PF3539MA = PF3539MA\_P \* PF3539 / PF3539\_P;  
PF4044MA = PF4044MA\_P \* PF4044 / PF4044\_P;  
PF4549MA = PF4549MA\_P \* PF4549 / PF4549\_P;  
PF5054MA = PF5054MA\_P \* PF5054 / PF5054\_P;

PF2024NMC6U = PF2024NMC6U\_P \* PF2024 / PF2024\_P;  
PF2529NMC6U = PF2529NMC6U\_P \* PF2529 / PF2529\_P;  
PF3034NMC6U = PF3034NMC6U\_P \* PF3034 / PF3034\_P;  
PF3539NMC6U = PF3539NMC6U\_P \* PF3539 / PF3539\_P;  
PF4044NMC6U = PF4044NMC6U\_P \* PF4044 / PF4044\_P;

PF2024NMNC6 = PF2024NMNC6\_P \* PF2024 / PF2024\_P;  
PF2529NMNC6 = PF2529NMNC6\_P \* PF2529 / PF2529\_P;  
PF3034NMNC6 = PF3034NMNC6\_P \* PF3034 / PF3034\_P;  
PF3539NMNC6 = PF3539NMNC6\_P \* PF3539 / PF3539\_P;  
PF4044NMNC6 = PF4044NMNC6\_P \* PF4044 / PF4044\_P;

PF2024MSC6U = PF2024MSC6U\_P \* PF2024 / PF2024\_P;  
PF2529MSC6U = PF2529MSC6U\_P \* PF2529 / PF2529\_P;  
PF3034MSC6U = PF3034MSC6U\_P \* PF3034 / PF3034\_P;  
PF3539MSC6U = PF3539MSC6U\_P \* PF3539 / PF3539\_P;  
PF4044MSC6U = PF4044MSC6U\_P \* PF4044 / PF4044\_P;

PF2024MSNC6 = PF2024MSNC6\_P \* PF2024 / PF2024\_P;  
PF2529MSNC6 = PF2529MSNC6\_P \* PF2529 / PF2529\_P;  
PF3034MSNC6 = PF3034MSNC6\_P \* PF3034 / PF3034\_P;

PF3539MSNC6 = PF3539MSNC6\_P \* PF3539 / PF3539\_P;  
PF4044MSNC6 = PF4044MSNC6\_P \* PF4044 / PF4044\_P;

PF2024MAC6U = PF2024MAC6U\_P \* PF2024 / PF2024\_P;  
PF2529MAC6U = PF2529MAC6U\_P \* PF2529 / PF2529\_P;  
PF3034MAC6U = PF3034MAC6U\_P \* PF3034 / PF3034\_P;  
PF3539MAC6U = PF3539MAC6U\_P \* PF3539 / PF3539\_P;  
PF4044MAC6U = PF4044MAC6U\_P \* PF4044 / PF4044\_P;

PF2024MANC6 = PF2024MANC6\_P \* PF2024 / PF2024\_P;  
PF2529MANC6 = PF2529MANC6\_P \* PF2529 / PF2529\_P;  
PF3034MANC6 = PF3034MANC6\_P \* PF3034 / PF3034\_P;  
PF3539MANC6 = PF3539MANC6\_P \* PF3539 / PF3539\_P;  
PF4044MANC6 = PF4044MANC6\_P \* PF4044 / PF4044\_P;

#### AGE 55 TO 61

PF55\_P = - 0.678427 \* RF55DI - 0.011198  
+ 0.00064 \* RF5559 + 0.00041 \* RF5559.1 - 0.00029 \* RF5559.2 - 0.00107 \* RF5559.3 - 0.00155 \* RF5559.4 - 0.00132 \* RF5559.5  
+ PF55E\_DE + PF55\_DM + 0.00368 \* PF55COH48 - 0.90941;

PF56\_P = - 0.651951 \* RF56DI - 0.014942  
+ 0.00064 \* RF5559 + 0.00041 \* RF5559.1 - 0.00029 \* RF5559.2 - 0.00107 \* RF5559.3 - 0.00155 \* RF5559.4 - 0.00132 \* RF5559.5  
+ PF56E\_DE + PF56\_DM + 0.00486 \* PF56COH48 - 0.96865;

PF57\_P = - 0.634496 \* RF57DI - 0.018113  
+ 0.00064 \* RF5559 + 0.00041 \* RF5559.1 - 0.00029 \* RF5559.2 - 0.00107 \* RF5559.3 - 0.00155 \* RF5559.4 - 0.00132 \* RF5559.5  
+ PF57E\_DE + PF57\_DM + 0.00344 \* PF57COH48 - 0.85033;

PF58\_P = - 0.604503 \* RF58DI - 0.023096  
+ 0.00064 \* RF5559 + 0.00041 \* RF5559.1 - 0.00029 \* RF5559.2 - 0.00107 \* RF5559.3 - 0.00155 \* RF5559.4 - 0.00132 \* RF5559.5  
+ PF58E\_DE + PF58\_DM + 0.00362 \* PF58COH48 - 0.83081;

PF59\_P = - 0.571801 \* RF59DI - 0.029463  
+ 0.00064 \* RF5559 + 0.00041 \* RF5559.1 - 0.00029 \* RF5559.2 - 0.00107 \* RF5559.3 - 0.00155 \* RF5559.4 - 0.00132 \* RF5559.5  
+ PF59E\_DE + PF59\_DM + 0.00470 \* PF59COH48 - 0.85665;

PF60\_P = - 0.526008 \* RF60DI - 0.033474  
+ 0.00141 \* RF6064 + 0.00166 \* RF6064.1 + 0.00116 \* RF6064.2 + 0.00033 \* RF6064.3 - 0.00041 \* RF6064.4 - 0.00066 \* RF6064.5  
+ PF60E\_DE + PF60\_DM + 0.00819 \* PF60COH48 - 1.18744;

PF61\_P = - 0.487750 \* RF61DI - 0.041036  
+ 0.00141 \* RF6064 + 0.00166 \* RF6064.1 + 0.00116 \* RF6064.2 + 0.00033 \* RF6064.3 - 0.00041 \* RF6064.4 - 0.00066 \* RF6064.5  
+ PF61E\_DE + PF61\_DM + 0.00520 \* PF61COH48 - 0.87850;

#### AGE 62 TO 74

PF62\_P = - 0.412411 \* RF61DI.4 - 0.063463  
+ 0.00141 \* RF6064 + 0.00166 \* RF6064.1 + 0.00116 \* RF6064.2 + 0.00033 \* RF6064.3 - 0.00041 \* RF6064.4 - 0.00066 \* RF6064.5  
+ PF62E\_DE + PF62\_DM + 0.00523 \* PF62COH48 - 0.56287 - 0.5100 \* RRADJ\_F62 - 0.02 \* POT\_ET\_TXRT\_62;

PF63\_P = - 0.359185 \* RF61DI.8 - 0.082104  
+ 0.00141 \* RF6064 + 0.00166 \* RF6064.1 + 0.00116 \* RF6064.2 + 0.00033 \* RF6064.3 - 0.00041 \* RF6064.4 - 0.00066 \* RF6064.5  
+ PF63E\_DE + PF63\_DM + 0.00659 \* PF63COH48 - 0.68289 - 0.4675 \* RRADJ\_F63 - 0.02 \* POT\_ET\_TXRT\_63;

PF64\_P = - 0.323866 \* RF61DI.12 - 0.094477  
+ 0.00141 \* RF6064 + 0.00166 \* RF6064.1 + 0.00116 \* RF6064.2 + 0.00033 \* RF6064.3 - 0.00041 \* RF6064.4 - 0.00066 \* RF6064.5  
+ PF64E\_DE + PF64\_DM + 0.00745 \* PF64COH48 - 0.72813 - 0.4250 \* RRADJ\_F64 - 0.02 \* POT\_ET\_TXRT\_64;

PF65\_P = - 0.256938 \* RF61DI.16 + 0.035143  
+ 0.00029 \* RF6569 + 0.00014 \* RF6569.1 - 0.00023 \* RF6569.2 - 0.00063 \* RF6569.3 - 0.00086 \* RF6569.4 - 0.00072 \* RF6569.5  
+ PF65E\_DE + PF65\_DM + 0.00348 \* PF65COH48 - 0.37490 - 0.3825 \* RRADJ\_F65 - 0.02 \* POT\_ET\_TXRT\_65;

PF66\_P = - 0.226911 \* RF61DI.20 + 0.028402

+ 0.00029 \* RF6569 + 0.00014 \* RF6569.1 - 0.00023 \* RF6569.2 - 0.00063 \* RF6569.3 - 0.00086 \* RF6569.4 - 0.00072 \* RF6569.5  
+ PF66E\_DE + PF66\_DM + 0.00512 \* PF66COH48 - 0.52851 - 0.3400 \* RRADJ\_F66 - 0.02 \* POT\_ET\_TXRT\_66;

PF67\_P = 0.00029 \* RF6569 + 0.00014 \* RF6569.1 - 0.00023 \* RF6569.2 - 0.00063 \* RF6569.3 - 0.00086 \* RF6569.4 - 0.00072 \* RF6569.5  
- 0.206835 \* RF61DI.24 + 0.025203 + PF67E\_DE + PF67\_DM + 0.00518 \* PF67COH48 - 0.53735 - 0.2975 \* RRADJ\_F67 - 0.02 \*  
POT\_ET\_TXRT\_67;

PF68\_P = 0.00029 \* RF6569 + 0.00014 \* RF6569.1 - 0.00023 \* RF6569.2 - 0.00063 \* RF6569.3 - 0.00086 \* RF6569.4 - 0.00072 \* RF6569.5  
- 0.180608 \* RF61DI.28 + 0.020367 + PF68E\_DE + PF68\_DM + 0.00400 \* PF68COH48 - 0.41046 - 0.2550 \* RRADJ\_F68 - 0.02 \*  
POT\_ET\_TXRT\_68;

PF69\_P = 0.00029 \* RF6569 + 0.00014 \* RF6569.1 - 0.00023 \* RF6569.2 - 0.00063 \* RF6569.3 - 0.00086 \* RF6569.4 - 0.00072 \* RF6569.5  
- 0.162386 \* RF61DI.32 + 0.017869 + PF69E\_DE + PF69\_DM + 0.00400 \* PF69COH48 - 0.36706 - 0.2550 \* RRADJ\_F69 - 0.02 \*  
POT\_ET\_TXRT\_69;

PF70\_P = - 0.00009 \* RF7074 - 0.00028 \* RF7074.1 - 0.00048 \* RF7074.2 - 0.00063 \* RF7074.3 - 0.00064 \* RF7074.4 - 0.00046 \* RF7074.5  
- 0.136965 \* RF61DI.36 + 0.015491 + PF70E\_DE + PF70\_DM + 0.00424 \* PF70COH48 - 0.49282;

PF71\_P = - 0.00009 \* RF7074 - 0.00028 \* RF7074.1 - 0.00048 \* RF7074.2 - 0.00063 \* RF7074.3 - 0.00064 \* RF7074.4 - 0.00046 \* RF7074.5  
- 0.123245 \* RF61DI.40 + 0.014381 + PF71E\_DE + PF71\_DM + 0.00300 \* PF71COH48 - 0.37390;

PF72\_P = - 0.00009 \* RF7074 - 0.00028 \* RF7074.1 - 0.00048 \* RF7074.2 - 0.00063 \* RF7074.3 - 0.00064 \* RF7074.4 - 0.00046 \* RF7074.5  
- 0.107978 \* RF61DI.44 + 0.013644 + PF72E\_DE + PF72\_DM + 0.00286 \* PF72COH48 - 0.34670;

PF73\_P = - 0.00009 \* RF7074 - 0.00028 \* RF7074.1 - 0.00048 \* RF7074.2 - 0.00063 \* RF7074.3 - 0.00064 \* RF7074.4 - 0.00046 \* RF7074.5  
- 0.094426 \* RF61DI.48 + 0.012196 + PF73E\_DE + PF73\_DM + 0.00370 \* PF73COH48 - 0.41058;

PF74\_P = - 0.00009 \* RF7074 - 0.00028 \* RF7074.1 - 0.00048 \* RF7074.2 - 0.00063 \* RF7074.3 - 0.00064 \* RF7074.4 - 0.00046 \* RF7074.5  
- 0.082404 \* RF61DI.52 + 0.010762 + PF74E\_DE + PF74\_DM + 0.00304 \* PF74COH48 - 0.35113;

AGE 75 TO 79

PF75\_P = PF74.4 \* 0.900 + DPF75O\_FE;  
PF76\_P = PF75.4 \* 0.900 + DPF75O\_FE;  
PF77\_P = PF76.4 \* 0.900 + DPF75O\_FE;  
PF78\_P = PF77.4 \* 0.900 + DPF75O\_FE;  
PF79\_P = PF78.4 \* 0.900 + DPF75O\_FE;

AGE 55 TO 79

PF55 = PF55\_P;  
PF56 = PF56\_P;  
PF57 = PF57\_P;  
PF58 = PF58\_P;  
PF59 = PF59\_P;  
PF60 = PF60\_P;  
PF61 = PF61\_P;  
PF62 = PF62\_P;  
PF63 = PF63\_P;  
PF64 = PF64\_P;  
PF65 = PF65\_P;  
PF66 = PF66\_P;  
PF67 = PF67\_P;  
PF68 = PF68\_P;  
PF69 = PF69\_P;  
PF70 = PF70\_P;  
PF71 = PF71\_P;  
PF72 = PF72\_P;  
PF73 = PF73\_P;  
PF74 = PF74\_P;  
PF75 = PF75\_P;  
PF76 = PF76\_P;  
PF77 = PF77\_P;  
PF78 = PF78\_P;

$$PF79 = PF79\_P;$$

AGE 80 AND OVER

$$\begin{aligned} PF80\_P &= PF79.4 * 0.965^{**}(1) + DPF75O\_FE; \\ PF81\_P &= PF79.8 * 0.965^{**}(2) + DPF75O\_FE; \\ PF82\_P &= PF79.12 * 0.965^{**}(3) + DPF75O\_FE; \\ PF83\_P &= PF79.16 * 0.965^{**}(4) + DPF75O\_FE; \\ PF84\_P &= PF79.20 * 0.965^{**}(5) + DPF75O\_FE; \\ PF85\_P &= MOVAVG(8,PF79.24) * 0.965^{**}(6) + DPF75O\_FE; \\ PF86\_P &= MOVAVG(8,PF79.28) * 0.965^{**}(7) + DPF75O\_FE; \\ PF87\_P &= MOVAVG(8,PF79.32) * 0.965^{**}(8) + DPF75O\_FE; \\ PF88\_P &= MOVAVG(8,PF79.36) * 0.965^{**}(9) + DPF75O\_FE; \\ PF89\_P &= MOVAVG(8,PF79.40) * 0.965^{**}(10) + DPF75O\_FE; \\ PF90\_P &= MOVAVG(8,PF79.44) * 0.965^{**}(11) + DPF75O\_FE; \\ PF91\_P &= MOVAVG(8,PF79.48) * 0.965^{**}(12) + DPF75O\_FE; \\ PF92\_P &= MOVAVG(8,PF79.52) * 0.965^{**}(13) + DPF75O\_FE; \\ PF93\_P &= MOVAVG(8,PF79.56) * 0.965^{**}(14) + DPF75O\_FE; \\ PF94\_P &= MOVAVG(8,PF79.60) * 0.965^{**}(15) + DPF75O\_FE; \\ PF95\_P &= PF94\_P * 0.965 + DPF75O\_FE; \\ PF96\_P &= PF95\_P * 0.965 + DPF75O\_FE; \\ PF97\_P &= PF96\_P * 0.965 + DPF75O\_FE; \\ PF98\_P &= PF97\_P * 0.965 + DPF75O\_FE; \\ PF99\_P &= PF98\_P * 0.965 + DPF75O\_FE; \\ PF100\_P &= PF99\_P * 0.965 + DPF75O\_FE; \end{aligned}$$

$$\begin{aligned} PF800\_P &= (PF80\_P * NF80 + PF81\_P * NF81 + PF82\_P * NF82 + PF83\_P * NF83 + PF84\_P * NF84 + PF85\_P * NF85 + PF86\_P * NF86 + \\ &PF87\_P * NF87 + PF88\_P * NF88 + PF89\_P * NF89 + \\ &PF90\_P * NF90 + PF91\_P * NF91 + PF92\_P * NF92 + PF93\_P * NF93 + PF94\_P * NF94 + PF95\_P * NF95 + PF96\_P * NF96 + \\ &PF97\_P * NF97 + PF98\_P * NF98 + PF99\_P * NF99 + \\ &PF100\_P * NF100) / NF800; \end{aligned}$$

$$PF800 = PF800\_P;$$

$$\begin{aligned} PF80 &= PF80\_P * PF800 / PF800\_P; \\ PF81 &= PF81\_P * PF800 / PF800\_P; \\ PF82 &= PF82\_P * PF800 / PF800\_P; \\ PF83 &= PF83\_P * PF800 / PF800\_P; \\ PF84 &= PF84\_P * PF800 / PF800\_P; \\ PF85 &= PF85\_P * PF800 / PF800\_P; \\ PF86 &= PF86\_P * PF800 / PF800\_P; \\ PF87 &= PF87\_P * PF800 / PF800\_P; \\ PF88 &= PF88\_P * PF800 / PF800\_P; \\ PF89 &= PF89\_P * PF800 / PF800\_P; \\ PF90 &= PF90\_P * PF800 / PF800\_P; \\ PF91 &= PF91\_P * PF800 / PF800\_P; \\ PF92 &= PF92\_P * PF800 / PF800\_P; \\ PF93 &= PF93\_P * PF800 / PF800\_P; \\ PF94 &= PF94\_P * PF800 / PF800\_P; \\ PF95 &= PF95\_P * PF800 / PF800\_P; \\ PF96 &= PF96\_P * PF800 / PF800\_P; \\ PF97 &= PF97\_P * PF800 / PF800\_P; \\ PF98 &= PF98\_P * PF800 / PF800\_P; \\ PF99 &= PF99\_P * PF800 / PF800\_P; \\ PF100 &= PF100\_P * PF800 / PF800\_P; \end{aligned}$$

LFPR EQUATIONS, AGE 16 AND OVER

$$\begin{aligned} PM160\_P &= ( \\ PM1617\_P &* NM1617 + \\ PM1819\_P &* NM1819 + \\ PM2024\_P &* NM2024 + \\ PM2529\_P &* NM2529 + \end{aligned}$$

PM3034\_P \* NM3034 +  
 PM3539\_P \* NM3539 +  
 PM4044\_P \* NM4044 +  
 PM4549\_P \* NM4549 +  
 PM5054\_P \* NM5054 +  
 PM55\_P \* NM55 +  
 PM56\_P \* NM56 +  
 PM57\_P \* NM57 +  
 PM58\_P \* NM58 +  
 PM59\_P \* NM59 +  
 PM60\_P \* NM60 +  
 PM61\_P \* NM61 +  
 PM62\_P \* NM62 +  
 PM63\_P \* NM63 +  
 PM64\_P \* NM64 +  
 PM65\_P \* NM65 +  
 PM66\_P \* NM66 +  
 PM67\_P \* NM67 +  
 PM68\_P \* NM68 +  
 PM69\_P \* NM69 +  
 PM70\_P \* NM70 +  
 PM71\_P \* NM71 +  
 PM72\_P \* NM72 +  
 PM73\_P \* NM73 +  
 PM74\_P \* NM74 +  
 PM75\_P \* NM75 +  
 PM76\_P \* NM76 +  
 PM77\_P \* NM77 +  
 PM78\_P \* NM78 +  
 PM79\_P \* NM79 +  
 PM80O\_P \* NM80O ) / NM160;

PF16O\_P = (  
 PF1617\_P \* NF1617 +  
 PF1819\_P \* NF1819 +  
 PF2024\_P \* NF2024 +  
 PF2529\_P \* NF2529 +  
 PF3034\_P \* NF3034 +  
 PF3539\_P \* NF3539 +  
 PF4044\_P \* NF4044 +  
 PF4549\_P \* NF4549 +  
 PF5054\_P \* NF5054 +  
 PF55\_P \* NF55 +  
 PF56\_P \* NF56 +  
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 PF69\_P \* NF69 +  
 PF70\_P \* NF70 +  
 PF71\_P \* NF71 +  
 PF72\_P \* NF72 +  
 PF73\_P \* NF73 +  
 PF74\_P \* NF74 +  
 PF75\_P \* NF75 +  
 PF76\_P \* NF76 +  
 PF77\_P \* NF77 +  
 PF78\_P \* NF78 +  
 PF79\_P \* NF79 +  
 PF80O\_P \* NF80O ) / NF160;

P16O\_P = (PM16O\_P \* NM16O + PF16O\_P \* NF16O) / (NM16O + NF16O);



LCM\_P = PM160\_P \* NM160;  
 LCF\_P = PF160\_P \* NF160;  
 LC\_P = LCM\_P + LCF\_P;

**LABOR FORCE PARTICIPATION RATES, FULL EMPLOYMENT**

**MALE LFPR EQUATIONS, FULL EMPLOYMENT**

DPM1617\_FE = (- 0.00158 \* RM1617\_FE - 0.00180 \* RM1617\_FE.1 - 0.00115 \* RM1617\_FE.2 - 0.00014 \* RM1617\_FE.3 + 0.00072 \* RM1617\_FE.4 + 0.00094 \* RM1617\_FE.5) - (- 0.00158 \* RM1617 - 0.00180 \* RM1617.1 - 0.00115 \* RM1617.2 - 0.00014 \* RM1617.3 + 0.00072 \* RM1617.4 + 0.00094 \* RM1617.5)

Restricted Ordinary Least Squares  
 QUARTERLY data for 148 periods from 1971Q1 to 2007Q4  
 Date: 2 SEP 2009

pm1617\_dpk

= - 0.00158 \* rm1617\_dpk - 0.00180 \* rm1617\_dpk[-1]  
 (5.56270) (6.13183)  
 - 0.00115 \* rm1617\_dpk[-2] - 0.00014 \* rm1617\_dpk[-3]  
 (7.49261) (0.94429)  
 + 0.00072 \* rm1617\_dpk[-4] + 0.00094 \* rm1617\_dpk[-5]  
 (2.47378) (3.30450)

Polynomial lags:

rm1617\_dpk  
 from 0 to 5 degree 3 near far

Sum Sq	0.0343	Std Err	0.0149	LHS Mean	-0.0011	Res Mean	0.0037
R Sq	0.2826	R Bar Sq	0.2777	F	2,146	%RMSE	46265.0
D.W.( 1)	0.3942	D.W.( 4)	0.9128				

DPM1819\_FE = (- 0.00108 \* RM1819\_FE - 0.00127 \* RM1819\_FE.1 - 0.00088 \* RM1819\_FE.2 - 0.00023 \* RM1819\_FE.3 + 0.00034 \* RM1819\_FE.4 + 0.00053 \* RM1819\_FE.5) - (- 0.00108 \* RM1819 - 0.00127 \* RM1819.1 - 0.00088 \* RM1819.2 - 0.00023 \* RM1819.3 + 0.00034 \* RM1819.4 + 0.00053 \* RM1819.5)

Restricted Ordinary Least Squares  
 QUARTERLY data for 148 periods from 1971Q1 to 2007Q4  
 Date: 2 SEP 2009

pm1819\_dpk

= - 0.00108 \* rm1819\_dpk - 0.00127 \* rm1819\_dpk[-1]  
 (5.22267) (5.94236)  
 - 0.00088 \* rm1819\_dpk[-2] - 0.00023 \* rm1819\_dpk[-3]  
 (7.96365) (2.16526)  
 + 0.00034 \* rm1819\_dpk[-4] + 0.00053 \* rm1819\_dpk[-5]  
 (1.61951) (2.56002)

Polynomial lags:

rm1819\_dpk  
 from 0 to 5 degree 3 near far

Sum Sq	0.0192	Std Err	0.0114	LHS Mean	-0.0040	Res Mean	0.0008
R Sq	0.2729	R Bar Sq	0.2679	F	2,146	%RMSE	17596.7
D.W.( 1)	0.7981	D.W.( 4)	1.2825				

DPM2024\_FE = (-0.00063 \* RM2024\_FE - 0.00077 \* RM2024\_FE.1 - 0.00059 \* RM2024\_FE.2 - 0.00027 \* RM2024\_FE.3 + 0.00005 \* RM2024\_FE.4 + 0.00020 \* RM2024\_FE.5) - (-0.00063 \* RM2024 - 0.00077 \* RM2024.1 - 0.00059 \* RM2024.2 - 0.00027 \* RM2024.3 + 0.00005 \* RM2024.4 + 0.00020 \* RM2024.5)

Restricted Ordinary Least Squares  
 QUARTERLY data for 148 periods from 1971Q1 to 2007Q4  
 Date: 2 SEP 2009

pm2024\_dpk

= - 0.00063 \* rm2024\_dpk - 0.00077 \* rm2024\_dpk[-1]  
 (4.32837) (5.14659)

- 0.00059 \* rm2024\_dpk[-2] - 0.00027 \* rm2024\_dpk[-3]  
 (7.47597) (3.39844)

+ 0.00005 \* rm2024\_dpk[-4] + 0.00020 \* rm2024\_dpk[-5]  
 (0.35674) (1.36468)

Polynomial lags:

rm2024\_dpk  
 from 0 to 5 degree 3 near far

Sum Sq	0.0067	Std Err	0.0068	LHS Mean	-0.0028	Res Mean	-0.0002
R Sq	0.2336	R Bar Sq	0.2284	F	2,146	%RMSE	32980.5
D.W.( 1)	0.5915	D.W.( 4)	1.0423				

DPM2529\_FE = (-0.00028 \* RM2529\_FE - 0.00044 \* RM2529\_FE.1 - 0.00050 \* RM2529\_FE.2 - 0.00047 \* RM2529\_FE.3 - 0.00037 \* RM2529\_FE.4 - 0.00021 \* RM2529\_FE.5) - (-0.00028 \* RM2529 - 0.00044 \* RM2529.1 - 0.00050 \* RM2529.2 - 0.00047 \* RM2529.3 - 0.00037 \* RM2529.4 - 0.00021 \* RM2529.5)

Restricted Ordinary Least Squares  
 QUARTERLY data for 101 periods from 1982Q4 to 2007Q4  
 Date: 2 SEP 2009

pm2529\_dpk

= - 0.00028 \* rm2529\_dpk - 0.00044 \* rm2529\_dpk[-1]  
 (1.40609) (2.14232)

- 0.00050 \* rm2529\_dpk[-2] - 0.00047 \* rm2529\_dpk[-3]  
 (4.60340) (4.70117)

- 0.00037 \* rm2529\_dpk[-4] - 0.00021 \* rm2529\_dpk[-5]  
 (1.87119) (1.06920)

Polynomial lags:

rm2529\_dpk  
 from 0 to 5 degree 3 near far

Sum Sq	0.0026	Std Err	0.0049	LHS Mean	-0.0033	Res Mean	-0.0016
R Sq	0.0492	R Bar Sq	0.0396	F	2, 99	%RMSE	48872.7
D.W.( 1)	0.7362	D.W.( 4)	1.0116				

DPM3034\_FE = (-0.00046 \* RM3034\_FE - 0.00061 \* RM3034\_FE.1 - 0.00054 \* RM3034\_FE.2 - 0.00036 \* RM3034\_FE.3 - 0.00014 \* RM3034\_FE.4 + 0.00001 \* RM3034\_FE.5) - (-0.00046 \* RM3034 - 0.00061 \* RM3034.1 - 0.00054 \* RM3034.2 - 0.00036 \* RM3034.3 - 0.00014 \* RM3034.4 + 0.00001 \* RM3034.5)

Restricted Ordinary Least Squares  
 QUARTERLY data for 101 periods from 1982Q4 to 2007Q4  
 Date: 2 SEP 2009

pm3034\_dpk

$$\begin{aligned}
&= -0.00046 * \text{rm3034\_dpk} - 0.00061 * \text{rm3034\_dpk}[-1] \\
&\quad (1.81713) \qquad\qquad\qquad (2.34240) \\
&- 0.00054 * \text{rm3034\_dpk}[-2] - 0.00036 * \text{rm3034\_dpk}[-3] \\
&\quad (4.05252) \qquad\qquad\qquad (2.76527) \\
&- 0.00014 * \text{rm3034\_dpk}[-4] + 0.00001 * \text{rm3034\_dpk}[-5] \\
&\quad (0.56353) \qquad\qquad\qquad (0.02760)
\end{aligned}$$

Polynomial lags:

rm3034\_dpk  
from 0 to 5 degree 3 near far

Sum Sq	0.0024	Std Err	0.0049	LHS Mean	-0.0015	Res Mean	-0.0001
R Sq	0.1497	R Bar Sq	0.1411	F	2, 99	%RMSE	50015.8
D.W.( 1)	0.6227	D.W.( 4)	0.8678				

$$\begin{aligned}
\text{DPM3539\_FE} = & (-0.00004 * \text{RM3539\_FE} - 0.00010 * \text{RM3539\_FE.1} - 0.00016 * \text{RM3539\_FE.2} - 0.00021 * \text{RM3539\_FE.3} - 0.00021 * \\
& \text{RM3539\_FE.4} - 0.00015 * \text{RM3539\_FE.5}) - (-0.00004 * \text{RM3539} - 0.00010 * \text{RM3539.1} - 0.00016 * \text{RM3539.2} - 0.00021 * \text{RM3539.3} - \\
& 0.00021 * \text{RM3539.4} - 0.00015 * \text{RM3539.5})
\end{aligned}$$

Restricted Ordinary Least Squares

QUARTERLY data for 101 periods from 1982Q4 to 2007Q4

Date: 2 SEP 2009

pm3539\_dpk

$$\begin{aligned}
&= -0.00004 * \text{rm3539\_dpk} - 0.00010 * \text{rm3539\_dpk}[-1] \\
&\quad (0.12650) \qquad\qquad\qquad (0.32986) \\
&- 0.00016 * \text{rm3539\_dpk}[-2] - 0.00021 * \text{rm3539\_dpk}[-3] \\
&\quad (1.10007) \qquad\qquad\qquad (1.48792) \\
&- 0.00021 * \text{rm3539\_dpk}[-4] - 0.00015 * \text{rm3539\_dpk}[-5] \\
&\quad (0.72412) \qquad\qquad\qquad (0.51868)
\end{aligned}$$

Polynomial lags:

rm3539\_dpk  
from 0 to 5 degree 3 near far

Sum Sq	0.0028	Std Err	0.0052	LHS Mean	-0.0017	Res Mean	-0.0010
R Sq	-0.0664	R Bar Sq	-0.0772	F	2, 99	NC	%RMSE
D.W.( 1)	0.4246	D.W.( 4)	0.5372				1817.43

$$\begin{aligned}
\text{DPM4044\_FE} = & (-0.00057 * \text{RM4044\_FE} - 0.00066 * \text{RM4044\_FE.1} - 0.00044 * \text{RM4044\_FE.2} - 0.00009 * \text{RM4044\_FE.3} + 0.00022 * \\
& \text{RM4044\_FE.4} + 0.00031 * \text{RM4044\_FE.5}) - (-0.00057 * \text{RM4044} - 0.00066 * \text{RM4044.1} - 0.00044 * \text{RM4044.2} - 0.00009 * \text{RM4044.3} + \\
& 0.00022 * \text{RM4044.4} + 0.00031 * \text{RM4044.5})
\end{aligned}$$

Restricted Ordinary Least Squares

QUARTERLY data for 101 periods from 1982Q4 to 2007Q4

Date: 2 SEP 2009

pm4044\_dpk

$$\begin{aligned}
&= -0.00057 * \text{rm4044\_dpk} - 0.00066 * \text{rm4044\_dpk}[-1] \\
&\quad (1.75853) \qquad\qquad\qquad (1.97180) \\
&- 0.00044 * \text{rm4044\_dpk}[-2] - 0.00009 * \text{rm4044\_dpk}[-3] \\
&\quad (2.56550) \qquad\qquad\qquad (0.54915) \\
&+ 0.00022 * \text{rm4044\_dpk}[-4] + 0.00031 * \text{rm4044\_dpk}[-5] \\
&\quad (0.66426) \qquad\qquad\qquad (0.95499)
\end{aligned}$$

Polynomial lags:

rm4044\_dpk

from 0 to 5 degree 3 near far

Sum Sq	0.0029	Std Err	0.0054	LHS Mean	-0.0012	Res Mean	-0.0004
R Sq	0.0268	R Bar Sq	0.0170	F	2, 99	%RMSE	310.335
D.W.( 1)	0.5028	D.W.( 4)	0.7333				

DPM4549\_FE = (- 0.00002 \* RM4549\_FE - 0.00016 \* RM4549\_FE.1 - 0.00034 \* RM4549\_FE.2 - 0.00049 \* RM4549\_FE.3 - 0.00054 \* RM4549\_FE.4 - 0.00040 \* RM4549\_FE.5) - (- 0.00002 \* RM4549 - 0.00016 \* RM4549.1 - 0.00034 \* RM4549.2 - 0.00049 \* RM4549.3 - 0.00054 \* RM4549.4 - 0.00040 \* RM4549.5)

Restricted Ordinary Least Squares  
QUARTERLY data for 101 periods from 1982Q4 to 2007Q4  
Date: 2 SEP 2009

pm4549\_dpk

= - 0.00002 \* rm4549\_dpk - 0.00016 \* rm4549\_dpk[-1]  
(0.06650) (0.55897)

- 0.00034 \* rm4549\_dpk[-2] - 0.00049 \* rm4549\_dpk[-3]  
(2.31789) (3.39192)

- 0.00054 \* rm4549\_dpk[-4] - 0.00040 \* rm4549\_dpk[-5]  
(1.92566) (1.46813)

Polynomial lags:

rm4549\_dpk  
from 0 to 5 degree 3 near far

Sum Sq	0.0015	Std Err	0.0039	LHS Mean	-0.0013	Res Mean	-0.0003
R Sq	0.0719	R Bar Sq	0.0625	F	2, 99	%RMSE	4821.60
D.W.( 1)	0.7819	D.W.( 4)	1.0968				

DPM5054\_FE = (0.00112 \* RM5054\_FE + 0.00103 \* RM5054\_FE.1 + 0.00023 \* RM5054\_FE.2 - 0.00078 \* RM5054\_FE.3 - 0.00149 \* RM5054\_FE.4 - 0.00139 \* RM5054\_FE.5) - (0.00112 \* RM5054 + 0.00103 \* RM5054.1 + 0.00023 \* RM5054.2 - 0.00078 \* RM5054.3 - 0.00149 \* RM5054.4 - 0.00139 \* RM5054.5)

Restricted Ordinary Least Squares  
QUARTERLY data for 101 periods from 1982Q4 to 2007Q4  
Date: 2 SEP 2009

pm5054\_dpk

= 0.00112 \* rm5054\_dpk + 0.00103 \* rm5054\_dpk[-1]  
(3.16181) (2.84569)

+ 0.00023 \* rm5054\_dpk[-2] - 0.00078 \* rm5054\_dpk[-3]  
(1.30991) (4.52791)

- 0.00149 \* rm5054\_dpk[-4] - 0.00139 \* rm5054\_dpk[-5]  
(4.15166) (3.96094)

Polynomial lags:

rm5054\_dpk  
from 0 to 5 degree 3 near far

Sum Sq	0.0037	Std Err	0.0061	LHS Mean	-0.0012	Res Mean	0.0001
R Sq	0.1417	R Bar Sq	0.1330	F	2, 99	%RMSE	42597.0
D.W.( 1)	1.0445	D.W.( 4)	1.5173				

DPM5559\_FE = (0.00062 \* RM5559\_FE + 0.00041 \* RM5559\_FE.1 - 0.00026 \* RM5559\_FE.2 - 0.00101 \* RM5559\_FE.3 - 0.00147 \* RM5559\_FE.4 - 0.00126 \* RM5559\_FE.5) - (0.00062 \* RM5559 + 0.00041 \* RM5559.1 - 0.00026 \* RM5559.2 - 0.00101 \* RM5559.3 - 0.00147 \* RM5559.4 - 0.00126 \* RM5559.5)

Restricted Ordinary Least Squares  
QUARTERLY data for 101 periods from 1982Q4 to 2007Q4

Date: 2 SEP 2009

pm5559\_dpk

$$\begin{aligned} &= 0.00062 * rm5559\_dpk + 0.00041 * rm5559\_dpk[-1] \\ &\quad (1.23508) \qquad\qquad\qquad (0.79452) \\ &- 0.00026 * rm5559\_dpk[-2] - 0.00101 * rm5559\_dpk[-3] \\ &\quad (1.02810) \qquad\qquad\qquad (4.16786) \\ &- 0.00147 * rm5559\_dpk[-4] - 0.00126 * rm5559\_dpk[-5] \\ &\quad (2.91432) \qquad\qquad\qquad (2.53301) \end{aligned}$$

Polynomial lags:

rm5559\_dpk  
from 0 to 5 degree 3 near far

Sum Sq	0.0066	Std Err	0.0080	LHS Mean	-0.0037	Res Mean	-0.0014
R Sq	0.0164	R Bar Sq	0.0065	F	2, 99	%RMSE	256947
D.W.( 1)	0.8793	D.W.( 4)	1.2992				

$$\begin{aligned} DPM6064\_FE = & (0.00203 * RM6064\_FE + 0.00160 * RM6064\_FE.1 - 0.00021 * RM6064\_FE.2 - 0.00235 * RM6064\_FE.3 - 0.00374 * \\ & RM6064\_FE.4 - 0.00331 * RM6064\_FE.5) - (0.00203 * RM6064 + 0.00160 * RM6064.1 - 0.00021 * RM6064.2 - 0.00235 * RM6064.3 - \\ & 0.00374 * RM6064.4 - 0.00331 * RM6064.5) \end{aligned}$$

Restricted Ordinary Least Squares  
QUARTERLY data for 101 periods from 1982Q4 to 2007Q4  
Date: 2 SEP 2009

pm6064\_dpk

$$\begin{aligned} &= 0.00203 * rm6064\_dpk + 0.00160 * rm6064\_dpk[-1] \\ &\quad (2.66008) \qquad\qquad\qquad (2.03611) \\ &- 0.00021 * rm6064\_dpk[-2] - 0.00235 * rm6064\_dpk[-3] \\ &\quad (0.51861) \qquad\qquad\qquad (5.71949) \\ &- 0.00374 * rm6064\_dpk[-4] - 0.00331 * rm6064\_dpk[-5] \\ &\quad (4.77362) \qquad\qquad\qquad (4.35298) \end{aligned}$$

Polynomial lags:

rm6064\_dpk  
from 0 to 5 degree 3 near far

Sum Sq	0.0165	Std Err	0.0110	LHS Mean	-0.0095	Res Mean	-0.0067	
R Sq	-0.2740	R Bar Sq	-0.2869	F	2, 99	NC	%RMSE	21316.0
D.W.( 1)	0.5297	D.W.( 4)	0.7821					

$$\begin{aligned} DPM6569\_FE = & (0.00067 * RM6569\_FE + 0.00040 * RM6569\_FE.1 - 0.00040 * RM6569\_FE.2 - 0.00127 * RM6569\_FE.3 - 0.00178 * \\ & RM6569\_FE.4 - 0.00151 * RM6569\_FE.5) - (0.00067 * RM6569 + 0.00040 * RM6569.1 - 0.00040 * RM6569.2 - 0.00127 * RM6569.3 - \\ & 0.00178 * RM6569.4 - 0.00151 * RM6569.5) \end{aligned}$$

Restricted Ordinary Least Squares  
QUARTERLY data for 101 periods from 1982Q4 to 2007Q4  
Date: 2 SEP 2009

pm6569\_dpk

$$\begin{aligned} &= 0.00067 * rm6569\_dpk + 0.00040 * rm6569\_dpk[-1] \\ &\quad (0.93838) \qquad\qquad\qquad (0.52443) \\ &- 0.00040 * rm6569\_dpk[-2] - 0.00127 * rm6569\_dpk[-3] \\ &\quad (0.89477) \qquad\qquad\qquad (2.96224) \\ &- 0.00178 * rm6569\_dpk[-4] - 0.00151 * rm6569\_dpk[-5] \\ &\quad (2.41737) \qquad\qquad\qquad (2.13109) \end{aligned}$$

Polynomial lags:

rm6569\_dpk  
from 0 to 5 degree 3 near far

Sum Sq	0.0210	Std Err	0.0138	LHS Mean	-0.0059	Res Mean	-0.0047	
R Sq	-0.0832	R Bar Sq	-0.0942	F	2, 99	NC	%RMSE	36465.0
D.W.( 1)	0.5122	D.W.( 4)	0.7034					

DPM7074\_FE = (-0.00013 \* RM7074\_FE - 0.00016 \* RM7074\_FE.1 - 0.00013 \* RM7074\_FE.2 - 0.00006 \* RM7074\_FE.3 + 0.00000 \* RM7074\_FE.4 + 0.00003 \* RM7074\_FE.5) - (-0.00013 \* RM7074 - 0.00016 \* RM7074.1 - 0.00013 \* RM7074.2 - 0.00006 \* RM7074.3 + 0.00000 \* RM7074.4 + 0.00003 \* RM7074.5)

Restricted Ordinary Least Squares

QUARTERLY data for 101 periods from 1982Q4 to 2007Q4

Date: 2 SEP 2009

pm7074\_dpk

= - 0.00013 \* rm7074\_dpk - 0.00016 \* rm7074\_dpk[-1]  
(0.30689) (0.35702)

- 0.00013 \* rm7074\_dpk[-2] - 0.00006 \* rm7074\_dpk[-3]  
(0.44247) (0.21289)

+ 0.00000 \* rm7074\_dpk[-4] + 0.00003 \* rm7074\_dpk[-5]  
(0.00874) (0.08371)

Polynomial lags:

rm7074\_dpk  
from 0 to 5 degree 3 near far

Sum Sq	0.0114	Std Err	0.0080	LHS Mean	-0.0073	Res Mean	-0.0071	
R Sq	-0.8795	R Bar Sq	-0.8984	F	2, 99	NC	%RMSE	1540.73
D.W.( 1)	0.5068	D.W.( 4)	0.7160					

DPM750\_FE = (-0.00043 \* RM750\_FE - 0.00051 \* RM750\_FE.1 - 0.00036 \* RM750\_FE.2 - 0.00010 \* RM750\_FE.3 + 0.00013 \* RM750\_FE.4 + 0.00021 \* RM750\_FE.5) - (-0.00043 \* RM750 - 0.00051 \* RM750.1 - 0.00036 \* RM750.2 - 0.00010 \* RM750.3 + 0.00013 \* RM750.4 + 0.00021 \* RM750.5)

Restricted Ordinary Least Squares

QUARTERLY data for 101 periods from 1982Q4 to 2007Q4

Date: 2 SEP 2009

pm750\_dpk

= - 0.00043 \* rm750\_dpk - 0.00051 \* rm750\_dpk[-1]  
(1.82379) (2.03996)

- 0.00036 \* rm750\_dpk[-2] - 0.00010 \* rm750\_dpk[-3]  
(2.39851) (0.66247)

+ 0.00013 \* rm750\_dpk[-4] + 0.00021 \* rm750\_dpk[-5]  
(0.51659) (0.86124)

Polynomial lags:

rm750\_dpk  
from 0 to 5 degree 3 near far

Sum Sq	0.0039	Std Err	0.0058	LHS Mean	-0.0031	Res Mean	-0.0025	
R Sq	-0.2424	R Bar Sq	-0.2549	F	2, 99	NC	%RMSE	19877.0
D.W.( 1)	0.8382	D.W.( 4)	1.0542					

**FEMALE LFPR EQUATIONS, FULL EMPLOYMENT DIFFERENTIALS**

$$\text{DPF1617\_FE} = (-0.00224 * \text{RF1617\_FE} - 0.00239 * \text{RF1617\_FE.1} - 0.00126 * \text{RF1617\_FE.2} + 0.00035 * \text{RF1617\_FE.3} + 0.00163 * \text{RF1617\_FE.4} + 0.00178 * \text{RF1617\_FE.5}) - (-0.00224 * \text{RF1617} - 0.00239 * \text{RF1617.1} - 0.00126 * \text{RF1617.2} + 0.00035 * \text{RF1617.3} + 0.00163 * \text{RF1617.4} + 0.00178 * \text{RF1617.5})$$

Restricted Ordinary Least Squares  
 QUARTERLY data for 148 periods from 1971Q1 to 2007Q4  
 Date: 2 SEP 2009

pf1617\_dpk

$$\begin{aligned} = & -0.00224 * \text{rf1617\_dpk} - 0.00239 * \text{rf1617\_dpk}[-1] \\ & (5.90261) \qquad (6.13505) \\ & -0.00126 * \text{rf1617\_dpk}[-2] + 0.00035 * \text{rf1617\_dpk}[-3] \\ & (6.26010) \qquad (1.72973) \\ & +0.00163 * \text{rf1617\_dpk}[-4] + 0.00178 * \text{rf1617\_dpk}[-5] \\ & (4.17464) \qquad (4.69274) \end{aligned}$$

Polynomial lags:

rf1617\_dpk  
 from 0 to 5 degree 3 near far

Sum Sq	0.0354	Std Err	0.0153	LHS Mean	0.0006	Res Mean	0.0030
R Sq	0.2161	R Bar Sq	0.2107	F	2,146	%RMSE	28883.0
D.W.( 1)	0.4141	D.W.( 4)	0.9322				

$$\text{DPF1819\_FE} = (-0.00124 * \text{RF1819\_FE} - 0.00147 * \text{RF1819\_FE.1} - 0.00106 * \text{RF1819\_FE.2} - 0.00035 * \text{RF1819\_FE.3} + 0.00030 * \text{RF1819\_FE.4} + 0.00053 * \text{RF1819\_FE.5}) - (-0.00124 * \text{RF1819} - 0.00147 * \text{RF1819.1} - 0.00106 * \text{RF1819.2} - 0.00035 * \text{RF1819.3} + 0.00030 * \text{RF1819.4} + 0.00053 * \text{RF1819.5})$$

Restricted Ordinary Least Squares  
 QUARTERLY data for 148 periods from 1971Q1 to 2007Q4  
 Date: 2 SEP 2009

pf1819\_dpk

$$\begin{aligned} = & -0.00124 * \text{rf1819\_dpk} - 0.00147 * \text{rf1819\_dpk}[-1] \\ & (4.35316) \qquad (5.03839) \\ & -0.00106 * \text{rf1819\_dpk}[-2] - 0.00035 * \text{rf1819\_dpk}[-3] \\ & (7.08785) \qquad (2.38461) \\ & +0.00030 * \text{rf1819\_dpk}[-4] + 0.00053 * \text{rf1819\_dpk}[-5] \\ & (1.03892) \qquad (1.89331) \end{aligned}$$

Polynomial lags:

rf1819\_dpk  
 from 0 to 5 degree 3 near far

Sum Sq	0.0217	Std Err	0.0120	LHS Mean	-0.0031	Res Mean	0.0021
R Sq	0.2645	R Bar Sq	0.2594	F	2,146	%RMSE	53411.9
D.W.( 1)	0.8392	D.W.( 4)	1.3288				

$$\text{DPF2024\_FE} = (-0.00087 * \text{RF2024\_FE} - 0.00099 * \text{RF2024\_FE.1} - 0.00063 * \text{RF2024\_FE.2} - 0.00007 * \text{RF2024\_FE.3} + 0.00041 * \text{RF2024\_FE.4} + 0.00052 * \text{RF2024\_FE.5}) - (-0.00087 * \text{RF2024} - 0.00099 * \text{RF2024.1} - 0.00063 * \text{RF2024.2} - 0.00007 * \text{RF2024.3} + 0.00041 * \text{RF2024.4} + 0.00052 * \text{RF2024.5})$$

Restricted Ordinary Least Squares  
 QUARTERLY data for 148 periods from 1971Q1 to 2007Q4  
 Date: 2 SEP 2009

pf2024\_dpk

$$\begin{aligned} &= - 0.00087 * rf2024\_dpk - 0.00099 * rf2024\_dpk[-1] \\ &\quad (1.95040) \qquad\qquad\qquad (2.16369) \\ &- 0.00063 * rf2024\_dpk[-2] - 0.00007 * rf2024\_dpk[-3] \\ &\quad (2.80524) \qquad\qquad\qquad (0.30336) \\ &+ 0.00041 * rf2024\_dpk[-4] + 0.00052 * rf2024\_dpk[-5] \\ &\quad (0.90125) \qquad\qquad\qquad (1.17782) \end{aligned}$$

Polynomial lags:

rf2024\_dpk  
from 0 to 5 degree 3 near far

Sum Sq	0.0212	Std Err	0.0120	LHS Mean	-0.0017	Res Mean	0.0002	
R Sq	0.0408	R Bar Sq	0.0343	F	2,146	3.1076	%RMSE	51970.8
D.W.( 1)	0.2424	D.W.( 4)	0.5144					

$$\begin{aligned} \text{DPF2529\_FE} = & (-0.00056 * \text{RF2529\_FE} - 0.00070 * \text{RF2529\_FE.1} - 0.00057 * \text{RF2529\_FE.2} - 0.00029 * \text{RF2529\_FE.3} - 0.00002 * \\ & \text{RF2529\_FE.4} + 0.00013 * \text{RF2529\_FE.5}) - (-0.00056 * \text{RF2529} - 0.00070 * \text{RF2529.1} - 0.00057 * \text{RF2529.2} - 0.00029 * \text{RF2529.3} - 0.00002 * \\ & \text{RF2529.4} + 0.00013 * \text{RF2529.5}) \end{aligned}$$

Restricted Ordinary Least Squares

QUARTERLY data for 101 periods from 1982Q4 to 2007Q4

Date: 2 SEP 2009

pf2529\_dpk

$$\begin{aligned} &= - 0.00056 * rf2529\_dpk - 0.00070 * rf2529\_dpk[-1] \\ &\quad (0.83571) \qquad\qquad\qquad (1.02414) \\ &- 0.00057 * rf2529\_dpk[-2] - 0.00029 * rf2529\_dpk[-3] \\ &\quad (1.64524) \qquad\qquad\qquad (0.87576) \\ &- 0.00002 * rf2529\_dpk[-4] + 0.00013 * rf2529\_dpk[-5] \\ &\quad (0.02505) \qquad\qquad\qquad (0.19165) \end{aligned}$$

Polynomial lags:

rf2529\_dpk  
from 0 to 5 degree 3 near far

Sum Sq	0.0129	Std Err	0.0110	LHS Mean	0.0014	Res Mean	0.0030	
R Sq	0.0265	R Bar Sq	0.0167	F	2, 99	1.3467	%RMSE	1908.57
D.W.( 1)	0.2611	D.W.( 4)	0.6593					

$$\begin{aligned} \text{DPF3034\_FE} = & (-0.00081 * \text{RF3034\_FE} - 0.00065 * \text{RF3034\_FE.1} + 0.00005 * \text{RF3034\_FE.2} + 0.00089 * \text{RF3034\_FE.3} + 0.00143 * \\ & \text{RF3034\_FE.4} + 0.00128 * \text{RF3034\_FE.5}) - (-0.00081 * \text{RF3034} - 0.00065 * \text{RF3034.1} + 0.00005 * \text{RF3034.2} + 0.00089 * \text{RF3034.3} + 0.00143 \\ & * \text{RF3034.4} + 0.00128 * \text{RF3034.5}) \end{aligned}$$

Restricted Ordinary Least Squares

QUARTERLY data for 101 periods from 1982Q4 to 2007Q4

Date: 2 SEP 2009

pf3034\_dpk

$$\begin{aligned} &= - 0.00081 * rf3034\_dpk - 0.00065 * rf3034\_dpk[-1] \\ &\quad (1.30466) \qquad\qquad\qquad (1.02194) \\ &+ 0.00005 * rf3034\_dpk[-2] + 0.00089 * rf3034\_dpk[-3] \\ &\quad (0.16121) \qquad\qquad\qquad (2.80112) \\ &+ 0.00143 * rf3034\_dpk[-4] + 0.00128 * rf3034\_dpk[-5] \\ &\quad (2.29055) \qquad\qquad\qquad (2.08640) \end{aligned}$$

Polynomial lags:



rf3034\_dpk  
 from 0 to 5 degree 3 near far

Sum Sq	0.0083	Std Err	0.0088	LHS Mean	0.0040	Res Mean	0.0026
R Sq	-0.1326	R Bar Sq	-0.1440	F	2, 99	NC	%RMSE
D.W.( 1)	0.3221	D.W.( 4)	0.8675				29049.2

$$\text{DPF3539\_FE} = (-0.00195 * \text{RF3539\_FE} - 0.00216 * \text{RF3539\_FE.1} - 0.00128 * \text{RF3539\_FE.2} + 0.00002 * \text{RF3539\_FE.3} + 0.00111 * \text{RF3539\_FE.4} + 0.00132 * \text{RF3539\_FE.5}) - (-0.00195 * \text{RF3539} - 0.00216 * \text{RF3539.1} - 0.00128 * \text{RF3539.2} + 0.00002 * \text{RF3539.3} + 0.00111 * \text{RF3539.4} + 0.00132 * \text{RF3539.5})$$

Restricted Ordinary Least Squares  
 QUARTERLY data for 101 periods from 1982Q4 to 2007Q4  
 Date: 2 SEP 2009

pf3539\_dpk

$$\begin{aligned} = & -0.00195 * \text{rf3539\_dpk} - 0.00216 * \text{rf3539\_dpk}[-1] \\ & (2.96355) \quad (3.19201) \\ & -0.00128 * \text{rf3539\_dpk}[-2] + 0.00002 * \text{rf3539\_dpk}[-3] \\ & (3.74105) \quad (0.06643) \\ & +0.00111 * \text{rf3539\_dpk}[-4] + 0.00132 * \text{rf3539\_dpk}[-5] \\ & (1.67998) \quad (2.03681) \end{aligned}$$

Polynomial lags:

rf3539\_dpk  
 from 0 to 5 degree 3 near far

Sum Sq	0.0079	Std Err	0.0089	LHS Mean	-0.0021	Res Mean	-0.0007
R Sq	0.0801	R Bar Sq	0.0708	F	2, 99	4.3116	%RMSE
D.W.( 1)	0.3914	D.W.( 4)	0.5620				6918.68

$$\text{DPF4044\_FE} = (-0.00026 * \text{RF4044\_FE} - 0.00050 * \text{RF4044\_FE.1} - 0.00068 * \text{RF4044\_FE.2} - 0.00076 * \text{RF4044\_FE.3} - 0.00070 * \text{RF4044\_FE.4} - 0.00046 * \text{RF4044\_FE.5}) - (-0.00026 * \text{RF4044} - 0.00050 * \text{RF4044.1} - 0.00068 * \text{RF4044.2} - 0.00076 * \text{RF4044.3} - 0.00070 * \text{RF4044.4} - 0.00046 * \text{RF4044.5})$$

Restricted Ordinary Least Squares  
 QUARTERLY data for 101 periods from 1982Q4 to 2007Q4  
 Date: 2 SEP 2009

pf4044\_dpk

$$\begin{aligned} = & -0.00026 * \text{rf4044\_dpk} - 0.00050 * \text{rf4044\_dpk}[-1] \\ & (0.53052) \quad (0.99291) \\ & -0.00068 * \text{rf4044\_dpk}[-2] - 0.00076 * \text{rf4044\_dpk}[-3] \\ & (2.55091) \quad (2.90760) \\ & -0.00070 * \text{rf4044\_dpk}[-4] - 0.00046 * \text{rf4044\_dpk}[-5] \\ & (1.41817) \quad (0.96194) \end{aligned}$$

Polynomial lags:

rf4044\_dpk  
 from 0 to 5 degree 3 near far

Sum Sq	0.0041	Std Err	0.0061	LHS Mean	0.0005	Res Mean	0.0021
R Sq	0.1306	R Bar Sq	0.1218	F	2, 99	7.4378	%RMSE
D.W.( 1)	0.5681	D.W.( 4)	0.8422				4872.89

$$\text{DPF4549\_FE} = (-0.00076 * \text{RF4549\_FE} - 0.00070 * \text{RF4549\_FE.1} - 0.00018 * \text{RF4549\_FE.2} + 0.00049 * \text{RF4549\_FE.3} + 0.00096 * \text{RF4549\_FE.4} + 0.00091 * \text{RF4549\_FE.5}) - (-0.00076 * \text{RF4549} - 0.00070 * \text{RF4549.1} - 0.00018 * \text{RF4549.2} + 0.00049 * \text{RF4549.3} + 0.00096 * \text{RF4549.4} + 0.00091 * \text{RF4549.5})$$

Restricted Ordinary Least Squares  
 QUARTERLY data for 101 periods from 1982Q4 to 2007Q4  
 Date: 2 SEP 2009

pf4549\_dpk

$$\begin{aligned}
 = & -0.00076 * rf4549\_dpk - 0.00070 * rf4549\_dpk[-1] \\
 & (1.20345) \qquad (1.08117) \\
 & -0.00018 * rf4549\_dpk[-2] + 0.00049 * rf4549\_dpk[-3] \\
 & (0.50034) \qquad (1.36204) \\
 & +0.00096 * rf4549\_dpk[-4] + 0.00091 * rf4549\_dpk[-5] \\
 & (1.47572) \qquad (1.44905)
 \end{aligned}$$

Polynomial lags:

rf4549\_dpk  
 from 0 to 5 degree 3 near far

Sum Sq	0.0046	Std Err	0.0063	LHS Mean	0.0028	Res Mean	0.0027
R Sq	-0.1835	R Bar Sq	-0.1954	F	2, 99	NC	%RMSE
D.W.( 1)	0.7137	D.W.( 4)	0.9879				316691

$$\begin{aligned}
 DPF5054\_FE = & (0.00003 * RF5054\_FE - 0.00011 * RF5054\_FE.1 - 0.00032 * RF5054\_FE.2 - 0.00051 * RF5054\_FE.3 - 0.00059 * \\
 & RF5054\_FE.4 - 0.00045 * RF5054\_FE.5) - (0.00003 * RF5054 - 0.00011 * RF5054.1 - 0.00032 * RF5054.2 - 0.00051 * RF5054.3 - 0.00059 * \\
 & RF5054.4 - 0.00045 * RF5054.5)
 \end{aligned}$$

Restricted Ordinary Least Squares  
 QUARTERLY data for 101 periods from 1982Q4 to 2007Q4  
 Date: 2 SEP 2009

pf5054\_dpk

$$\begin{aligned}
 = & 0.00003 * rf5054\_dpk - 0.00011 * rf5054\_dpk[-1] \\
 & (0.05929) \qquad (0.18046) \\
 & -0.00032 * rf5054\_dpk[-2] - 0.00051 * rf5054\_dpk[-3] \\
 & (1.13804) \qquad (1.96823) \\
 & -0.00059 * rf5054\_dpk[-4] - 0.00045 * rf5054\_dpk[-5] \\
 & (1.04732) \qquad (0.80816)
 \end{aligned}$$

Polynomial lags:

rf5054\_dpk  
 from 0 to 5 degree 3 near far

Sum Sq	0.0054	Std Err	0.0073	LHS Mean	-0.0004	Res Mean	0.0010
R Sq	0.0704	R Bar Sq	0.0611	F	2, 99	3.7511	%RMSE
D.W.( 1)	0.8578	D.W.( 4)	1.1467				66278.7

$$\begin{aligned}
 DPF5559\_FE = & (0.00064 * RF5559\_FE + 0.00041 * RF5559\_FE.1 - 0.00029 * RF5559\_FE.2 - 0.00107 * RF5559\_FE.3 - 0.00155 * \\
 & RF5559\_FE.4 - 0.00132 * RF5559\_FE.5) - (0.00064 * RF5559 + 0.00041 * RF5559.1 - 0.00029 * RF5559.2 - 0.00107 * RF5559.3 - 0.00155 * \\
 & RF5559.4 - 0.00132 * RF5559.5)
 \end{aligned}$$

Restricted Ordinary Least Squares  
 QUARTERLY data for 101 periods from 1982Q4 to 2007Q4  
 Date: 2 SEP 2009

pf5559\_dpk

$$\begin{aligned}
 = & 0.00064 * rf5559\_dpk + 0.00041 * rf5559\_dpk[-1] \\
 & (0.89335) \qquad (0.55546) \\
 & -0.00029 * rf5559\_dpk[-2] - 0.00107 * rf5559\_dpk[-3] \\
 & (0.75840) \qquad (2.90227) \\
 & -0.00155 * rf5559\_dpk[-4] - 0.00132 * rf5559\_dpk[-5]
 \end{aligned}$$

(2.15075) (1.87882)

Polynomial lags:

rf5559\_dpk  
from 0 to 5 degree 3 near far

Sum Sq	0.0102	Std Err	0.0102	LHS Mean	-0.0011	Res Mean	0.0005
R Sq	0.0769	R Bar Sq	0.0676	F	2, 99	%RMSE	4599.06
D.W.( 1)	0.8791	D.W.( 4)	0.8944				

DPF6064\_FE = (0.00141 \* RF6064\_FE + 0.00166 \* RF6064\_FE.1 + 0.00116 \* RF6064\_FE.2 + 0.00033 \* RF6064\_FE.3 - 0.00041 \* RF6064\_FE.4 - 0.00066 \* RF6064\_FE.5) - (0.00141 \* RF6064 + 0.00166 \* RF6064.1 + 0.00116 \* RF6064.2 + 0.00033 \* RF6064.3 - 0.00041 \* RF6064.4 - 0.00066 \* RF6064.5)

Restricted Ordinary Least Squares

QUARTERLY data for 101 periods from 1982Q4 to 2007Q4  
Date: 2 SEP 2009

pf6064\_dpk

= 0.00141 \* rf6064\_dpk + 0.00166 \* rf6064\_dpk[-1]  
(1.84124) (2.11172)

+ 0.00116 \* rf6064\_dpk[-2] + 0.00033 \* rf6064\_dpk[-3]  
(2.99557) (0.93319)

- 0.00041 \* rf6064\_dpk[-4] - 0.00066 \* rf6064\_dpk[-5]  
(0.54220) (0.88278)

Polynomial lags:

rf6064\_dpk  
from 0 to 5 degree 3 near far

Sum Sq	0.0113	Std Err	0.0105	LHS Mean	0.0007	Res Mean	-0.0017
R Sq	0.1074	R Bar Sq	0.0984	F	2, 99	%RMSE	8386.58
D.W.( 1)	0.6636	D.W.( 4)	0.8453				

DPF6569\_FE = (0.00029 \* RF6569\_FE + 0.00014 \* RF6569\_FE.1 - 0.00023 \* RF6569\_FE.2 - 0.00063 \* RF6569\_FE.3 - 0.00086 \* RF6569\_FE.4 - 0.00072 \* RF6569\_FE.5) - (0.00029 \* RF6569 + 0.00014 \* RF6569.1 - 0.00023 \* RF6569.2 - 0.00063 \* RF6569.3 - 0.00086 \* RF6569.4 - 0.00072 \* RF6569.5)

Restricted Ordinary Least Squares

QUARTERLY data for 101 periods from 1982Q4 to 2007Q4  
Date: 2 SEP 2009

pf6569\_dpk

= 0.00029 \* rf6569\_dpk + 0.00014 \* rf6569\_dpk[-1]  
(0.39369) (0.18572)

- 0.00023 \* rf6569\_dpk[-2] - 0.00063 \* rf6569\_dpk[-3]  
(0.46891) (1.29792)

- 0.00086 \* rf6569\_dpk[-4] - 0.00072 \* rf6569\_dpk[-5]  
(1.10980) (0.98371)

Polynomial lags:

rf6569\_dpk  
from 0 to 5 degree 3 near far

Sum Sq	0.0161	Std Err	0.0097	LHS Mean	-0.0088	Res Mean	-0.0083
R Sq	-0.8729	R Bar Sq	-0.8918	F	2, 99	NC	%RMSE
D.W.( 1)	0.3864	D.W.( 4)	0.3951				5935.52

DPF7074\_FE = (- 0.00009 \* RF7074\_FE - 0.00028 \* RF7074\_FE.1 - 0.00048 \* RF7074\_FE.2 - 0.00063 \* RF7074\_FE.3 - 0.00064 \* RF7074\_FE.4 - 0.00046 \* RF7074\_FE.5) - (- 0.00009 \* RF7074 - 0.00028 \* RF7074.1 - 0.00048 \* RF7074.2 - 0.00063 \* RF7074.3 - 0.00064 \* RF7074.4 - 0.00046 \* RF7074.5)

Restricted Ordinary Least Squares  
 QUARTERLY data for 101 periods from 1982Q4 to 2007Q4  
 Date: 2 SEP 2009

pf7074\_dpk

= - 0.00009 \* rf7074\_dpk - 0.00028 \* rf7074\_dpk[-1]  
 (0.41200) (1.18982)  
 - 0.00048 \* rf7074\_dpk[-2] - 0.00063 \* rf7074\_dpk[-3]  
 (3.71663) (4.89240)  
 - 0.00064 \* rf7074\_dpk[-4] - 0.00046 \* rf7074\_dpk[-5]  
 (2.78954) (2.06896)

Polynomial lags:

rf7074\_dpk  
 from 0 to 5 degree 3 near far

Sum Sq	0.0038	Std Err	0.0059	LHS Mean	-0.0043	Res Mean	-0.0018
R Sq	-0.1504	R Bar Sq	-0.1620	F	2, 99	NC	%RMSE
D.W.( 1)	0.7462	D.W.( 4)	1.0245				14566.3

DPF75O\_FE = (- 0.00007 \* RF75O\_FE - 0.00012 \* RF75O\_FE.1 - 0.00015 \* RF75O\_FE.2 - 0.00014 \* RF75O\_FE.3 - 0.00012 \* RF75O\_FE.4 - 0.00007 \* RF75O\_FE.5) - (- 0.00007 \* RF75O - 0.00012 \* RF75O.1 - 0.00015 \* RF75O.2 - 0.00014 \* RF75O.3 - 0.00012 \* RF75O.4 - 0.00007 \* RF75O.5)

Restricted Ordinary Least Squares  
 QUARTERLY data for 101 periods from 1982Q4 to 2007Q4  
 Date: 2 SEP 2009

pf75o\_dpk

= - 0.00007 \* rf75o\_dpk - 0.00012 \* rf75o\_dpk[-1]  
 (0.83244) (1.28137)  
 - 0.00015 \* rf75o\_dpk[-2] - 0.00014 \* rf75o\_dpk[-3]  
 (2.41595) (2.48652)  
 - 0.00012 \* rf75o\_dpk[-4] - 0.00007 \* rf75o\_dpk[-5]  
 (1.27553) (0.79882)

Polynomial lags:

rf75o\_dpk  
 from 0 to 5 degree 3 near far

Sum Sq	0.0008	Std Err	0.0028	LHS Mean	0.0001	Res Mean	0.0004
R Sq	0.0818	R Bar Sq	0.0725	F	2, 99	4.4079	%RMSE
D.W.( 1)	0.7531	D.W.( 4)	1.3841				43067.0

## 2.2 U.S. Earnings (MODSOL2)

Equation numbers identify the corresponding equations in the Fortran program EconModSol2EquationsMod.f90.

### Quarterly Employment Equations

Agricultural Workers

$$\begin{aligned} EA &= \text{IF LONGRANGE} = 0 \\ &\quad \text{THEN GDPPF09} / (1.125 * 1.138 * \text{EXP}(-0.20541 + 0.03254 * \text{YEAR} - 0.07829 + 0.37854)) \\ &\quad \text{ELSE } E * EA.1/E.1 \end{aligned} \quad (20)$$

Nonagricultural workers

$$\text{ENA} = E - EA \quad (21)$$

Nonagricultural Self-employed workers

$$\text{EF1617NAS} = (0.12015 * \text{RTP}.1 - 0.10551) * \text{EF1617} \quad (3)$$

Ordinary Least Squares

ANNUAL data for 5 periods from 2000 to 2004

Date: 9 NOV 2005

$$\begin{aligned} \text{ef1617nas/ef1617} &= & 0.12015 * \text{rtp}.1 &- & 0.10551 \\ & & (1.96868) & & (1.73441) \end{aligned}$$

Sum Sq 0.0000  
Std Error 0.0030  
LHS Mean 0.0142  
R-Squared 0.5637  
R Bar Squared 0.4182  
F-stat 1, 3 3.8757  
D.W. (1) 1.5620  
D.W. (2) 2.3626

$$\text{EF1819NAS} = (0.11184 * \text{RTP}.1 - 0.10241) * \text{EF1819} \quad (4)$$

Ordinary Least Squares

ANNUAL data for 5 periods from 2000 to 2004

Date: 9 NOV 2005

$$\begin{aligned} \text{ef1819nas/ef1819} &= & 0.11184 * \text{rtp}.1 &- & 0.10241 \\ & & (2.99537) & & (2.75170) \end{aligned}$$

Sum Sq 0.0000  
Std Error 0.0018  
LHS Mean 0.0090  
R-Squared 0.7494  
R Bar Squared 0.6659  
F-STAT 1, 3 8.9722  
D.W. (1) 3.2586  
D.W. (2) 0.9766

$$\text{EF2024NAS} = (0.08908 * \text{RTP}.1 - 0.07176) * \text{EF2024} \quad (5)$$

Ordinary Least Squares

ANNUAL data for 5 periods from 2000 to 2004

Date: 9 NOV 2005

$$\begin{aligned} \text{ef2024nas/ef2024} &= & 0.08908 * \text{rtp}.1 &- & 0.07176 \\ & & (2.54605) & & (2.05763) \end{aligned}$$

Sum Sq 0.0000  
Std Error 0.0017  
LHS Mean 0.0170  
R-Squared 0.6836  
R Bar Squared 0.5782  
F-STAT 1, 3 6.4824  
D.W. (1) 2.6600  
D.W. (2) 1.5247

$$\text{EF2534NAS} = (0.00906 * \text{RTP}.1 + 0.03539) * \text{EF2534} \quad (6)$$

Ordinary Least Squares

ANNUAL data for 5 periods from 2000 to 2004  
Date: 9 NOV 2005

$$\text{ef2534nas/ef2534} = \begin{matrix} 0.00906 * \text{rtp.1} + & 0.03539 \\ (0.34277) & (1.34366) \end{matrix}$$

Sum Sq 0.0000  
Std Error 0.0013  
LHS Mean 0.0444  
R-Squared 0.0377  
R Bar Squared 0.2831  
F-STAT 1, 3 0.1175  
D.W. (1) 3.0818  
D.W. (2) 1.1094

$$\text{EF3544NAS} = (-0.01869 * \text{RTP.1} + 0.08087) * \text{EF3544} \quad (7)$$

Ordinary Least Squares

ANNUAL data for 5 periods from 2000 to 2004  
Date: 9 NOV 2005

$$\text{ef3544nas/ef3544} = \begin{matrix} -0.01869 * \text{rtp.1} + & 0.08087 \\ (0.70565) & (3.06320) \end{matrix}$$

Sum Sq 0.0000  
Std Error 0.0013  
LHS Mean 0.0622  
R-Squared 0.1424  
R Bar Squared 0.1435  
F-STAT 1, 3 0.4979  
D.W. (1) 2.2440  
D.W. (2) 2.1852

$$\text{EF4554NAS} = (0.07232 * \text{RTP.1} - 0.00701) * \text{EF4554} \quad (8)$$

Ordinary Least Squares

ANNUAL data for 5 periods from 2000 to 2004  
Date: 9 NOV 2005

$$\text{ef4554nas/ef4554} = \begin{matrix} 0.07232 * \text{rtp.1} - & 0.00701 \\ (2.86756) & (0.27876) \end{matrix}$$

Sum Sq 0.0000  
Std Error 0.0012  
LHS Mean 0.0651  
R-Squared 0.7327  
R Bar Squared 0.6436  
F-STAT 1, 3 8.2229  
D.W. (1) 1.7821  
D.W. (2) 2.7029

$$\text{EF5564NAS} = (0.07872 * \text{RTP.1} + 0.00466) * \text{EF5564} \quad (9)$$

Ordinary Least Squares

ANNUAL data for 5 periods from 2000 to 2004  
Date: 9 NOV 2005

$$\text{ef5564nas/ef5564} = \begin{matrix} 0.07872 * \text{rtp.1} + & 0.00466 \\ (1.38159) & (0.08196) \end{matrix}$$

Sum Sq 0.0000  
Std Error 0.0028  
LHS Mean 0.0831  
R-Squared 0.3889  
R Bar Squared 0.1851  
F-STAT 1, 3 1.9088  
D.W. (1) 2.6092  
D.W. (2) 2.2686

$$\text{EF65ONAS} = (0.10940 * \text{EF6569} + 0.12265 * \text{EF7074} + 0.14137 * \text{EF750}) \quad (10)$$

Ordinary Least Squares

ANNUAL data for 5 periods from 2000 to 2004  
Date: 9 NOV 2005

$$\text{ef6569nas/ef6569} = 0.10940 \\ (37.7493)$$

Sum Sq 0.0002  
 Std Error 0.0065  
 LHS Mean 0.1094  
 R-Squared 0.0000  
 R Bar Squared 0.0000  
 F 0, 4 NC  
 D.W. (1) 3.0431  
 D.W. (2) 1.2204

Ordinary Least Squares  
 ANNUAL data for 5 periods from 2000 to 2004  
 Date: 9 NOV 2005

$$\text{ef7074nas/ef7074} = 0.12265 \\ (16.4939)$$

Sum Sq 0.0011  
 Std Error 0.0166  
 LHS Mean 0.1226  
 R-Squared 0.0000  
 R Bar Squared 0.0000  
 F 0, 4 NC  
 D.W. (1) 1.0289  
 D.W. (2) 1.7188

Ordinary Least Squares  
 ANNUAL data for 5 periods from 2000 to 2004  
 Date: 9 NOV 2005

$$\text{ef75onas/ef75o} = 0.14137 \\ (17.7500)$$

Sum Sq 0.0013  
 Std Error 0.0178  
 LHS Mean 0.1414  
 R-Squared 0.0000  
 R Bar Squared 0.0000  
 F 0, 4 NC  
 D.W. (1) 1.6889  
 D.W. (2) 1.2345

$$\text{EM1617NAS} = (-0.23035 * \text{RTP.1} + 0.24985) * \text{EM1617} \quad (2)$$

Ordinary Least Squares  
 ANNUAL data for 5 periods from 2000 to 2004  
 Date: 9 NOV 2005

$$\text{em1617nas/em1617} = -0.23035 * \text{rtp.1} + 0.24985 \\ (5.08538) \quad (5.53372)$$

Sum Sq 0.0000  
 Std Error 0.0022  
 LHS Mean 0.0203  
 R-Squared 0.8961  
 R Bar Squared 0.8614  
 F-STAT 1, 3 25.8611  
 D.W. (1) 2.4658  
 D.W. (2) 1.6839

$$\text{EM1819NAS} = (-0.05782 * \text{RTP.1} + 0.07265) * \text{EM1819} \quad (11)$$

Ordinary Least Squares  
 ANNUAL data for 5 periods from 2000 to 2004  
 Date: 9 NOV 2005

$$\text{em1819nas/em1819} = -0.05782 * \text{rtp.1} + 0.07265 \\ (3.43044) \quad (4.32458)$$

Sum Sq 0.0000  
 Std Error 0.0008  
 LHS Mean 0.0150  
 R-Squared 0.7969  
 R Bar Squared 0.7291  
 F-STAT 1, 3 11.7679  
 D.W. (1) 3.3262  
 D.W. (2) 1.0399

EM2024NAS = (-0.09206 \* RTP.1 + 0.11567) \* EM2024 (12)  
 Ordinary Least Squares  
 ANNUAL data for 5 periods from 2000 to 2004  
 Date: 9 NOV 2005

em2024nas/em2024 = -0.09206 \* rtp.1 + 0.11567  
 (2.44839) (3.08618)

Sum Sq 0.0000  
 Std Error 0.0018  
 LHS Mean 0.0239  
 R-Squared 0.6665  
 R Bar Squared 0.5553  
 F-STAT 1, 3 5.9946  
 D.W. (1) 2.1493  
 D.W. (2) 1.7046

EM2534NAS = (-0.09661 \* RTP.1 + 0.14843) \* EM2534 (13)  
 Ordinary Least Squares  
 ANNUAL data for 5 periods from 2000 to 2004  
 Date: 9 NOV 2005

em2534nas/em2534 = -0.09661 \* rtp.1 + 0.14843  
 (2.81478) (4.33847)

Sum Sq 0.0000  
 Std Error 0.0017  
 LHS Mean 0.0522  
 R-Squared 0.7254  
 R Bar Squared 0.6338  
 F-STAT 1, 3 7.9230  
 D.W. (1) 1.8300  
 D.W. (2) 2.9632

EM3544NAS = (0.02739 \* RTP.1 + 0.05236) \* EM3544 (14)  
 Ordinary Least Squares  
 ANNUAL data for 5 periods from 2000 to 2004  
 Date: 9 NOV 2005

em3544nas/em3544 = 0.02739 \* rtp.1 + 0.05236  
 (0.61129) (1.17241)

Sum Sq 0.0000  
 Std Error 0.0022  
 LHS Mean 0.0797  
 R-Squared 0.1108  
 R Bar Squared 0.1857  
 F-STAT 1, 3 0.3737  
 D.W. (1) 2.5508  
 D.W. (2) 2.2676

EM4554NAS = (0.06217 \* RTP.1 + 0.03411) \* EM4554 (15)  
 Ordinary Least Squares  
 ANNUAL data for 5 periods from 2000 to 2004  
 Date: 9 NOV 2005

em4554nas/em4554 = 0.06217 \* rtp.1 + 0.03411  
 (1.91738) (1.05544)

Sum Sq 0.0000  
 Std Error 0.0016



LHS Mean 0.0961  
 R-Squared 0.5507  
 R Bar Squared 0.4009  
 F-STAT 1, 3 3.6764  
 D.W. (1) 2.5497  
 D.W. (2) 1.5554

$$EM5564NAS = (-0.04776 * RTP.1 + 0.16626) * EM5564 \quad (16)$$

Ordinary Least Squares  
 ANNUAL data for 5 periods from 2000 to 2004  
 Date: 9 NOV 2005

$$em5564nas/em5564 = -0.04776 * rtp.1 + 0.16626 \\ (0.60480) \quad (2.11226)$$

Sum Sq 0.0000  
 Std Error 0.0039  
 LHS Mean 0.1187  
 R-Squared 0.1087  
 R Bar Squared 0.1884  
 F-STAT 1, 3 0.3658  
 D.W. (1) 2.9234  
 D.W. (2) 1.9432

$$EM65ONAS = (0.16527 * EM6569 + 0.17798 * EM7074 + 0.19058 * EM75O) \quad (17)$$

Ordinary Least Squares  
 ANNUAL data for 5 periods from 2000 to 2004  
 Date: 9 NOV 2005

$$em6569nas/em6569 = 0.16527 \\ (53.9126)$$

Sum Sq 0.0002  
 Std Error 0.0069  
 LHS Mean 0.1653  
 R-Squared 0.0000  
 R Bar Squared 0.0000  
 F-stat 0, 4 NC  
 D.W. (1) 1.7716  
 D.W. (2) 2.9645

Ordinary Least Squares  
 ANNUAL data for 5 periods from 2000 to 2004  
 Date: 9 NOV 2005

$$em7074nas/em7074 = 0.17798 \\ (22.9265)$$

Sum Sq 0.0012  
 Std Error 0.0174  
 LHS Mean 0.1780  
 R-Squared 0.0000  
 R Bar Squared 0.0000  
 F-stat 0, 4 NC  
 D.W. (1) 1.7116  
 D.W. (2) 2.1991

Ordinary Least Squares  
 ANNUAL data for 5 periods from 2000 to 2004  
 Date: 9 NOV 2005

$$em75onas/em75o = 0.19058 \\ (20.1892)$$

Sum Sq 0.0018  
 Std Error 0.0211  
 LHS Mean 0.1906  
 R-Squared 0.0000  
 R Bar Squared 0.0000  
 F-stat 0, 4 NC  
 D.W. (1) 2.7330

D.W. (2) 0.9992

Nonagricultural Self-employed Workers:

“Raw” equations (before scaling the totals):

Female

$$\begin{aligned} \text{EF1617NAS\_R} &= (0.12015 * \text{RTP.1} - 0.10551) * \text{EF1617} + & (3) \\ \text{EF1617NAS\_ADJ} & & \\ \text{EF1819NAS\_R} &= (0.11184 * \text{RTP.1} - 0.10241) * \text{EF1819} + & (4) \\ \text{EF1819NAS\_ADJ} & & \\ \text{EF2024NAS\_R} &= (0.08908 * \text{RTP.1} - 0.07176) * \text{EF2024} + & (5) \\ \text{EF2024NAS\_ADJ} & & \\ \text{EF2534NAS\_R} &= (0.00906 * \text{RTP.1} + 0.03539) * \text{EF2534} + & (6) \\ \text{EF2534NAS\_ADJ} & & \\ \text{EF3544NAS\_R} &= (-0.01869 * \text{RTP.1} + 0.08087) * \text{EF3544} + & (7) \\ \text{EF3544NAS\_ADJ} & & \\ \text{EF4554NAS\_R} &= (0.07232 * \text{RTP.1} - 0.00701) * \text{EF4554} + & (8) \\ \text{EF4554NAS\_ADJ} & & \\ \text{EF5564NAS\_R} &= (0.07872 * \text{RTP.1} + 0.00466) * \text{EF5564} + & (9) \\ \text{EF5564NAS\_ADJ} & & \\ \text{EF65ONAS\_R} &= (0.10940 * \text{EF6569} + 0.12265 * \text{EF7074} + 0.14137 * \text{EF75O}) + & \\ \text{EF65ONAS\_ADJ} & & (10) \end{aligned}$$

Male

$$\begin{aligned} \text{EM1617NAS\_R} &= (-0.23035 * \text{RTP.1} + 0.24985) * \text{EM1617} + & (2) \\ \text{EM1617NAS\_ADJ} & & \\ \text{EM1819NAS\_R} &= (-0.05782 * \text{RTP.1} + 0.07265) * \text{EM1819} + & (11) \\ \text{EM1819NAS\_ADJ} & & \\ \text{EM2024NAS\_R} &= (-0.09206 * \text{RTP.1} + 0.11567) * \text{EM2024} + & (12) \\ \text{EM2024NAS\_ADJ} & & \\ \text{EM2534NAS\_R} &= (-0.09661 * \text{RTP.1} + 0.14843) * \text{EM2534} + & (13) \\ \text{EM2534NAS\_ADJ} & & \\ \text{EM3544NAS\_R} &= (0.02739 * \text{RTP.1} + 0.05236) * \text{EM3544} + & (14) \\ \text{EM3544NAS\_ADJ} & & \\ \text{EM4554NAS\_R} &= (0.06217 * \text{RTP.1} + 0.03411) * \text{EM4554} + & (15) \\ \text{EM4554NAS\_ADJ} & & \\ \text{EM5564NAS\_R} &= (-0.04776 * \text{RTP.1} + 0.16626) * \text{EM5564} + & (16) \\ \text{EM5564NAS\_ADJ} & & \\ \text{EM65ONAS\_R} &= (0.16527 * \text{EM6569} + 0.17798 * \text{EM7074} + 0.19058 * \text{EM75O}) + & \\ \text{EM65ONAS\_ADJ} & & (17) \end{aligned}$$

$$\begin{aligned} \text{ENAS\_R} &= \text{EF1617NAS\_R} + \text{EF1819NAS\_R} + \text{EF2024NAS\_R} + \text{EF2534NAS\_R} + \text{EF3544NAS\_R} + \text{EF4554NAS\_R} + \text{EF5564NAS\_R} + \\ & \text{EF65ONAS\_R} + \text{EM1617NAS\_R} + \text{EM1819NAS\_R} + \text{EM2024NAS\_R} + \text{EM2534NAS\_R} + \text{EM3544NAS\_R} + \\ & \text{EM4554NAS\_R} + \text{EM5564NAS\_R} + \text{EM65ONAS\_R} \quad (18) \end{aligned}$$

Total nonagricultural SE workers:

$$\begin{aligned} \text{ENAS} &= \text{IF LONGRANGE} = 0 \\ & \text{THEN ENAS\_R} \\ & \text{ELSE ENA} * (\text{ENAS.1}/\text{ENA.1}) \quad (22) \end{aligned}$$

Final (scaled) equations:

Male

$$\begin{aligned} \text{EM1617NAS} &= \text{EM1617NAS\_R} * (\text{ENAS}/\text{ENAS\_R}) \quad (23) \\ \text{EM1819NAS} &= \text{EM1819NAS\_R} * (\text{ENAS}/\text{ENAS\_R}) \quad (102) \\ \text{EM2024NAS} &= \text{EM2024NAS\_R} * (\text{ENAS}/\text{ENAS\_R}) \quad (109) \\ \text{EM2534NAS} &= \text{EM2534NAS\_R} * (\text{ENAS}/\text{ENAS\_R}) \quad (116) \\ \text{EM3544NAS} &= \text{EM3544NAS\_R} * (\text{ENAS}/\text{ENAS\_R}) \quad (123) \\ \text{EM4554NAS} &= \text{EM4554NAS\_R} * (\text{ENAS}/\text{ENAS\_R}) \quad (130) \\ \text{EM5564NAS} &= \text{EM5564NAS\_R} * (\text{ENAS}/\text{ENAS\_R}) \quad (137) \\ \text{EM65ONAS} &= \text{EM65ONAS\_R} * (\text{ENAS}/\text{ENAS\_R}) \quad (144) \end{aligned}$$

Female

$$\begin{aligned} \text{EF1617NAS} &= \text{EF1617NAS\_R} * (\text{ENAS}/\text{ENAS\_R}) \quad (157) \\ \text{EF1819NAS} &= \text{EF1819NAS\_R} * (\text{ENAS}/\text{ENAS\_R}) \quad (164) \\ \text{EF2024NAS} &= \text{EF2024NAS\_R} * (\text{ENAS}/\text{ENAS\_R}) \quad (171) \end{aligned}$$

$$\begin{aligned}
EF2534NAS &= EF2534NAS\_R * (ENAS/ENAS\_R) && (178) \\
EF3544NAS &= EF3544NAS\_R * (ENAS/ENAS\_R) && (185) \\
EF4554NAS &= EF4554NAS\_R * (ENAS/ENAS\_R) && (192) \\
EF5564NAS &= EF5564NAS\_R * (ENAS/ENAS\_R) && (199) \\
EF65ONAS &= EF65ONAS\_R * (ENAS/ENAS\_R) && (206) \\
\\
EFNAS &= EF1617NAS + EF1819NAS + EF2024NAS + EF2534NAS + EF3544NAS + EF4554NAS + EF5564NAS + \\
EF65ONAS &&& (212) \\
EMNAS &= EM1617NAS + EM1819NAS + EM2024NAS + EM2534NAS + EM3544NAS + EM4554NAS + EM5564NAS + \\
EM65ONAS &&& (150)
\end{aligned}$$

Nonagricultural Unpaid Family Workers

“Raw” equations (before scaling the totals):

$$\begin{aligned}
\text{Female} &&& (25-32) \\
EF1617NAU\_R &= 0.00012 * ENAS + EF1617NAU.ADJ \\
EF1819NAU\_R &= 0.00025 * ENAS + EF1819NAU.ADJ \\
EF2024NAU\_R &= 0.00024 * ENAS + EF2024NAU.ADJ \\
EF2534NAU\_R &= 0.00117 * ENAS + EF2534NAU.ADJ \\
EF3544NAU\_R &= 0.00218 * ENAS + EF3544NAU.ADJ \\
EF4554NAU\_R &= 0.00226 * ENAS + EF4554NAU.ADJ \\
EF5564NAU\_R &= 0.00083 * ENAS + EF5564NAU.ADJ \\
EF65ONAU\_R &= (0.00027 + 0.00021 + 0.00008) * ENAS + EF65ONAU.ADJ \\
\\
\text{Male} &&& \\
EM1617NAU\_R &= 0.00028 * ENAS + EM1617NAU.ADJ && (24) \\
EM1819NAU\_R &= 0.00033 * ENAS + EM1819NAU.ADJ && (33) \\
EM2024NAU\_R &= 0.00050 * ENAS + EM2024NAU.ADJ && (34) \\
EM2534NAU\_R &= 0.00044 * ENAS + EM2534NAU.ADJ && (35) \\
EM3544NAU\_R &= 0.00043 * ENAS + EM3544NAU.ADJ && (36) \\
EM4554NAU\_R &= 0.00052 * ENAS + EM4554NAU.ADJ && (37) \\
EM5564NAU\_R &= 0.00037 * ENAS + EM5564NAU.ADJ && (38) \\
EM65ONAU\_R &= (0.00023 + 0.00010 + 0.00011) * ENAS + EM65ONAU.ADJ && (39) \\
\\
ENAU\_R &= EF1617NAU\_R + EF1819NAU\_R + EF2024NAU\_R + EF2534NAU\_R + EF3544NAU\_R + EF4554NAU\_R + \\
&EF5564NAU\_R + EF65ONAU\_R + EM1617NAU\_R + EM1819NAU\_R + EM2024NAU\_R + EM2534NAU\_R + \\
&EM3544NAU\_R + EM4554NAU\_R + EM5564NAU\_R + EM65ONAU\_R && (40)
\end{aligned}$$

$$\begin{aligned}
\text{Total Nonagricultural Unpaid Family Workers:} \\
ENAU &= ENAU\_R && (41)
\end{aligned}$$

Final (scaled) equations:

$$\begin{aligned}
EM1617NAU &= EM1617NAU\_R * (ENAU/ENAU\_R) && (42) \\
EM1819NAU &= EM1819NAU\_R * (ENAU/ENAU\_R) && (103) \\
EM2024NAU &= EM2024NAU\_R * (ENAU/ENAU\_R) && (110) \\
EM2534NAU &= EM2534NAU\_R * (ENAU/ENAU\_R) && (117) \\
EM3544NAU &= EM3544NAU\_R * (ENAU/ENAU\_R) && (124) \\
EM4554NAU &= EM4554NAU\_R * (ENAU/ENAU\_R) && (131) \\
EM5564NAU &= EM5564NAU\_R * (ENAU/ENAU\_R) && (138) \\
EM65ONAU &= EM65ONAU\_R * (ENAU/ENAU\_R) && (145) \\
\\
EF1617NAU &= EF1617NAU\_R * (ENAU/ENAU\_R) && (158) \\
EF1819NAU &= EF1819NAU\_R * (ENAU/ENAU\_R) && (165) \\
EF2024NAU &= EF2024NAU\_R * (ENAU/ENAU\_R) && (172) \\
EF2534NAU &= EF2534NAU\_R * (ENAU/ENAU\_R) && (179) \\
EF3544NAU &= EF3544NAU\_R * (ENAU/ENAU\_R) && (186) \\
EF4554NAU &= EF4554NAU\_R * (ENAU/ENAU\_R) && (193) \\
EF5564NAU &= EF5564NAU\_R * (ENAU/ENAU\_R) && (200) \\
EF65ONAU &= EF65ONAU\_R * (ENAU/ENAU\_R) && (207) \\
\\
EFNAU &= EF1617NAU + EF1819NAU + EF2024NAU + EF2534NAU + EF3544NAU + EF4554NAU + EF5564NAU + \\
EF65ONAU &&& (213) \\
EMNAU &= EM1617NAU + EM1819NAU + EM2024NAU + EM2534NAU + EM3544NAU + EM4554NAU + EM5564NAU + \\
EM65ONAU &&& (151)
\end{aligned}$$

Agricultural Wage Workers

Total Agricultural Wage Workers

$$\begin{aligned} \text{EAW} &= \text{IF LONGRANGE} = 0 \\ &\quad \text{THEN EA} * (0.00893 * \text{YEAR} + 0.33159 * \text{RTP} - 0.67943) \\ &\quad \text{ELSE EA} * (\text{EAW}_1 / \text{EA}_1) \end{aligned} \quad (43)$$

Raw Disaggregation of EAW:

Male

$$\begin{aligned} \text{EM1617AW}_R &= \text{MAX}(0, \text{EAW} * (-0.00594 - 0.09353 * \text{MOVAVG}(2, \text{RTP}.1) + 5.28754 * \text{EM1617/E} + 0.08116) + \\ &\quad \text{EM1617AW.ADJ}) \quad (44) \\ \text{EM1819AW}_R &= \text{MAX}(0, \text{EAW} * (-0.00131 - 0.18120 * \text{MOVAVG}(2, \text{RTP}.1) + 3.87151 * \text{EM1819/E} + 0.16636) + \text{EM1819AW.ADJ}) \quad (53) \\ \text{EM2024AW}_R &= \text{MAX}(0, \text{EAW} * (-0.00664 + 0.10493 * \text{MOVAVG}(2, \text{RTP}.1) + 2.00153 * \text{EM2024/E} - 0.08191) + \text{EM2024AW.ADJ}) \quad (54) \\ \text{EM2534AW}_R &= \text{MAX}(0, \text{EAW} * (-0.02065 + 0.38358 * \text{MOVAVG}(2, \text{RTP}.1) - 0.98380 * \text{EM2534/E} + 0.00751) + \text{EM2534AW.ADJ}) \quad (55) \\ \text{EM3544AW}_R &= \text{MAX}(0, \text{EAW} * (0.00402 - 0.15663 * \text{MOVAVG}(2, \text{RTP}.1) + 1.72119 * \text{EM3544/E} + 0.05679) + \text{EM3544AW.ADJ}) \quad (56) \\ \text{EM4554AW}_R &= \text{MAX}(0, \text{EAW} * (0.00834 + 0.03746 * \text{MOVAVG}(2, \text{RTP}.1) + 0.46522 * \text{EM4554/E} + 0.00144) + \text{EM4554AW.ADJ}) \quad (57) \\ \text{EM5564AW}_R &= \text{MAX}(0, \text{EAW} * (-0.00655 + 0.03521 * \text{MOVAVG}(2, \text{RTP}.1) + 0.46852 * \text{EM5564/E} - 0.00037) + \text{EM5564AW.ADJ}) \quad (58) \\ \text{EM65OAW}_R &= \text{MAX}(0, \text{EAW} * (-0.00114 + 0.07640 * \text{MOVAVG}(2, \text{RTP}.1) + 3.25911 * \text{EM65O/E} - 0.10058) + \text{EM65OAW.ADJ}) \quad (59) \end{aligned}$$

Female

$$\begin{aligned} \text{EF1617AW}_R &= \text{MAX}(0, \text{EAW} * (-0.00055 - 0.05470 * \text{MOVAVG}(2, \text{RTP}.1) + 1.41760 * \text{EF1617/E} + 0.04979) + \text{EF1617AW.ADJ}) \quad (45-52) \\ \text{EF1819AW}_R &= \text{MAX}(0, \text{EAW} * (0.00102 - 0.07375 * \text{MOVAVG}(2, \text{RTP}.1) + 0.78394 * \text{EF1819/E} + 0.07226) + \text{EF1819AW.ADJ}) \\ \text{EF2024AW}_R &= \text{MAX}(0, \text{EAW} * (0.00112 - 0.05971 * \text{MOVAVG}(2, \text{RTP}.1) + 0.57256 * \text{EF2024/E} + 0.05907) + \text{EF2024AW.ADJ}) \\ \text{EF2534AW}_R &= \text{MAX}(0, \text{EAW} * (0.00623 + 0.08868 * \text{MOVAVG}(2, \text{RTP}.1) + 1.00897 * \text{EF2534/E} - 0.15142) + \text{EF2534AW.ADJ}) \\ \text{EF3544AW}_R &= \text{MAX}(0, \text{EAW} * (0.00687 - 0.00259 * \text{MOVAVG}(2, \text{RTP}.1) + 0.51319 * \text{EF3544/E} - 0.00937) + \text{EF3544AW.ADJ}) \\ \text{EF4554AW}_R &= \text{MAX}(0, \text{EAW} * (0.00185 + 0.08747 * \text{MOVAVG}(2, \text{RTP}.1) + 0.28022 * \text{EF4554/E} - 0.08053) + \text{EF4554AW.ADJ}) \\ \text{EF5564AW}_R &= \text{MAX}(0, \text{EAW} * (-0.00140 - 0.03001 * \text{MOVAVG}(2, \text{RTP}.1) - 0.59383 * \text{EF5564/E} + 0.07088) + \text{EF5564AW.ADJ}) \\ \text{EF65OAW}_R &= \text{MAX}(0, \text{EAW} * (0.00096 + 0.06768 * \text{MOVAVG}(2, \text{RTP}.1) + 1.04213 * \text{EF65O/E} - 0.07359) + \text{EF65OAW.ADJ}) \end{aligned}$$

$$\begin{aligned} \text{EAW}_R &= \text{EF1617AW}_R + \text{EF1819AW}_R + \text{EF2024AW}_R + \text{EF2534AW}_R + \text{EF3544AW}_R + \text{EF4554AW}_R + \text{EF5564AW}_R + \\ &\quad \text{EF65OAW}_R + \text{EM1617AW}_R + \text{EM1819AW}_R + \text{EM2024AW}_R + \text{EM2534AW}_R + \text{EM3544AW}_R + \\ &\quad \text{EM4554AW}_R + \text{EM5564AW}_R + \text{EM65OAW}_R \quad (60) \end{aligned}$$

Final (scaled) equations:

$$\begin{aligned} \text{EM1617AW} &= \text{EM1617AW}_R * (\text{EAW} / \text{EAW}_R) \quad (61) \\ \text{EM1819AW} &= \text{EM1819AW}_R * (\text{EAW} / \text{EAW}_R) \quad (104) \\ \text{EM2024AW} &= \text{EM2024AW}_R * (\text{EAW} / \text{EAW}_R) \quad (111) \\ \text{EM2534AW} &= \text{EM2534AW}_R * (\text{EAW} / \text{EAW}_R) \quad (118) \\ \text{EM3544AW} &= \text{EM3544AW}_R * (\text{EAW} / \text{EAW}_R) \quad (125) \\ \text{EM4554AW} &= \text{EM4554AW}_R * (\text{EAW} / \text{EAW}_R) \quad (132) \\ \text{EM5564AW} &= \text{EM5564AW}_R * (\text{EAW} / \text{EAW}_R) \quad (139) \\ \text{EM65OAW} &= \text{EM65OAW}_R * (\text{EAW} / \text{EAW}_R) \quad (146) \\ \\ \text{EF1617AW} &= \text{EF1617AW}_R * (\text{EAW} / \text{EAW}_R) \quad (159) \\ \text{EF1819AW} &= \text{EF1819AW}_R * (\text{EAW} / \text{EAW}_R) \quad (166) \\ \text{EF2024AW} &= \text{EF2024AW}_R * (\text{EAW} / \text{EAW}_R) \quad (173) \\ \text{EF2534AW} &= \text{EF2534AW}_R * (\text{EAW} / \text{EAW}_R) \quad (180) \\ \text{EF3544AW} &= \text{EF3544AW}_R * (\text{EAW} / \text{EAW}_R) \quad (187) \\ \text{EF4554AW} &= \text{EF4554AW}_R * (\text{EAW} / \text{EAW}_R) \quad (194) \\ \text{EF5564AW} &= \text{EF5564AW}_R * (\text{EAW} / \text{EAW}_R) \quad (201) \\ \text{EF65OAW} &= \text{EF65OAW}_R * (\text{EAW} / \text{EAW}_R) \quad (208) \end{aligned}$$

$$\text{EFAW} = \text{EF1617AW} + \text{EF1819AW} + \text{EF2024AW} + \text{EF2534AW} + \text{EF3544AW} + \text{EF4554AW} + \text{EF5564AW} + \text{EF65OAW} \quad (214)$$

$$\text{EMAW} = \text{EM1617AW} + \text{EM1819AW} + \text{EM2024AW} + \text{EM2534AW} + \text{EM3544AW} + \text{EM4554AW} + \text{EM5564AW} + \text{EM65OAW} \quad (152)$$

Unpaid Agricultural Family Workers

Raw equations:

$$\text{Male} \quad (71-78)$$

EM1617AU\_R = MAX (0, 0.002 + EM1617AU.ADJ)  
 EM1819AU\_R = MAX (0, 0.001 + EM1819AU.ADJ)  
 EM2024AU\_R = MAX (0, 0.001 + EM2024AU.ADJ)  
 EM2534AU\_R = MAX (0, 0.003 + EM2534AU.ADJ)  
 EM3544AU\_R = MAX (0, 0.004 + EM3544AU.ADJ)  
 EM4554AU\_R = MAX (0, 0.005 + EM4554AU.ADJ)  
 EM5564AU\_R = MAX (0, 0.003 + EM5564AU.ADJ)  
 EM65OAU\_R = MAX (0, 0.001 + EM65OAU.ADJ)

Female

(63-70)

EF1617AU\_R = MAX (0, 0.006 + EM1617AU.ADJ)  
 EF1819AU\_R = MAX (0, 0.005 + EF1819AU.ADJ)  
 EF2024AU\_R = MAX (0, 0.005 + EF2024AU.ADJ)  
 EF2534AU\_R = MAX (0, 0.002 + EF2534AU.ADJ)  
 EF3544AU\_R = MAX (0, 0.002 + EF3544AU.ADJ)  
 EF4554AU\_R = MAX (0, 0.001 + EF4554AU.ADJ)  
 EF5564AU\_R = MAX (0, 0.001 + EF5564AU.ADJ)  
 EF65OAU\_R = MAX (0, 0.002 + EF65OAU.ADJ)

EAU\_R = EF1617AU\_R + EF1819AU\_R + EF2024AU\_R + EF2534AU\_R + EF3544AU\_R + EF4554AU\_R + EF5564AU\_R +  
 EF65OAU\_R + EM1617AU\_R + EM1819AU\_R + EM2024AU\_R + EM2534AU\_R + EM3544AU\_R + EM4554AU\_R +  
 EM5564AU\_R + EM65OAU\_R (79)

Total Unpaid Agricultural Family Workers :

EAU = IF LONGRANGE = 0  
 THEN EAU\_R  
 ELSE EAU.I/EA.1 \* EA (80)

Final (scaled) equations :

EM1617AU = EM1617AU\_R \* (EAU/EAU\_R) (99)  
 EM1819AU = EM1819AU\_R \* (EAU/EAU\_R) (106)  
 EM2024AU = EM2024AU\_R \* (EAU/EAU\_R) (113)  
 EM2534AU = EM2534AU\_R \* (EAU/EAU\_R) (120)  
 EM3544AU = EM3544AU\_R \* (EAU/EAU\_R) (127)  
 EM4554AU = EM4554AU\_R \* (EAU/EAU\_R) (134)  
 EM5564AU = EM5564AU\_R \* (EAU/EAU\_R) (141)  
 EM65OAU = EM65OAU\_R \* (EAU/EAU\_R) (148)

EF1617AU = EF1617AU\_R \* (EAU/EAU\_R) (161)  
 EF1819AU = EF1819AU\_R \* (EAU/EAU\_R) (168)  
 EF2024AU = EF2024AU\_R \* (EAU/EAU\_R) (175)  
 EF2534AU = EF2534AU\_R \* (EAU/EAU\_R) (182)  
 EF3544AU = EF3544AU\_R \* (EAU/EAU\_R) (189)  
 EF4554AU = EF4554AU\_R \* (EAU/EAU\_R) (196)  
 EF5564AU = EF5564AU\_R \* (EAU/EAU\_R) (203)  
 EF65OAU = EF65OAU\_R \* (EAU/EAU\_R) (210)

EFAU = EF1617AU + EF1819AU + EF2024AU + EF2534AU + EF3544AU + EF4554AU + EF5564AU + EF65OAU (216)  
 EMAU = EM1617AU + EM1819AU + EM2024AU + EM2534AU + EM3544AU + EM4554AU + EM5564AU + EM65OAU (154)

Self-employed Agricultural Workers

Total

EAS = EA - EAU - EAW (81)

Raw disaggregation:

EM1617AS\_R = MAX (0, NM1617 \* (0.00528 + 0.00404) + EM1617AS.ADJ) (62)  
 EM1819AS\_R = MAX (0, NM1819 \* (0.00309 + 0.28448 \* EA / (NM16O+ NF16O) - 0.00165) +  
 EM1819AS.ADJ) (90)  
 EM2024AS\_R = MAX (0, NM2024 \* (-0.00181 + 0.97958 \* EA / (NM16O+ NF16O) - 0.01093) + EM2024AS.ADJ)  
 (91)  
 EM2534AS\_R = MAX (0, NM2534 \* (-0.00263 + 1.23186 \* EA / (NM16O+ NF16O) - 0.01021) + EM2534AS.ADJ)  
 (92)  
 EM3544AS\_R = MAX (0, NM3544 \* (-0.00151 + 1.66765 \* EA / (NM16O+ NF16O) - 0.01450) + EM3544AS.ADJ)  
 (93)  
 EM4554AS\_R = MAX (0, NM4554 \* (-0.00381 + 2.86654 \* EA / (NM16O+ NF16O) - 0.03175) + EM4554AS.ADJ)  
 (94)  
 EM5564AS\_R = MAX (0, NM5564 \* (-0.00460 + 2.78817 \* EA / (NM16O+ NF16O) - 0.02398) + EM5564AS.ADJ)  
 (95)  
 EM65OAS\_R = MAX (0, NM65O \* (0.00079 + 1.76904 \* EA / (NM16O+ NF16O) - 0.01437) + EM65OAS.ADJ) (96)

$$\begin{aligned}
EF1617AS\_R &= \text{MAX}(0, NF1617 * (0.00181 + 0.00030) + EF1617AS.ADJ) && (82) \\
EF1819AS\_R &= \text{MAX}(0, EM1819AS.1 * (-0.02393 + 0.63672 * \text{MOVAVG}(2, RTP.1) + 0.98791 * EF1819/EM1819 - 4.43926) + \\
&\quad EF1819AS.ADJ) && (83) \\
EF2024AS\_R &= \text{MAX}(0, EM2024AS.1 * (0.07353 - 0.40207 * \text{MOVAVG}(2, RTP.1) + 0.57572 * EF2024/EM2024 - 0.01117) + \\
&\quad EF2024AS.ADJ) && (84) \\
EF2534AS\_R &= \text{MAX}(0, EM2534AS.1 * (0.16575 + 0.16967 * \text{MOVAVG}(2, RTP.1) + 0.55503 * EF2534/EM2534 - 0.43412) + \\
&\quad EF2534AS.ADJ) && (85) \\
EF3544AS\_R &= \text{MAX}(0, EM3544AS.1 * (0.15848 + 0.37839 * \text{MOVAVG}(2, RTP.1) + 0.37764 * EF3544/EM3544 - 0.45362) + \\
&\quad EF3544AS.ADJ) && (86) \\
EF4554AS\_R &= \text{MAX}(0, EM4554AS.1 * (0.21947 + 0.29497 * \text{MOVAVG}(2, RTP.1) + 0.58974 * EF4554/EM4554 - 0.51966) + \\
&\quad EF4554AS.ADJ) && (87) \\
EF5564AS\_R &= \text{MAX}(0, EM5564AS.1 * (0.20892 + 0.36294 * \text{MOVAVG}(2, RTP.1) + 0.65320 * EF5564/EM5564 - 0.66626) + \\
&\quad EF5564AS.ADJ) && (88) \\
EF65OAS\_R &= \text{MAX}(0, EM65OAS.1 * (0.16242 + 0.54916 * \text{MOVAVG}(2, RTP.1) + 0.06199 * EF65O/EM65O - 0.47556) + \\
&\quad EF65OAS.ADJ) && (89) \\
EAS\_R &= EF1617AS\_R + EF1819AS\_R + EF2024AS\_R + EF2534AS\_R + EF3544AS\_R + EF4554AS\_R + EF5564AS\_R + \\
&\quad EF65OAS\_R + EM1617AS\_R + EM1819AS\_R + EM2024AS\_R + EM2534AS\_R + EM3544AS\_R + EM4554AS\_R + \\
&\quad EM5564AS\_R + EM65OAS\_R && (97)
\end{aligned}$$

Final (scaled) equations:

$$\begin{aligned}
EM1617AS &= EM1617AS\_R * (EAS/EAS\_R) && (98) \\
EM1819AS &= EM1819AS\_R * (EAS/EAS\_R) && (105) \\
EM2024AS &= EM2024AS\_R * (EAS/EAS\_R) && (112) \\
EM2534AS &= EM2534AS\_R * (EAS/EAS\_R) && (119) \\
EM3544AS &= EM3544AS\_R * (EAS/EAS\_R) && (126) \\
EM4554AS &= EM4554AS\_R * (EAS/EAS\_R) && (133) \\
EM5564AS &= EM5564AS\_R * (EAS/EAS\_R) && (140) \\
EM65OAS &= EM65OAS\_R * (EAS/EAS\_R) && (147) \\
EF1617AS &= EF1617AS\_R * (EAS/EAS\_R) && (160) \\
EF1819AS &= EF1819AS\_R * (EAS/EAS\_R) && (167) \\
EF2024AS &= EF2024AS\_R * (EAS/EAS\_R) && (174) \\
EF2534AS &= EF2534AS\_R * (EAS/EAS\_R) && (181) \\
EF3544AS &= EF3544AS\_R * (EAS/EAS\_R) && (188) \\
EF4554AS &= EF4554AS\_R * (EAS/EAS\_R) && (195) \\
EF5564AS &= EF5564AS\_R * (EAS/EAS\_R) && (202) \\
EF65OAS &= EF65OAS\_R * (EAS/EAS\_R) && (209) \\
EFAS &= EF1617AS + EF1819AS + EF2024AS + EF2534AS + EF3544AS + EF4554AS + EF5564AS + \\
&\quad EF65OAS && (215) \\
EMAS &= EM1617AS + EM1819AS + EM2024AS + EM2534AS + EM3544AS + EM4554AS + EM5564AS + \\
&\quad EM65OAS && (153)
\end{aligned}$$

Nonagricultural Private Household Wage Workers:

“Raw” equations (before scaling the totals): (229-244)

$$\begin{aligned}
EF1617NAWPH\_R &= \text{MAX}(0.001, -0.20802 * \text{MOVAVG}(4, RTP.1) - 0.40988 * \text{MOVAVG}(4, RTP.5) + 0.01015 + 61.2465 * 1/YEAR - \\
&\quad 0.00965 * \text{MINW}/\text{CPIW\_U} + 0.01561 * \text{NU10}/\text{NF1617} - 0.13398) * EF1617 + EF1617NAWPH.ADJ \\
EF1819NAWPH\_R &= \text{MAX}(0.001, -0.03363 * \text{MOVAVG}(4, RTP.1) - 0.12989 * \text{MOVAVG}(4, RTP.5) - 0.00661 + 8.44701 * 1/YEAR - \\
&\quad 0.00539 * \text{MINW}/\text{CPIW\_U} + 0.00345 * \text{NU10}/\text{NF1819} + 0.07597) * EF1819 + EF1819NAWPH.ADJ \\
EF2024NAWPH\_R &= \text{MAX}(0.001, -0.18707 * \text{MOVAVG}(20, RTP.1) - 0.00223 + 2.12060 * 1/YEAR + 0.00820 * \text{NU10}/\text{NF2024} + \\
&\quad 0.14537) * EF2024 + EF2024NAWPH.ADJ \\
EF2534NAWPH\_R &= \text{MAX}(0.001, 0.01874 * \text{MOVAVG}(4, RTP.1) - 0.04167 * \text{MOVAVG}(20, RTP.5) - 0.00090 + 1.55167 * 1/YEAR + \\
&\quad 0.01021 * \text{NU10}/\text{NF2534} - 0.00170) * EF2534 + EF2534NAWPH.ADJ \\
EF3544NAWPH\_R &= (0.00622 * \text{MOVAVG}(4, RTP.1) - 0.06062 * \text{MOVAVG}(20, RTP.5) + 0.00008 + 0.29372 * \text{MOVAVG}(12, \\
&\quad EF2534NAWPH.36/EF2534.36) + 0.06187) * EF3544 + EF3544NAWPH.ADJ \\
EF4554NAWPH\_R &= (0.02788 * \text{MOVAVG}(4, RTP.1) - 0.10996 * \text{MOVAVG}(20, RTP.5) - 0.00349 + 0.53068 * \text{MOVAVG}(12, \\
&\quad EF3544NAWPH.36/EF3544.36) + 0.08883) * EF4554 + EF4554NAWPH.ADJ \\
EF5564NAWPH\_R &= (0.05939 * \text{MOVAVG}(4, RTP.1) - 0.10618 * \text{MOVAVG}(8, RTP.5) - 0.00579 + 0.66195 * \text{MOVAVG}(12, \\
&\quad EF4554NAWPH.36/EF4554.36) + 0.05966) * EF5564 + EF5564NAWPH.ADJ \\
EF65ONAWPH\_R &= (0.22642 * \text{MOVAVG}(4, RTP.1) - 0.02069 + 0.33505 * \text{MOVAVG}(12, EF5564NAWPH.36) - 0.19707) + \\
&\quad EF65ONAWPH.ADJ \\
EM1617NAWPH\_R &= \text{MAX}(0.001, -0.05284 * \text{MOVAVG}(4, RTP.1) - 0.17833 * \text{MOVAVG}(4, RTP.5) - 0.00768 + 9.19738 * 1/YEAR - \\
&\quad 0.00588 * \text{MINW}/\text{CPIW\_U} + 0.16862) * EM1617 + EM1617NAWPH.ADJ \\
EM1819NAWPH\_R &= \text{MAX}(0.001, -0.07122 * \text{MOVAVG}(4, RTP.1) - 0.03737 * \text{MOVAVG}(4, RTP.5) - 0.00282 + 3.76796 * 1/YEAR -
\end{aligned}$$

$$\begin{aligned}
& 0.00499 * \text{MINW/CPIW\_U} + 0.08727) * \text{EM1819} + \text{EM1819NAWPH.ADJ} \\
\text{EM2024NAWPH\_R} = & \text{MAX}(0.001, -0.00450 * \text{MOVAVG}(4, \text{RTP.1}) - 0.02345 * \text{MOVAVG}(4, \text{RTP.5}) - 0.00113 - 0.00057 * \\
& \text{MINW/CPIW\_U} + 0.03265) * \text{EM2024} + \text{EM2024NAWPH.ADJ} \\
\text{EM2534NAWPH\_R} = & \text{MAX}(0.001, -0.00490 * \text{MOVAVG}(4, \text{RTP.5}) - 0.00054 - 0.00051 * \text{MINW/CPIW\_U} + 0.00789) * \text{EM2534} + \\
& \text{EM2534NAWPH.ADJ} \\
\text{EM3544NAWPH\_R} = & (-0.00446 * \text{MOVAVG}(4, \text{RTP.5}) - 0.00041 - 0.00053 * \text{MINW/CPIW\_U} + 0.00726) * \text{EM3544} + \\
& \text{EM3544NAWPH.ADJ} \\
\text{EM4554NAWPH\_R} = & (-0.00039 + 0.00129) * \text{EM4554} + \text{EM4554NAWPH.ADJ} \\
\text{EM5564NAWPH\_R} = & (-0.00015 + 0.00200) * \text{EM5564} + \text{EM5564NAWPH.ADJ} \\
\text{EM65ONAWPH\_R} = & (-0.00679 + 0.64405 * \text{MOVAVG}(12, \text{EM5564NAWPH.36}) + 0.00231) + \text{EM65ONAWPH.ADJ} \\
\text{ENAWPH\_R} = & \text{EF1617NAWPH\_R} + \text{EF1819NAWPH\_R} + \text{EF2024NAWPH\_R} + \text{EF2534NAWPH\_R} + \text{EF3544NAWPH\_R} + \\
& \text{EF4554NAWPH\_R} + \text{EF5564NAWPH\_R} + \text{EF65ONAWPH\_R} + \text{EM1617NAWPH\_R} + \text{EM1819NAWPH\_R} + \\
& \text{EM2024NAWPH\_R} + \text{EM2534NAWPH\_R} + \text{EM3544NAWPH\_R} + \text{EM4554NAWPH\_R} \\
& + \text{EM5564NAWPH\_R} + \text{EM65ONAWPH\_R} \quad (245)
\end{aligned}$$

Total Private Household Wage Workers:

$$\begin{aligned}
\text{ENAWPH} = & \text{IF LONGRANGE} = 0 \\
& \text{THEN ENAWPH\_R} \\
& \text{ELSE ENAWPH.1} * (\text{E\_FE/E\_FE.1}) \quad (246)
\end{aligned}$$

Final (scaled) equations:

Male (260-267)

$$\begin{aligned}
\text{EM1617NAWPH} = & \text{EM1617NAWPH\_R} * (\text{ENAWPH/ENAWPH\_R}) \\
\text{EM1819NAWPH} = & \text{EM1819NAWPH\_R} * (\text{ENAWPH/ENAWPH\_R}) \\
\text{EM2024NAWPH} = & \text{EM2024NAWPH\_R} * (\text{ENAWPH/ENAWPH\_R}) \\
\text{EM2534NAWPH} = & \text{EM2534NAWPH\_R} * (\text{ENAWPH/ENAWPH\_R}) \\
\text{EM3544NAWPH} = & \text{EM3544NAWPH\_R} * (\text{ENAWPH/ENAWPH\_R}) \\
\text{EM4554NAWPH} = & \text{EM4554NAWPH\_R} * (\text{ENAWPH/ENAWPH\_R}) \\
\text{EM5564NAWPH} = & \text{EM5564NAWPH\_R} * (\text{ENAWPH/ENAWPH\_R}) \\
\text{EM65ONAWPH} = & \text{EM65ONAWPH\_R} * (\text{ENAWPH/ENAWPH\_R})
\end{aligned}$$

Female (247-254)

$$\begin{aligned}
\text{EF1617NAWPH} = & \text{EF1617NAWPH\_R} * (\text{ENAWPH/ENAWPH\_R}) \\
\text{EF1819NAWPH} = & \text{EF1819NAWPH\_R} * (\text{ENAWPH/ENAWPH\_R}) \\
\text{EF2024NAWPH} = & \text{EF2024NAWPH\_R} * (\text{ENAWPH/ENAWPH\_R}) \\
\text{EF2534NAWPH} = & \text{EF2534NAWPH\_R} * (\text{ENAWPH/ENAWPH\_R}) \\
\text{EF3544NAWPH} = & \text{EF3544NAWPH\_R} * (\text{ENAWPH/ENAWPH\_R}) \\
\text{EF4554NAWPH} = & \text{EF4554NAWPH\_R} * (\text{ENAWPH/ENAWPH\_R}) \\
\text{EF5564NAWPH} = & \text{EF5564NAWPH\_R} * (\text{ENAWPH/ENAWPH\_R}) \\
\text{EF65ONAWPH} = & \text{EF65ONAWPH\_R} * (\text{ENAWPH/ENAWPH\_R})
\end{aligned}$$

$$\begin{aligned}
\text{EFNAWPH} = & \text{EF1617NAWPH} + \text{EF1819NAWPH} + \text{EF2024NAWPH} + \text{EF2534NAWPH} + \text{EF3544NAWPH} + \text{EF4554NAWPH} + \\
& \text{EF5564NAWPH} + \text{EF65ONAWPH} \quad (255)
\end{aligned}$$

$$\begin{aligned}
\text{EMNAWPH} = & \text{EM1617NAWPH} + \text{EM1819NAWPH} + \text{EM2024NAWPH} + \text{EM2534NAWPH} + \text{EM3544NAWPH} + \text{EM4554NAWPH} + \\
& \text{EM5564NAWPH} + \text{EM65ONAWPH} \quad (268)
\end{aligned}$$

## OTHER EMPLOYMENT MEASURES

Federal Civilian Government and Government Enterprises

$$\begin{aligned}
\text{EGFC} = & \text{IF LONGRANGE} = 0 \\
& \text{THEN (EGFC.1} * 1.0094^{0.25}) \\
& \text{ELSE (EGFC.1} * (\text{E\_FE/E\_FE.1})) \quad (257)
\end{aligned}$$

$$\begin{aligned}
\text{EGEFCPS} = & \text{IF LONGRANGE} = 0 \\
& \text{THEN (EGEFCPS.1} * 1.0075^{0.25}) \\
& \text{ELSE (EGEFCPS.1} * (\text{E\_FE/E\_FE.1})) \quad (256)
\end{aligned}$$

$$\begin{aligned}
\text{EGGEFC} = & \text{EGFC} + \text{EGEFCPS} \quad (258)
\end{aligned}$$

State and Local Government and Government Enterprises

$$\begin{aligned}
\text{EGGESL} = & \text{IF LONGRANGE} = 0 \\
& \text{THEN EGGESL.1} * (\text{LC\_FE/LC\_FE.4})^{0.25} \\
& \text{ELSE EGGESL.1} * (\text{E\_FE/E\_FE.1}) \quad (259)
\end{aligned}$$

#### Military

Decrease (if any) in EDMIL compared to a year ago

$$\text{DNEDMIL} = \begin{cases} \text{IF (EDMIL-EDMIL.4) < 0} \\ \text{THEN (EDMIL-EDMIL.4)} \\ \text{ELSE 0} \end{cases} \quad (228)$$

#### Private employment

$$\text{EP} = \text{E-EGGESL} - \text{EGGEFC} - \text{EAS} - \text{ENAS} \quad (269)$$

#### Compensation and Output Sectors

##### Price Deflator for Medical Services

$$\text{CPIWMS} = \text{CPIWMS.1} * (1 + ((\text{CPIW\_U}/\text{CPIW\_U.4})^{0.25} - 1) * \text{CPIWMSWT}) \quad (287)$$

##### Unemployment Insurance and Workers Compensation Effective Tax Rates

$$\text{TMAXUI\_SL} = \text{TMAXUI\_SL.1} * \text{AWSUI.1}/\text{AWSUI.2} \quad (404)$$

$$\text{RELMAX\_UI} = \text{TMAXUI\_SL}/\text{AWSUI.1}/1000 \quad (405)$$

$$\text{CR\_UI} = 0.775 \quad (402)$$

$$\text{TRATIO\_UI} = 0.96996 * \text{RELMAX\_UI} - 0.13744 * \text{MOVAVG}(4, \text{RTP.1}) + 0.10368 * \text{MOVAVG}(4, \text{RTP.5}) + 0.04887 \quad (406)$$

$$\text{TRATE\_UI} = 0.00143 * \text{MOVAVG}(4, \text{RU.5}) + 0.00128 * \text{MOVAVG}(4, \text{RU.9}) + 0.00057 * \text{MOVAVG}(4, \text{RU.13}) + 0.00356 \quad (407)$$

$$\text{RUIWS1} = \text{CR\_UI} * \text{TRATIO\_UI} * \text{TRATE\_UI} \quad (408)$$

$$\text{RUIWS2} = 0.32476 * \text{MOVAVG}(4, \text{RUIWS1.8} * (\text{WSP.8} - \text{WSPRRB.8} + \text{WSGGESL.8})) / (\text{WSP.1} - \text{WSPRR2.1} + \text{WSGGESL.1}) \quad (409)$$

##### Workers' Compensation

$$\text{RWCWS} = \text{RWCWS.1} - (\text{RWCWS.1} - 0.0144)/12 \quad (311)$$

#### Wages

##### Average lagged private-sector wage

$$\text{AWSPL} = \text{MOVAVG}(8, \text{AWSP.1}) \quad (272)$$

##### Average lagged private-sector compensation

$$\text{AWSSPL} = \text{MOVAVG}(8, \text{AWSSP.1}) \quad (343)$$

##### Average wage in state & local government (incl. gov't enterprises)

$$\text{AWSGGESL} = \begin{cases} \text{IF LONGRANGE} = 0 \\ \text{THEN AWSGGESL.1} * \text{AWSPL}/\text{AWSPL.1} \\ \text{ELSE AWSGGESL.1} * \text{AVG\_GDP}/\text{AVG\_GDP.1} * (1 + \text{WS\_TO\_WSS\_D}/100)^{0.25} \end{cases} \quad (273)$$

##### Total wages in state & local government (incl. gov't enterprises)

$$\text{WSGGESL} = \text{AWSGGESL} * \text{EGGESL} \quad (274)$$

##### Employer Contribution for Government Social Insurance in State & Local Government Sector

$$\text{OASDISL\_L} = (\text{EMPTRASI} + \text{EMPTRDI}) * 0.978 * \text{CSLA} * \text{WSGGESL} \quad (307)$$

$$\text{HISL\_L} = \text{EMPTRHI} * 1.0 * \text{CSLHI} * \text{WSGGESL} \quad (308)$$

$$\text{SOC\_UISL} = (-0.02821 * \text{MOVAVG}(4, \text{RTP.2}) + 0.03145) * \text{WSGGESL} \quad (309)$$

$$\text{RSOCSL\_WC} = \text{RSOCSL\_WC.1} - (\text{RSOCSL\_WC.1} - 0.176)/12 \quad (310)$$

$$\text{SOC\_WCSL} = \text{RSOCSL\_WC} * \text{RWCWS} * \text{WSGGESL} \quad (312)$$

$$\text{SOC\_SL} = (\text{OASDISL\_L} + \text{HISL\_L} + \text{SOC\_UISL} + \text{SOC\_WCSL}) \quad (313)$$

##### Employer Contributions for Employee Pension and Insurance funds in State & Local Government Sector

##### Workers' Compensation - employees and annuitants

$$\text{OLI\_WCSL} = (1 - \text{RSOCSL\_WC}) * \text{RWCWS} * \text{WSGGESL} \quad (316)$$

##### Pensions

$$\text{OLI\_RETSL} = \text{WSGGESL} * (\text{OLI\_RETSL.1}/\text{WSGGESL.1}) \quad (317)$$



Life Insurance - employees and annuitants  
 $OLI\_GLI\_SL = 2.0 * EGGESL * ((WSGGESL/EGGESL) + 2.0) * 0.075 * 26/1000$  (314)

Health Insurance - employees and annuitants  
 $OLI\_GHI\_SL = (OLI\_GHI\_SL.1 / EGGESL.1) * CPIWMS/CPIWMS.1 * EGGESL * RGR\_GHI$  (315)

Total  
 $OLI\_SL = (OLI\_GLI\_SL + OLI\_GHI\_SL + OLI\_WCSL + OLI\_RETSL)$  (318)

$RCWSSL = (1 + (SOC\_SL + OLI\_SL)/WSGGESL)$  (319)

$WSGGESL = IF\ LONGRANGE = 0$   
 THEN  $RCWSSL * WSGGESL$   
 ELSE  $(WSGGESL.1/EGGESL.1) * AVG\_GDP/AVG\_GDP.1 * EGGESL$  (320)

$WSSGSL = WSGGESL * WSSGSL.1/WSSGGESL.1$  (321)

$WSSGESL = WSGGESL - WSSGSL$  (324)

$CFCGSL = IF\ LONGRANGE = 0$   
 THEN  $WSSGSL * RCFCGSL$   
 ELSE  $CFCGSL.1 * WSGGESL/WSSGGESL.1$  (322)

$GDPGSL = WSSGSL + CFCGSL$  (323)

$CFCGESL = IF\ LONGRANGE = 0$   
 THEN  $WSSGESL * RCFCGESL$   
 ELSE  $CFCGESL.1 * WSGGESL/WSSGGESL.1$  (325)

$GDPGESL = WSSGESL + CFCGESL$  (326)

$GDPGGESL = GDPGSL + GDPGESL$  (327)

#### Federal Civilian General Government and Government Enterprises

##### Wages

##### General Government and Government Enterprises

##### Civilian pay raise

$CRAZ1 = IF\ LONGRANGE = 0$   
 THEN  $((IF\ QTR = 1\ THEN\ (0.82429 * (AWSP.6/AWSP.10 - 1) - 0.005)\ ELSE\ 0))$   
 ELSE  $(IF\ QTR = 1\ THEN\ (AWSP.6/AWSP.10 - 1)\ ELSE\ 0)$  (270)

##### Military pay raise

$MRAZ = IF\ LONGRANGE = 0$   
 THEN  $((IF\ QTR = 1\ THEN\ (0.82429 * (AWSP.6/AWSP.10 - 1) - 0.005)\ ELSE\ 0))$   
 ELSE  $(IF\ QTR = 1\ THEN\ (AWSP.6/AWSP.10 - 1)\ ELSE\ 0)$  (277)

##### Average wage in Federal Civilian Government

$AWSGGEFC = IF\ LONGRANGE = 0$   
 THEN  $(AWSGGEFC.1 * (1 + 1.0 * CRAZ1 + 0.0015))$   
 ELSE  $AWSGGEFC.1 * AVG\_GDP/AVG\_GDP.1 * (1 + WS\_TO\_WSS\_D/100)^{0.25}$  (275)

##### Total wages in FCG

$WSGGEFC = AWSGGEFC * EGGEFC$  (276)

##### CSRS workers

$AWEFC\_N = IF\ LONGRANGE = 0$   
 THEN  $(AWEFC\_N.1 * (1 + 1.0 * CRAZ1 + 0.00082))$   
 ELSE  $AWEFC\_N.1 * AVG\_GDP/AVG\_GDP.1 * (1 + WS\_TO\_WSS\_D/100)^{0.25}$  (271)

$WEFC\_N = AWEFC\_N * TEFC\_N$  (283)

##### Government Enterprises (Mostly U.S. Postal Service)

$AWSGEFC = IF\ LONGRANGE = 0$   
 THEN  $(AWSGEFC.1 * (1 + 1.0 * CRAZ1 + 0.0015))$   
 ELSE  $AWSGEFC.1 * AVG\_GDP/AVG\_GDP.1 * (1 + WS\_TO\_WSS\_D/100)^{0.25}$  (290)

$WSGEFC = AWSGEFC * EGEFCPS$  (291)

##### General Government

$WSGFC = WSGGEFC - WSGEFC$  (292)

$AWSGFC = WSGFC/EGFC$  (378)

Employer Contribution for Government Social Insurance

General Government and Government Enterprises

$$\begin{aligned} \text{OASDIFC\_L} &= (\text{EMPTRASI} + \text{EMPTRDI}) * 1.04 * (\text{WSGGFC} - \text{WEFC\_N}) * \text{ADJ\_FSA\_FC} & (284) \\ \text{HIFC\_L} &= \text{EMPTRHI} * 1.055 * \text{WSGGFC} * \text{ADJ\_FSA\_FC} & (285) \\ \text{SOCF\_UIFC} &= (-0.05934 * \text{RTP} + 0.06165) * \text{WSGGFC} & (281) \\ \text{SOCF\_WC} &= 0.0159 * \text{WSGGFC} & (282) \\ \text{SOC\_FC} &= (\text{SOCF\_UIFC} + \text{SOCF\_WC} + \text{OASDIFC\_L} + \text{HIFC\_L}) & (286) \end{aligned}$$

Employer Contributions for Employee Pension and Insurance funds

General Government and Government Enterprises

Pensions

$$\begin{aligned} \text{OLI\_CSRS1} &= ((0.174 * \text{WSGGFC} + 0.07 * \text{WSGFC}) / \text{WSGGFC}) * \text{WEFC\_N} & (293) \\ \text{OLI\_FERS1} &= 0.107 * (\text{WSGGFC} * 0.9 - \text{WEFC\_N}) & (294) \\ \text{OLI\_FERSFC} &= 0.048 * (\text{WSGGFC} * 0.9 - \text{WEFC\_N}) & (295) \\ \text{OLI\_RETFC} &= \text{OLI\_CSRS1} + \text{OLI\_FERS1} + \text{OLI\_FERSFC} + \text{OLIF\_RETFCO} & (296) \end{aligned}$$

Life Insurance - employees and annuitants

$$\text{OLI\_GLI\_FC} = 2.0 * \text{EGGFC} * ((\text{WSGGFC} / \text{EGGFC}) + 2.0) * 0.075 * 26 / 1000 \quad (289)$$

Health Insurance - employees and annuitants

$$\begin{aligned} \text{OLI\_GHI\_FC} &= (\text{OLI\_GHI\_FC.1} / \text{EGGFC.1}) * \text{CPIWMS} / \text{CPIWMS.1} * \text{EGGFC} * \text{RGR\_GHI} & (288) \\ \text{OLI\_FC} &= (\text{OLI\_GHI\_FC} + \text{OLI\_GLI\_FC} + \text{OLI\_RETFC}) & (297) \end{aligned}$$

Compensation

General Government and Government Enterprises

$$\begin{aligned} \text{RCWSF} &= (1 + (\text{SOC\_FC} + \text{OLI\_FC}) / \text{WSGGFC}) & (298) \\ \text{WSSGGFC} &= \text{IF LONGRANGE} = 0 & \\ & \quad \text{THEN RCWSF} * \text{WSGGFC} & \\ & \quad \text{ELSE } (\text{WSSGGFC.1} / \text{EGGFC.1}) * \text{AVG\_GDP} / \text{AVG\_GDP.1} * \text{EGGFC} & (300) \\ \text{WSSGFC} &= \text{IF LONGRANGE} = 0 & \\ & \quad \text{THEN RCWSF} * \text{WSGFC} & \\ & \quad \text{ELSE } (\text{WSSGFC.1} / (\text{EGGFC.1} - \text{EGEFCPS.1})) * \text{AVG\_GDP} / \text{AVG\_GDP.1} * (\text{EGGFC} - \text{EGEFCPS}) & (299) \\ \text{WSSGEFC} &= \text{IF LONGRANGE} = 0 & \\ & \quad \text{THEN RCWSF} * \text{WSGEFC} & \\ & \quad \text{ELSE } (\text{WSSGEFC.1} / \text{EGEFCPS.1}) * \text{AVG\_GDP} / \text{AVG\_GDP.1} * \text{EGEFCPS} & (303) \end{aligned}$$

Consumption of Fixed Capital

General Government and Government Enterprises

$$\begin{aligned} \text{CFCGFC} &= \text{IF LONGRANGE} = 0 & \\ & \quad \text{THEN WSSGFC} * \text{RCFCGFC} & \\ & \quad \text{ELSE } \text{CFCGFC.1} * \text{WSSGGFC} / \text{WSSGGFC.1} & (301) \\ \text{CFCGEFC} &= \text{IF LONGRANGE} = 0 & \\ & \quad \text{THEN WSSGFC} * \text{RCFCGEFC} & \\ & \quad \text{ELSE } \text{CFCGEFC.1} * \text{WSSGGFC} / \text{WSSGGFC.1} & (304) \end{aligned}$$

Gross Domestic Product

General Government and Government Enterprises

$$\begin{aligned} \text{GDPGFC} &= \text{WSSGFC} + \text{CFCGFC} & (302) \\ \text{GDPGEFC} &= \text{WSSGEFC} + \text{CFCGEFC} & (305) \\ \text{GDPGGEFC} &= \text{GDPGFC} + \text{GDPGEFC} & (306) \end{aligned}$$

Federal Government Military

Wages

$$\begin{aligned} \text{AWSGFM} &= \text{IF LONGRANGE} = 0 & \\ & \quad \text{THEN } (\text{AWSGFM.1} * (1.0027 + 1.0 * \text{MRAZ})) & \\ & \quad \text{ELSE } \text{AWSGFM.1} * \text{AVG\_GDP} / \text{AVG\_GDP.1} * (1 + \text{WS\_TO\_WSS\_D} / 100)^{0.25} & (278) \end{aligned}$$

$$\text{WSGFM} = \text{AWSGFM} * (\text{EDMIL} + \text{EDMIL\_R}) \quad (279)$$

Employer Contribution for Government Social Insurance

$$\text{OASDIFM\_L} = (\text{EMPTRASI} + \text{EMPTRDI}) * 0.9975 * \text{CML} * \text{WSGFM} \quad (331)$$

$$\text{HIFM\_L} = \text{EMPTRHI} * 1.0 * \text{CML} * \text{WSGFM} \quad (332)$$

$$\text{SOCF\_UIFM} = \text{MAX} (0.001, (-0.05263 * \text{DIFF} (\text{EDMIL} + \text{EDMIL\_R}) - 0.03079 * \text{RTP} + 0.03310)) * \text{WSGFM} \quad (329)$$

$$\text{SOCF\_MIFM} = 0.30 * \text{CPIWMS} * (\text{EDMIL} + \text{EDMIL\_R}) \quad (330)$$

$$\text{SOC\_FM} = (\text{SOCF\_UIFM} + \text{SOCF\_MIFM} + \text{OASDIFM\_L} + \text{HIFM\_L}) \quad (333)$$

Employer Contributions for Employee Pension and Insurance funds

$$\text{OLI\_RETFM} = (\text{OLI\_RETFM.1} / \text{WSGFM.1} - (\text{OLI\_RETFM.1} / \text{WSGFM.1} - 0.472) / 12) * \text{WSGFM} \quad (328)$$

Compensation

$$\text{RCWSM} = (1 + (\text{OLI\_RETFM} + \text{SOC\_FM}) / \text{WSGFM}) \quad (334)$$

$$\begin{aligned} \text{WSSGFM} = & \text{IF LONGRANGE} = 0 \\ & \text{THEN RCWSM} * \text{WSGFM} \\ & \text{ELSE } (\text{WSSGFM.1} / \text{EDMIL.1}) * \text{AVG\_GDP} / \text{AVG\_GDP.1} * \text{EDMIL} \end{aligned} \quad (335)$$

Consumption of Fixed Capital

$$\begin{aligned} \text{CFCGFM} = & \text{IF LONGRANGE} = 0 \\ & \text{THEN WSSGFM} * \text{RCFCGFM} \\ & \text{ELSE CFCGFM.1} * \text{WSSGFM} / \text{WSSGFM.1} \end{aligned} \quad (336)$$

Gross Domestic Product

$$\text{GDPGFM} = \text{WSSGFM} + \text{CFCGFM} \quad (337)$$

$$\text{GDPGF} = \text{GDPGFC} + \text{GDPGFM} \quad (387)$$

$$\text{GDPGGE} = \text{GDPGGEFC} + \text{GDPGGEFC} + \text{GDPGFM} \quad (338)$$

Total (Civilian and Military) Federal General Government and Government Enterprises

$$\text{WSSGF} = \text{WSSGFC} + \text{WSSGFM} \quad (392)$$

$$\text{WSSGE} = \text{WSSGEFC} + \text{WSSGESL} \quad (394)$$

$$\text{WSSG} = \text{WSSGF} + \text{WSSGSL} \quad (393)$$

$$\text{GDPGE} = \text{GDPGEFC} + \text{GDPGESL} \quad (389)$$

$$\text{GDPG} = \text{GDPGF} + \text{GDPGSL} \quad (388)$$

NIPA Farm Output and Earnings

Real farm output

$$\begin{aligned} \text{GDPPF09} = & \text{IF LONGRANGE} = 0 \\ & \text{THEN EXP} (-3.52340 + 0.02055 * \text{YEAR}) * \text{N\_SSA} * 1.125 * 1.138 \\ & \text{ELSE GDPPF09.1} * \text{GDP09} / \text{GDP09.1} \end{aligned} \quad (19)$$

Farm sector deflator

$$\begin{aligned} \text{PGDPAF} = & \text{IF LONGRANGE} = 0 \\ & \text{THEN PGDPAF.1} * ((\text{PGDP} / \text{PGDP.1})^4 - 0.01)^{0.25} \\ & \text{ELSE PGDPAF.1} * ((\text{PGDP} / \text{PGDP.1})^4)^{0.25} \end{aligned} \quad (223)$$

Nominal farm output

$$\text{GDPPF} = \text{GDPPF09} * \text{PGDPAF} \quad (339)$$

Farm compensation and wages

$$\begin{aligned} \text{WSSPF} = & \text{IF LONGRANGE} = 0 \\ & \text{THEN EAW} * \text{MOVAVG} (4, \text{WSSP.2} / \text{EP.2}) * (3.15749 / (\text{YEAR} - 65) - 0.43419 * \text{RTP} + 0.68725) \\ & \text{ELSE } (\text{WSSPF.1} / \text{EAW.1}) * \text{AVG\_GDP} / \text{AVG\_GDP.1} * \text{EAW} \end{aligned} \quad (360)$$

$$\begin{aligned} \text{WSPF} = & \text{IF LONGRANGE} = 0 \\ & \text{THEN WSSPF} * (\text{MOVAVG} (12, (\text{WSP.1} / \text{WSSP.1})) + 0.015) \\ & \text{ELSE } (\text{WSPF.1} / \text{WSSPF.1}) * (\text{WSP.1} / \text{WSSP.1}) / (\text{WSP.2} / \text{WSSP.2}) * \text{WSSPF} \end{aligned} \quad (381)$$

$$\text{AWSPF} = \text{WSPF} / \text{EAW} \quad (382)$$

Farm proprietors' income

$$\text{AYF\_K} = ((\text{YF.1} / \text{EAS.1}) / (\text{WSSPF.1} / \text{EAW.1}) - 5.0) * 0.8 + 5.0 \quad (395)$$

$$\text{YF} = \text{AYF\_K} * (\text{WSSPF} / \text{EAW}) * \text{EAS} \quad (396)$$

GDP, WSS and WS, Private Households & Nonprofit Institutions

Private Households

Compensation & Wages

$$\begin{aligned} \text{WSSPH} &= \text{IF LONGRANGE} = 0 \\ &\quad \text{THEN } (((\text{WSSPH.1}/\text{ENAWPH.1})/\text{MOVAVG}(4, \text{WSSP.3}/\text{EP.3}) - 0.41) * 0.875 + 0.41) \\ &\quad \quad * \text{MOVAVG}(4, \text{WSSP.2}/\text{EP.2}) * \text{ENAWPH} \\ &\quad \text{ELSE } (\text{AVG\_GDP}/\text{AVG\_GDP.1}) * \text{ENAWPH} * (\text{WSSPH.1}/\text{ENAWPH.1}) \end{aligned} \quad (340)$$

$$\begin{aligned} \text{WSPH} &= \text{IF LONGRANGE} = 0 \\ &\quad \text{THEN } \text{WSSPH} / (1 + \text{CPH} * 1 * (\text{EMPTROASI} + \text{EMPTRDI} + \text{EMPTRHI})) \\ &\quad \text{ELSE } (\text{AWSPH.1} * \text{ENAWPH.1}/\text{WSSPH.1}) * (1 + \text{WS\_TO\_WSS\_D}/100)^{0.25} * \text{WSSPH} \end{aligned} \quad (383)$$

$$\text{AWSPH} = \text{WSPH} / \text{ENAWPH} \quad (384)$$

Owner Occupied Housing

$$\text{OOH} = \text{OOH.1} * (\text{KGDP09} * \text{PGDP}) / (\text{KGDP09.1} * \text{PGDP.1}) \quad (341)$$

Gross Value Added

$$\begin{aligned} \text{GDPPH} &= \text{IF LONGRANGE} = 0 \\ &\quad \text{THEN } \text{WSSPH} + \text{OOH} \\ &\quad \text{ELSE } (\text{AVG\_GDP}/\text{AVG\_GDP.1}) * \text{ENAWPH} * (\text{GDPPH.1}/\text{ENAWPH.1}) \end{aligned} \quad (342)$$

Nonprofit Institutions

Health Services

$$\begin{aligned} \text{EPHS\_EST} &= \text{IF LONGRANGE} = 0 \\ &\quad \text{THEN } \text{EPHS\_EST.1} + 0.275/4 \\ &\quad \text{ELSE } \text{EPHS\_EST.1} * (\text{E\_FE}/\text{E\_FE.1}) \end{aligned} \quad (345)$$

$$\begin{aligned} \text{AWSSPHS} &= \text{IF LONGRANGE} = 0 \\ &\quad \text{THEN } \text{AWSSPHS.1} * \text{AWSSPL}/\text{AWSSPL.1} \\ &\quad \text{ELSE } \text{AWSSPHS.1} * \text{AVG\_GDP}/\text{AVG\_GDP.1} \end{aligned} \quad (344)$$

$$\text{WSSPHS} = \text{AWSSPHS} * \text{EPHS\_EST} \quad (346)$$

Educational Services

$$\begin{aligned} \text{EPES\_EST} &= \text{IF LONGRANGE} = 0 \\ &\quad \text{THEN } \text{EPES\_EST.1} + 0.075/4 \\ &\quad \text{ELSE } \text{EPES\_EST.1} * (\text{E\_FE}/\text{E\_FE.1}) \end{aligned} \quad (348)$$

$$\begin{aligned} \text{AWSSPES} &= \text{IF LONGRANGE} = 0 \\ &\quad \text{THEN } \text{AWSSPES.1} * \text{AWSSPL}/\text{AWSSPL.1} \\ &\quad \text{ELSE } \text{AWSSPES.1} * \text{AVG\_GDP}/\text{AVG\_GDP.1} \end{aligned} \quad (347)$$

$$\text{WSSPES} = \text{AWSSPES} * \text{EPES\_EST} \quad (349)$$

Social Services

$$\begin{aligned} \text{EPSS\_EST} &= \text{IF LONGRANGE} = 0 \\ &\quad \text{THEN } \text{EPSS\_EST.1} + 0.075/4 \\ &\quad \text{ELSE } \text{EPSS\_EST.1} * (\text{E\_FE}/\text{E\_FE.1}) \end{aligned} \quad (351)$$

$$\begin{aligned} \text{AWSSPSS} &= \text{IF LONGRANGE} = 0 \\ &\quad \text{THEN } \text{AWSSPSS.1} * \text{AWSSPL}/\text{AWSSPL.1} \\ &\quad \text{ELSE } \text{AWSSPSS.1} * \text{AVG\_GDP}/\text{AVG\_GDP.1} \end{aligned} \quad (350)$$

$$\text{WSSPSS} = \text{AWSSPSS} * \text{EPSS\_EST} \quad (352)$$

Gross Value Added

$$\begin{aligned} \text{WSSPNI} &= \text{WSSPNI.1} * (\text{WSSPHS} + \text{WSSPES} + \text{WSSPSS}) / (\text{WSSPHS.1} + \text{WSSPES.1} + \text{WSSPSS.1}) \end{aligned} \quad (353)$$

$$\begin{aligned} \text{WSPNI} &= \text{IF LONGRANGE} = 0 \\ &\quad \text{THEN } \text{WSSPNI} * (\text{WSPNI.1}/\text{WSSPNI.1}) * ((\text{WSP.1}/\text{WSSP.1}) / (\text{WSP.9}/\text{WSSP.9}))^{(1/8)} \\ &\quad \text{ELSE } \text{WSSPNI} * (\text{WSPNI.1}/\text{WSSPNI.1}) * (1 + \text{WS\_TO\_WSS\_D}/100)^{0.25} \end{aligned} \quad (391)$$

$$\begin{aligned} \text{GDPPNI} &= \text{IF LONGRANGE} = 0 \\ &\quad \text{THEN } \text{WSSPNI} / ((\text{WSSPNI.1}/\text{GDPPNI.1} - 0.866) * 0.8 + 0.866) \\ &\quad \text{ELSE } \text{WSSPNI} / 0.866 \end{aligned} \quad (354)$$

Private Output and Compensation

$$\begin{aligned} \text{ROADIP\_L} &= (\text{EMPTROASI} + \text{EMPTRDI}) * \text{TXRP} * \text{CP} \quad (365) \\ \text{RHIP\_L} &= \text{EMPTRHI} * 1.0 * \text{CP} \quad (366) \\ \text{RSOC\_UIP} &= 0.00109 * \text{MOVAVG}(4, \text{RU.2}) + 0.00045 * \text{MOVAVG}(4, \text{RU.10}) + 0.00048 * \text{MOVAVG}(4, \text{RU.18}) - 0.00331 \quad (367) \end{aligned}$$

RSOC\_WCP = RWCWS \* RSOC\_SL\_WC (368)  
 RSOCF\_PBG = 0.00022 (369)

OLI  
 ROLI\_WCP = RWCWS \* (1 - RSOC\_SL\_WC) (370)  
 ROLI\_SU = 0.0005 (371)  
 OLI\_GLI\_P = 0.0025 \* EP \* AWSP.1 (363)  
 OLI\_GHI\_P = (OLI\_GHI\_P.1 / EP.1) \* CPIWMS/CPIWMS.1 \* EP \* RGR\_GHI (364)  
 ROLI\_PPPS = MAX (ROLI\_PPPS.1, 0.00031 \* YEAR + 0.00866) (372)

Employee Compensation and Nonfarm Proprietor Income (WSS and YNF)

WSSGGE = (WSSGGE\_SL + WSSGGE\_FC + WSSGGE\_FM) (374)  
 GDPPBNFXGE = (GDP - GDPPGE - GDPPF - GDPPH - GDPPNI) (355)  
 RWSSPBNFXGE = 0.30026 \* RTP.1 + 0.31936 + (0.971 \* 0.621 - (0.30026 \* 1.0 + 0.31936)) + RWSSPBNFXGE\_ADJ (280)  
 ENAW = ENA - ENAS - ENAU (356)  
 ENAWPBXGE = ENAW - (ENAWPH + EGGEFC + EGGE\_SL + WSSPNI / (WSSPHS + WSSPES + WSSPSS)) \* (EPHS\_EST + EPES\_EST + EPSS\_EST) (357)  
 ENAWSPBXGE = ENAWPBXGE + ENAS (403)  
 AYNF\_K = ((YNF.1/ENAS.1 / (WSSPBNFXGE.1/ENAWPBXGE.1)) - 1.65) \* 0.9 + 1.65 (401)  
 AYF = YF/EAS (399)  
 AWSSPF = WSSPF/EAW (398)  
 AYNF = YNF/ENAS (400)  
 AWSSPBNFXGE = WSSPBNFXGE/ENAWPBXGE (397)  
 YNF = YNF.1 \* (GDPPBNFXGE / GDPPBNFXGE.1) \* (ENAS / (ENAS + ENAWPBXGE)) / (ENAS.1 / (ENAS.1 + ENAWPBXGE.1)) (358)  
 WSSPBNFXGE = RWSSPBNFXGE \* (GDPPBNFXGE - YNF) (359)  
 WSSP = WSSPBNFXGE + WSSPF + WSSPH + WSSPNI (361)  
 RCWSP = WSSP / (WSSP - SOCF\_RETRR - OLI\_GLI\_P - OLI\_GHI\_P) \* (1 + ROASDIP\_L + RHIP\_L + RSOC\_UIP + RSOC\_WCP + RSOCF\_PBG + ROLI\_WCP + ROLI\_SU + ROLI\_PPPS) (373)  
 WS = IF WS\_TO\_WSS\_DYR = 0  
 THEN (WSGGE\_SL + WSGGE\_FC + WSGFM + WSSP/RCWSP)  
 ELSE WSS \* WS.1/WSS.1 \* (1 + WS\_TO\_WSS\_D/100)<sup>0.25</sup> (376)  
 WSD = WS (410)  
 WSP = (WS - WSGGE\_SL - WSGGE\_FC - WSGFM) (379)  
 AWSP = WSP/EP (380)  
 AWSSP = WSSP/EP (385)

Other Variables

WSDP = (WSD - WSGGE\_SL - WSGGE\_FC - WSGFM) (411)  
 AWSE = WS / (E + EDMIL - EAS - ENAS) (377)  
 AWSUI = (WS - WSGGE\_FC - WSGFM) / (E - EGGE\_FC - EAS - ENAS) (386)  
 WSS = (WSSP + WSSGGE) (375)  
 OLI\_GGE = OLI\_FC + OLI\_SL + OLI\_RETFM (412)  
 OLI\_WCP = ROLI\_WCP \* WSP (413)  
 OLI\_SU = ROLI\_SU \* WSP (414)  
 OLI\_PPPS = ROLI\_PPPS \* WSP (415)  
 OLI\_P = OLI\_WCP + OLI\_SU + OLI\_GHI\_P + OLI\_GLI\_P + OLI\_PPPS (416)  
 OLI = OLI\_GGE + OLI\_P (417)  
 SOC\_GGE = SOC\_FC + SOC\_FM + SOC\_SL (418)  
 SOC\_UIP = RSOC\_UIP \* WSP (419)  
 SOC\_WCP = RSOC\_WCP \* WSP (420)  
 SOCF\_PBG = RSOCF\_PBG \* WSP (423)  
 SOCF\_RETRR = 0.20 \* WSPRRB (362)  
 SOC\_P = SOC\_UIP + SOC\_WCP + OASDIP\_L + HIP\_L + SOCF\_PBG + SOCF\_RETRR (424)  
 SOC = SOC\_GGE + SOC\_P (425)  
 OASDIP\_L = ROASDIP\_L \* WSP (421)  
 HIP\_L = RHIP\_L \* WSP (422)  
 OLI\_PPS = OLI\_PPPS + OLI\_RETFC + OLI\_RETFM + OLI\_RETSL (426)  
 OLI\_GHI = OLI\_GHI\_P + OLI\_GHI\_FC + OLI\_GHI\_SL (428)  
 OLI\_GLI = OLI\_GLI\_P + OLI\_GLI\_FC + OLI\_GLI\_SL (429)  
 OLI\_WC = OLI\_WCP + OLI\_WCSL (427)  
 SOC\_SL\_WC = SOC\_WCSL + SOC\_WCP (430)  
 SOCF\_UIFED = SOCF\_UIFC + SOCF\_UIFM (431)  
 SOCF\_UIS = (SOC\_UIP + SOC\_UISL) \* RUIWS1 / (RUIWS1 + RUIWS2) (432)  
 SOCF\_UIF = (SOC\_UIP + SOC\_UISL) - SOCF\_UIS (433)  
 SOCF\_OASDI = OASDIP\_L + OASDISL\_L + OASDIFC\_L + OASDIFM\_L (434)

```
SOCF_HI = HIP_L + HISL_L + HIFC_L + HIFM_L (435)
TAXMAX = IF (first quarter of the year) THEN
          300 *NINT(0.5+MOVAVG(4,AWSE.5)/MOVAVG(4,AWSE.9)*1000*TAXMAX.1/300)/1000
        ELSE TAXMAX.1 (390)
```

## 2.3 OASDI Covered Employment and Earnings (MODSOLA)

Total At-Any-Time Employment (Equations 1–52)

Ages 0 through 15, where s=sex;a=age 0,1,2,3,...15; i=calendar year (1–10, 21, 22, 27–36, 47, 48)

$$\begin{aligned} \text{he\_m\_sy}(s,a,i) = & (\text{he\_m\_sy}(s,a,\text{histend}) / \text{nsy\_a}(s,a,\text{histend}) \& \\ & + \text{he\_m\_sy}(s,a,\text{histend}-1) / \text{nsy\_a}(s,a,\text{histend}-1) \& \\ & + \text{he\_m\_sy}(s,a,\text{histend}-2) / \text{nsy\_a}(s,a,\text{histend}-2) ) / 3 \& \\ & * \text{nsy\_a}(s,a,i) \end{aligned}$$

HI covered workers age groups 10-13 and 14-15, by sex and calendar year (21, 22, 47, 48)

$$\begin{aligned} \text{he\_m\_1013}(s,i) = & \text{sum}(\text{he\_m\_sy}(s,10:13,i)) \\ \text{he\_m\_1415}(s,i) = & \text{sum}(\text{he\_m\_sy}(s,14:15,i)) \end{aligned}$$

HI covered workers age group 15u, by sex and calendar year (23, 49)

$$\text{he\_m\_15u}(s,i) = \text{sum}(\text{he\_m\_sy}(s,0:9,i)) + \text{he\_m\_1013}(s,i) + \text{he\_m\_1415}(s,i)$$

OASDI covered = HI covered, by sex, single year of age, and calendar year (11–22, 37–48)

$$\text{ce\_m\_sy}(s,a,i) = \text{he\_m}(s,a,i)$$

OASDI covered workers age groups 10-13 and 14-15, by sex and calendar year (24, 25, 50, 51)

$$\begin{aligned} \text{ce\_m\_1013}(s,i) = & \text{sum}(\text{ce\_m\_sy}(s,10:13,i)) \\ \text{ce\_m\_1415}(s,i) = & \text{sum}(\text{ce\_m\_sy}(s,14:15,i)) \end{aligned}$$

OASDI covered workers age group 15u, by sex and calendar year (26, 52)

$$\text{ce\_m\_15u}(s,i) = \text{sum}(\text{ce\_m\_sy}(s,0:9,i)) + \text{ce\_m\_1013}(s,i) + \text{ce\_m\_1415}(s,i)$$

Male Disaggregates Aged 16 and Over

Preliminary

Average Weeks Worked

$$\text{AWWM1617\_P} = 0.35417 * \text{TREND\_TE} - 0.17568 * \text{RM1617} + 8.80229; \quad (53)$$

$$\text{AWWM1819\_P} = 0.28021 * \text{TREND\_TE} - 0.16633 * \text{RM1819} + 15.4522; \quad (58)$$

$$\text{AWWM2024\_P} = 0.17338 * \text{TREND\_TE} - 0.32843 * \text{RM2024} + 31.4779; \quad (63)$$

$$\text{AWWM2529\_P} = 0.04353 * \text{TREND\_TE} - 0.32898 * \text{RM2529} + 46.8304; \quad (68)$$

$$\text{AWWM3034\_P} = 0.04353 * \text{TREND\_TE} - 0.32898 * \text{RM3034} + 46.8304; \quad (73)$$

$$\text{AWWM3539\_P} = 0.03256 * \text{TREND\_TE} - 0.26573 * \text{RM3539} + 47.9512; \quad (78)$$

$$\text{AWWM4044\_P} = 0.03256 * \text{TREND\_TE} - 0.26573 * \text{RM4044} + 47.9512; \quad (83)$$

$$\text{AWWM4549\_P} = 0.03923 * \text{TREND\_TE} - 0.23146 * \text{RM4549} + 46.8025; \quad (88)$$

$$\text{AWWM5054\_P} = 0.03923 * \text{TREND\_TE} - 0.23146 * \text{RM5054} + 46.8025; \quad (93)$$

$$\text{AWWM5559\_P} = 0.04481 * \text{TREND\_TE} - 0.28537 * \text{RM5559} + 45.0196; \quad (98)$$

$$\text{AWWM6064\_P} = 0.14488 * \text{TREND\_TE} + 0.01910 * \text{RM6064} + 29.5797; \quad (103)$$

$$\text{AWWM6569\_P} = 0.21483 * \text{TREND\_TE} - 0.23366 * \text{RM6569} + 21.1343; \quad (108)$$

$$\text{AWWM700\_P} = 0.09069 * \text{TREND\_TE} + 0.43206 * \text{RM700} + 28.6903; \quad (113)$$

$$\text{AWWM1617\_PL} = 0.35417 * \text{TREND\_TE.1} - 0.17568 * \text{RM1617.1} + 8.80229; \quad (55)$$

$$\text{AWWM1819\_PL} = 0.28021 * \text{TREND\_TE.1} - 0.16633 * \text{RM1819.1} + 15.4522; \quad (60)$$

$$\text{AWWM2024\_PL} = 0.17338 * \text{TREND\_TE.1} - 0.32843 * \text{RM2024.1} + 31.4779; \quad (65)$$

$$\text{AWWM2529\_PL} = 0.04353 * \text{TREND\_TE.1} - 0.32898 * \text{RM2529.1} + 46.8304; \quad (70)$$

$$\text{AWWM3034\_PL} = 0.04353 * \text{TREND\_TE.1} - 0.32898 * \text{RM3034.1} + 46.8304; \quad (75)$$

$$\text{AWWM3539\_PL} = 0.03256 * \text{TREND\_TE.1} - 0.26573 * \text{RM3539.1} + 47.9512; \quad (80)$$

$$\text{AWWM4044\_PL} = 0.03256 * \text{TREND\_TE.1} - 0.26573 * \text{RM4044.1} + 47.9512; \quad (85)$$

$$\text{AWWM4549\_PL} = 0.03923 * \text{TREND\_TE.1} - 0.23146 * \text{RM4549.1} + 46.8025; \quad (90)$$

$$\text{AWWM5054\_PL} = 0.03923 * \text{TREND\_TE.1} - 0.23146 * \text{RM5054.1} + 46.8025; \quad (95)$$

$$\text{AWWM5559\_PL} = 0.04481 * \text{TREND\_TE.1} - 0.28537 * \text{RM5559.1} + 45.0196; \quad (100)$$

$AWWM6064\_PL = 0.14488 * TREND\_TE.1 + 0.01910 * RM6064.1 + 29.5797;$  (105)  
 $AWWM6569\_PL = 0.21483 * TREND\_TE.1 - 0.23366 * RM6569.1 + 21.1343;$  (110)  
 $AWWM700\_PL = 0.09069 * TREND\_TE.1 + 0.43206 * RM700.1 + 28.6903;$  (115)

Work Experience

$WEM1617\_3\_P = EM1617 * 52 / AWWM1617\_P;$  (54)  
 $WEM1819\_3\_P = EM1819 * 52 / AWWM1819\_P;$  (59)  
 $WEM2024\_3\_P = EM2024 * 52 / AWWM2024\_P;$  (64)

$WEM2529\_3\_P = EM2529 * 52 / AWWM2529\_P;$  (69)  
 $WEM3034\_3\_P = EM3034 * 52 / AWWM3034\_P;$  (74)  
 $WEM3539\_3\_P = EM3539 * 52 / AWWM3539\_P;$  (79)  
 $WEM4044\_3\_P = EM4044 * 52 / AWWM4044\_P;$  (84)  
 $WEM4549\_3\_P = EM4549 * 52 / AWWM4549\_P;$  (89)  
 $WEM5054\_3\_P = EM5054 * 52 / AWWM5054\_P;$  (94)

$WEM5559\_3\_P = EM5559 * 52 / AWWM5559\_P;$  (99)  
 $WEM6064\_3\_P = EM6064 * 52 / AWWM6064\_P;$  (104)  
 $WEM6569\_3\_P = EM6569 * 52 / AWWM6569\_P;$  (109)  
 $WEM700\_3\_P = EM700 * 52 / AWWM700\_P;$  (114)

$WEM1617\_3\_PL = EM1617.1 * 52 / AWWM1617\_PL;$  (56)  
 $WEM1819\_3\_PL = EM1819.1 * 52 / AWWM1819\_PL;$  (61)  
 $WEM2024\_3\_PL = EM2024.1 * 52 / AWWM2024\_PL;$  (66)

$WEM2529\_3\_PL = EM2529.1 * 52 / AWWM2529\_PL;$  (71)  
 $WEM3034\_3\_PL = EM3034.1 * 52 / AWWM3034\_PL;$  (76)  
 $WEM3539\_3\_PL = EM3539.1 * 52 / AWWM3539\_PL;$  (81)  
 $WEM4044\_3\_PL = EM4044.1 * 52 / AWWM4044\_PL;$  (86)  
 $WEM4549\_3\_PL = EM4549.1 * 52 / AWWM4549\_PL;$  (91)  
 $WEM5054\_3\_PL = EM5054.1 * 52 / AWWM5054\_PL;$  (96)

$WEM5559\_3\_PL = EM5559.1 * 52 / AWWM5559\_PL;$  (101)  
 $WEM6064\_3\_PL = EM6064.1 * 52 / AWWM6064\_PL;$  (106)  
 $WEM6569\_3\_PL = EM6569.1 * 52 / AWWM6569\_PL;$  (111)  
 $WEM700\_3\_PL = EM700.1 * 52 / AWWM700\_PL;$  (116)

Total Employed

$TEM1617\_P = ((WEM1617\_3\_P / WEM1617\_3\_PL) * (TEM1617.1 - NM1617M.1) + NM1617M) * MULT1\_TEM1617 * MULT2\_TEM1617;$  (57)  
 $TEM1819\_P = ((WEM1819\_3\_P / WEM1819\_3\_PL) * (TEM1819.1 - NM1819M.1) + NM1819M) * MULT1\_TEM1819 * MULT2\_TEM1819;$  (62)  
 $TEM2024\_P = ((WEM2024\_3\_P / WEM2024\_3\_PL) * (TEM2024.1 - NM2024M.1) + NM2024M) * MULT1\_TEM2024 * MULT2\_TEM2024;$  (67)

$TEM2529\_P = ((WEM2529\_3\_P / WEM2529\_3\_PL) * (TEM2529.1 - NM2529M.1) + NM2529M) * MULT1\_TEM2529 * MULT2\_TEM2529;$  (72)  
 $TEM3034\_P = ((WEM3034\_3\_P / WEM3034\_3\_PL) * (TEM3034.1 - NM3034M.1) + NM3034M) * MULT1\_TEM3034 * MULT2\_TEM3034;$  (77)  
 $TEM3539\_P = ((WEM3539\_3\_P / WEM3539\_3\_PL) * (TEM3539.1 - NM3539M.1) + NM3539M) * MULT1\_TEM3539 * MULT2\_TEM3539;$  (82)  
 $TEM4044\_P = ((WEM4044\_3\_P / WEM4044\_3\_PL) * (TEM4044.1 - NM4044M.1) + NM4044M) * MULT1\_TEM4044 * MULT2\_TEM4044;$  (87)  
 $TEM4549\_P = ((WEM4549\_3\_P / WEM4549\_3\_PL) * (TEM4549.1 - NM4549M.1) + NM4549M) * MULT1\_TEM4549 * MULT2\_TEM4549;$  (92)  
 $TEM5054\_P = ((WEM5054\_3\_P / WEM5054\_3\_PL) * (TEM5054.1 - NM5054M.1) + NM5054M) * MULT1\_TEM5054 * MULT2\_TEM5054;$  (97)

$TEM5559\_P = ((WEM5559\_3\_P / WEM5559\_3\_PL) * (TEM5559.1 - NM5559M.1) + NM5559M) * MULT1\_TEM5559 * MULT2\_TEM5559;$  (102)  
 $TEM6064\_P = ((WEM6064\_3\_P / WEM6064\_3\_PL) * (TEM6064.1)) * MULT1\_TEM6064 * MULT2\_TEM6064;$  (107)  
 $TEM6569\_P = ((WEM6569\_3\_P / WEM6569\_3\_PL) * (TEM6569.1)) * MULT1\_TEM6569 * MULT2\_TEM6569;$  (112)  
 $TEM700\_P = ((WEM700\_3\_P / WEM700\_3\_PL) * (TEM700.1)) * MULT1\_TEM700 * MULT2\_TEM700;$  (117)



$$\begin{aligned} \text{WEM160}_3\text{P} &= \text{WEM1617}_3\text{P} + \text{WEM1819}_3\text{P} + \text{WEM2024}_3\text{P} + \text{WEM2529}_3\text{P} + \text{WEM3034}_3\text{P} + \text{WEM3539}_3\text{P} + \\ &\quad \text{WEM4044}_3\text{P} + \text{WEM4549}_3\text{P} \\ &\quad + \text{WEM5054}_3\text{P} + \text{WEM5559}_3\text{P} + \text{WEM6064}_3\text{P} + \text{WEM6569}_3\text{P} + \text{WEM700}_3\text{P}; \end{aligned} \quad (190)$$

$$\text{AWWM160}_P = \text{EM160} * 52 / \text{WEM160}_3\text{P}; \quad (191)$$

$$\begin{aligned} \text{TEM160}_P &= \text{TEM1617}_P + \text{TEM1819}_P + \text{TEM2024}_P + \text{TEM2529}_P + \text{TEM3034}_P + \text{TEM3539}_P + \text{TEM4044}_P + \text{TEM4549}_P + \\ &\quad \text{TEM5054}_P + \text{TEM5559}_P + \text{TEM6064}_P + \text{TEM6569}_P + \text{TEM700}_P; \end{aligned} \quad (118)$$

Final (Pre-TE.ADD) (192-230)

Average Weeks Worked

$$\begin{aligned} \text{AWWM1617} &= \text{AWWM1617}_P; \\ \text{AWWM1819} &= \text{AWWM1819}_P; \\ \text{AWWM2024} &= \text{AWWM2024}_P; \end{aligned}$$

$$\begin{aligned} \text{AWWM2529} &= \text{AWWM2529}_P; \\ \text{AWWM3034} &= \text{AWWM3034}_P; \\ \text{AWWM3539} &= \text{AWWM3539}_P; \\ \text{AWWM4044} &= \text{AWWM4044}_P; \\ \text{AWWM4549} &= \text{AWWM4549}_P; \\ \text{AWWM5054} &= \text{AWWM5054}_P; \end{aligned}$$

$$\begin{aligned} \text{AWWM5559} &= \text{AWWM5559}_P; \\ \text{AWWM6064} &= \text{AWWM6064}_P; \\ \text{AWWM6569} &= \text{AWWM6569}_P; \\ \text{AWWM700} &= \text{AWWM700}_P; \end{aligned}$$

Work Experience

$$\begin{aligned} \text{WEM1617}_3 &= \text{WEM1617}_3\text{P}; \\ \text{WEM1819}_3 &= \text{WEM1819}_3\text{P}; \\ \text{WEM2024}_3 &= \text{WEM2024}_3\text{P}; \end{aligned}$$

$$\begin{aligned} \text{WEM2529}_3 &= \text{WEM2529}_3\text{P}; \\ \text{WEM3034}_3 &= \text{WEM3034}_3\text{P}; \\ \text{WEM3539}_3 &= \text{WEM3539}_3\text{P}; \\ \text{WEM4044}_3 &= \text{WEM4044}_3\text{P}; \\ \text{WEM4549}_3 &= \text{WEM4549}_3\text{P}; \\ \text{WEM5054}_3 &= \text{WEM5054}_3\text{P}; \end{aligned}$$

$$\begin{aligned} \text{WEM5559}_3 &= \text{WEM5559}_3\text{P}; \\ \text{WEM6064}_3 &= \text{WEM6064}_3\text{P}; \\ \text{WEM6569}_3 &= \text{WEM6569}_3\text{P}; \\ \text{WEM700}_3 &= \text{WEM700}_3\text{P}; \end{aligned}$$

Total Employed

$$\begin{aligned} \text{TEM1617} &= \text{TEM1617}_P; \\ \text{TEM1819} &= \text{TEM1819}_P; \\ \text{TEM2024} &= \text{TEM2024}_P; \end{aligned}$$

$$\begin{aligned} \text{TEM2529} &= \text{TEM2529}_P; \\ \text{TEM3034} &= \text{TEM3034}_P; \\ \text{TEM3539} &= \text{TEM3539}_P; \\ \text{TEM4044} &= \text{TEM4044}_P; \\ \text{TEM4549} &= \text{TEM4549}_P; \\ \text{TEM5054} &= \text{TEM5054}_P; \end{aligned}$$

$$\begin{aligned} \text{TEM5559} &= \text{TEM5559}_P; \\ \text{TEM6064} &= \text{TEM6064}_P; \\ \text{TEM6569} &= \text{TEM6569}_P; \\ \text{TEM700} &= \text{TEM700}_P; \end{aligned}$$

$$\text{WEM160}_3 = \text{WEM160}_3\text{P};$$

$AWWM16O = AWWM16O\_P;$  (119)  
 $TEM16O = TEM16O\_P;$  (120)  
 $TEM = TEM16O + HE\_M\_15U(1, YEAR)$

Female Disaggregates Aged 16 and Over

Preliminary

Average Weeks Worked

$AWWF1617\_P = 0.44829 * TREND\_TE - 0.06786 * RF1617 + 0.37331;$  (121)  
 $AWWF1819\_P = 0.24262 * TREND\_TE - 0.00950 * RF1819 + 17.0791;$  (126)  
 $AWWF2024\_P = 0.18291 * TREND\_TE - 0.06453 * RF2024 + 26.6823;$  (131)

$AWWF2529\_P = 0.07674 * TREND\_TE - 0.10131 * RF2529 + 40.0210;$  (136)  
 $AWWF3034\_P = 0.07674 * TREND\_TE - 0.10131 * RF3034 + 40.0210;$  (141)  
 $AWWF3539\_P = 0.05004 * TREND\_TE - 0.10322 * RF3539 + 43.9974;$  (146)  
 $AWWF4044\_P = 0.05004 * TREND\_TE - 0.10322 * RF4044 + 43.9974;$  (151)  
 $AWWF4549\_P = 0.08209 * TREND\_TE - 0.17307 * RF4549 + 41.1649;$  (156)  
 $AWWF5054\_P = 0.08209 * TREND\_TE - 0.17307 * RF5054 + 41.1649;$  (161)

$AWWF5559\_P = 0.04868 * TREND\_TE + 0.17072 * RF5559 + 41.9580;$  (166)  
 $AWWF6064\_P = 0.14339 * TREND\_TE + 0.01918 * RF6064 + 29.1567;$  (171)  
 $AWWF6569\_P = 0.01857 * TREND\_TE + 0.64199 * RF6569 + 36.1193;$  (176)  
 $AWWF700\_P = 0.20193 * TREND\_TE + 0.92866 * RF700 + 14.2412;$  (181)

$AWWF1617\_PL = 0.44829 * TREND\_TE.1 - 0.06786 * RF1617.1 + 0.37331;$  (123)  
 $AWWF1819\_PL = 0.24262 * TREND\_TE.1 - 0.00950 * RF1819.1 + 17.0791;$  (128)  
 $AWWF2024\_PL = 0.18291 * TREND\_TE.1 - 0.06453 * RF2024.1 + 26.6823;$  (133)  
 $AWWF2529\_PL = 0.07674 * TREND\_TE.1 - 0.10131 * RF2529.1 + 40.0210;$  (138)  
 $AWWF3034\_PL = 0.07674 * TREND\_TE.1 - 0.10131 * RF3034.1 + 40.0210;$  (143)  
 $AWWF3539\_PL = 0.05004 * TREND\_TE.1 - 0.10322 * RF3539.1 + 43.9974;$  (148)  
 $AWWF4044\_PL = 0.05004 * TREND\_TE.1 - 0.10322 * RF4044.1 + 43.9974;$  (153)  
 $AWWF4549\_PL = 0.08209 * TREND\_TE.1 - 0.17307 * RF4549.1 + 41.1649;$  (158)  
 $AWWF5054\_PL = 0.08209 * TREND\_TE.1 - 0.17307 * RF5054.1 + 41.1649;$  (163)

$AWWF5559\_PL = 0.04868 * TREND\_TE.1 + 0.17072 * RF5559.1 + 41.9580;$  (168)  
 $AWWF6064\_PL = 0.14339 * TREND\_TE.1 + 0.01918 * RF6064.1 + 29.1567;$  (173)  
 $AWWF6569\_PL = 0.01857 * TREND\_TE.1 + 0.64199 * RF6569.1 + 36.1193;$  (178)  
 $AWWF700\_PL = 0.20193 * TREND\_TE.1 + 0.92866 * RF700.1 + 14.2412;$  (183)

Work Experience

$WEF1617\_3\_P = EF1617 * 52 / AWWF1617\_P;$  (122)  
 $WEF1819\_3\_P = EF1819 * 52 / AWWF1819\_P;$  (127)  
 $WEF2024\_3\_P = EF2024 * 52 / AWWF2024\_P;$  (132)

$WEF2529\_3\_P = EF2529 * 52 / AWWF2529\_P;$  (137)  
 $WEF3034\_3\_P = EF3034 * 52 / AWWF3034\_P;$  (142)  
 $WEF3539\_3\_P = EF3539 * 52 / AWWF3539\_P;$  (147)  
 $WEF4044\_3\_P = EF4044 * 52 / AWWF4044\_P;$  (152)  
 $WEF4549\_3\_P = EF4549 * 52 / AWWF4549\_P;$  (157)  
 $WEF5054\_3\_P = EF5054 * 52 / AWWF5054\_P;$  (162)

$WEF5559\_3\_P = EF5559 * 52 / AWWF5559\_P;$  (167)  
 $WEF6064\_3\_P = EF6064 * 52 / AWWF6064\_P;$  (172)  
 $WEF6569\_3\_P = EF6569 * 52 / AWWF6569\_P;$  (177)  
 $WEF700\_3\_P = EF700 * 52 / AWWF700\_P;$  (182)

$WEF1617\_3\_PL = EF1617.1 * 52 / AWWF1617\_PL;$  (124)  
 $WEF1819\_3\_PL = EF1819.1 * 52 / AWWF1819\_PL;$  (129)  
 $WEF2024\_3\_PL = EF2024.1 * 52 / AWWF2024\_PL;$  (134)

$WEF2529\_3\_PL = EF2529.1 * 52 / AWWF2529\_PL;$  (139)  
 $WEF3034\_3\_PL = EF3034.1 * 52 / AWWF3034\_PL;$  (144)

WEF3539\_3\_PL = EF3539.1 \* 52 / AWWF3539\_PL; (149)  
 WEF4044\_3\_PL = EF4044.1 \* 52 / AWWF4044\_PL; (154)  
 WEF4549\_3\_PL = EF4549.1 \* 52 / AWWF4549\_PL; (159)  
 WEF5054\_3\_PL = EF5054.1 \* 52 / AWWF5054\_PL; (164)  
  
 WEF5559\_3\_PL = EF5559.1 \* 52 / AWWF5559\_PL; (169)  
 WEF6064\_3\_PL = EF6064.1 \* 52 / AWWF6064\_PL; (174)  
 WEF6569\_3\_PL = EF6569.1 \* 52 / AWWF6569\_PL; (179)  
 WEF700\_3\_PL = EF700.1 \* 52 / AWWF700\_PL; (184)

Total Employed

TEF1617\_P = ((WEF1617\_3\_P / WEF1617\_3\_PL) \* (TEF1617.1 - NF1617M.1) + NF1617M) \* MULT1\_TEF1617 \* MULT2\_TEF1617; (125)  
 TEF1819\_P = ((WEF1819\_3\_P / WEF1819\_3\_PL) \* (TEF1819.1 - NF1819M.1) + NF1819M) \* MULT1\_TEF1819 \* MULT2\_TEF1819; (130)  
 TEF2024\_P = ((WEF2024\_3\_P / WEF2024\_3\_PL) \* (TEF2024.1 - NF2024M.1) + NF2024M) \* MULT1\_TEF2024 \* MULT2\_TEF2024; (135)  
  
 TEF2529\_P = ((WEF2529\_3\_P / WEF2529\_3\_PL) \* (TEF2529.1 - NF2529M.1) + NF2529M) \* MULT1\_TEF2529 \* MULT2\_TEF2529; (140)  
 TEF3034\_P = ((WEF3034\_3\_P / WEF3034\_3\_PL) \* (TEF3034.1 - NF3034M.1) + NF3034M) \* MULT1\_TEF3034 \* MULT2\_TEF3034; (145)  
 TEF3539\_P = ((WEF3539\_3\_P / WEF3539\_3\_PL) \* (TEF3539.1 - NF3539M.1) + NF3539M) \* MULT1\_TEF3539 \* MULT2\_TEF3539; (150)  
 TEF4044\_P = ((WEF4044\_3\_P / WEF4044\_3\_PL) \* (TEF4044.1 - NF4044M.1) + NF4044M) \* MULT1\_TEF4044 \* MULT2\_TEF4044; (155)  
 TEF4549\_P = ((WEF4549\_3\_P / WEF4549\_3\_PL) \* (TEF4549.1 - NF4549M.1) + NF4549M) \* MULT1\_TEF4549 \* MULT2\_TEF4549; (160)  
 TEF5054\_P = ((WEF5054\_3\_P / WEF5054\_3\_PL) \* (TEF5054.1 - NF5054M.1) + NF5054M) \* MULT1\_TEF5054 \* MULT2\_TEF5054; (165)  
  
 TEF5559\_P = ((WEF5559\_3\_P / WEF5559\_3\_PL) \* (TEF5559.1 - NF5559M.1) + NF5559M) \* MULT1\_TEF5559 \* MULT2\_TEF5559; (170)  
 TEF6064\_P = ((WEF6064\_3\_P / WEF6064\_3\_PL) \* (TEF6064.1)) \* MULT1\_TEF6064 \* MULT2\_TEF6064; (175)  
 TEF6569\_P = ((WEF6569\_3\_P / WEF6569\_3\_PL) \* (TEF6569.1)) \* MULT1\_TEF6569 \* MULT2\_TEF6569; (180)  
 TEF700\_P = ((WEF700\_3\_P / WEF700\_3\_PL) \* (TEF700.1)) \* MULT1\_TEF700 \* MULT2\_TEF700; (185)  
  
 WEF160\_3\_P = WEF1617\_3\_P + WEF1819\_3\_P + WEF2024\_3\_P + WEF2529\_3\_P + WEF3034\_3\_P + WEF3539\_3\_P + WEF4044\_3\_P + WEF4549\_3\_P + WEF5054\_3\_P + WEF5559\_3\_P + WEF6064\_3\_P + WEF6569\_3\_P + WEF700\_3\_P; (233)  
 AWWF160\_P = EF160 \* 52 / WEF160\_3\_P; (234)  
 TEF160\_P = TEF1617\_P + TEF1819\_P + TEF2024\_P + TEF2529\_P + TEF3034\_P + TEF3539\_P + TEF4044\_P + TEF4549\_P + TEF5054\_P + TEF5559\_P + TEF6064\_P + TEF6569\_P + TEF700\_P; (186)

Final (Pre-TE.ADD) (235-273)

Average Weeks Worked

AWWF1617 = AWWF1617\_P;  
 AWWF1819 = AWWF1819\_P;  
 AWWF2024 = AWWF2024\_P;  
  
 AWWF2529 = AWWF2529\_P;  
 AWWF3034 = AWWF3034\_P;  
 AWWF3539 = AWWF3539\_P;  
 AWWF4044 = AWWF4044\_P;  
 AWWF4549 = AWWF4549\_P;  
 AWWF5054 = AWWF5054\_P;  
  
 AWWF5559 = AWWF5559\_P;  
 AWWF6064 = AWWF6064\_P;  
 AWWF6569 = AWWF6569\_P;  
 AWWF700 = AWWF700\_P;

Work Experience

WEF1617\_3 = WEF1617\_3\_P;  
WEF1819\_3 = WEF1819\_3\_P;  
WEF2024\_3 = WEF2024\_3\_P;

WEF2529\_3 = WEF2529\_3\_P;  
WEF3034\_3 = WEF3034\_3\_P;  
WEF3539\_3 = WEF3539\_3\_P;  
WEF4044\_3 = WEF4044\_3\_P;  
WEF4549\_3 = WEF4549\_3\_P;  
WEF5054\_3 = WEF5054\_3\_P;

WEF5559\_3 = WEF5559\_3\_P;  
WEF6064\_3 = WEF6064\_3\_P;  
WEF6569\_3 = WEF6569\_3\_P;  
WEF700\_3 = WEF700\_3\_P;

Total Employed

TEF1617 = TEF1617\_P;  
TEF1819 = TEF1819\_P;  
TEF2024 = TEF2024\_P;

TEF2529 = TEF2529\_P;  
TEF3034 = TEF3034\_P;  
TEF3539 = TEF3539\_P;  
TEF4044 = TEF4044\_P;  
TEF4549 = TEF4549\_P;  
TEF5054 = TEF5054\_P;

TEF5559 = TEF5559\_P;  
TEF6064 = TEF6064\_P;  
TEF6569 = TEF6569\_P;  
TEF700 = TEF700\_P;

WEF160\_3 = WEF160\_3\_P; (274)  
AWWF160 = AWWF160\_P; (275)  
TEF160 = TEF160\_P; (187)  
TEF = TEF160 + HE\_M\_15U(2, YEAR) (188)

Combined, Age 16 and Over

WE160\_3\_P = WEM160\_3\_P + WEF160\_3\_P; (276)  
AWW160\_P = E160 \* 52 / WE160\_3\_P; (277)

WE160\_3 = WE160\_3\_P; (278)  
AWW160 = AWW160\_P; (279)

TE = TEM + TEF (189)

Underground Economy and the Earnings Suspense File

TE\_U = TEO\_UND (312)  
TEL\_SO = TEL\_SO.1 \* (TE - TEO\_UND - TEO\_ESF) / (TE.1 - TEO\_UND.1 - TEO\_ESF.1) (313)  
TE\_S = TEL\_SO + TEO\_ESF (314)  
TE\_SFO\_LRP = TEL\_SO (389)  
WE\_SFO\_LRP = TE\_SFO\_LRP \* ACWA (390)  
TE\_SFM\_LRP = TE\_SFO\_LRP (391)  
WE\_SFM\_LRP = TE\_SFM\_LRP \* ACWA \* 0.5 (392)  
WE\_SF\_LRP = WE\_SFO\_LRP + WE\_SFM\_LRP (393)  
WE\_SF = WS\_EO\_ESF + WE\_SF\_LRP (394)

MEF

TE\_M = TE - TE\_U - TE\_S (315)  
TE\_MN = TE\_RRO\_M + TE\_SLOO\_M + TE\_SLOS\_M + TE\_SLOE\_M + TE+PS\_M + TE\_PH\_M + TEO\_ASF1 + TEO\_ASJ1 + TEO\_AWH (316)  
HE\_M = TE\_M - TE\_MN (317)  
WS\_MEF = WSCAHI - WE\_SF + WSPRRB + WESL\_N\_NHI +  
(WESL\_N\_NHI\_S / TESL\_N\_S) \* TE\_PS\_M +  
(0.5 \* 1.8 / 44.32167) \* (AIW.1 / 1000 \* PROD / PROD.1 \* AHRS / AHRS.1 \* PGDP / PGDP.1) \* TE\_PH\_M +  
WS\_EO\_ASF1 + WS\_EO\_ASJ1 + WS\_EO\_AWJ + WS\_EO\_AWH (395)

Self-Employed Only

SEOCMB = WSW\_HIO\_OTH\_SE + TEFC\_N\_N\_SE + TESL\_N\_N\_HI\_SE (308)  
SEOCMBL1 = WSW\_HIO\_OTH\_SE + TEFC\_N\_N\_SE + TESL\_N\_N\_HI\_SE (309)  
SEO = (SEO.1 \* (EAS + ENAS) / (EAS.1 + ENAS.1) + (SEOCMB - SEOCMBL1)) \* MULTSEO (310)

Combination Workers

CMB\_TOT = ((-0.01468 + 0.06227 \* RTP.1 - 0.0008) \* WSWA - SEOCMB) \* MULTCMB (322)  
CSW\_TOT = SEO + CMB\_TOT  
AW\_CMBTOT = 1.4953 \* ACWA (337)  
W\_CMBTOT = AW\_CMBTOT \* CMB\_TOT (338)  
CMB\_WRELMAX = TAXMAX / AW\_CMBTOT (344)

CMB Wage Andover Curve

CMB\_WAO1 = IF (CMB\_WRELMAX < 0.0543009)  
THEN 1 - 0.722659 \* CMB\_WRELMAX<sup>0.65</sup> - 0.461913 \* CMB\_WRELMAX<sup>0.8</sup>  
ELSE IF (CMB\_WRELMAX < 0.1086018)  
THEN -1.02884 \* CMB\_WRELMAX<sup>0.6</sup> + 0.324761 \* CMB\_WRELMAX<sup>1.6</sup> + 1.02015  
ELSE IF (CMB\_WRELMAX < 0.1629027)  
THEN -0.906607 \* CMB\_WRELMAX<sup>0.7</sup> + 0.947662  
ELSE IF (CMB\_WRELMAX < 0.2172037)  
THEN -0.813951 \* CMB\_WRELMAX<sup>0.55</sup> + 0.991722  
ELSE IF (CMB\_WRELMAX < 0.3258055)  
THEN -0.755135 \* CMB\_WRELMAX<sup>0.55</sup> + 0.964593  
ELSE 0 (345-349)

CMB\_WAO2 = IF (CMB\_WRELMAX < 0.5430091)  
THEN -0.649755 \* CMB\_WRELMAX<sup>0.6</sup> + 0.886467  
ELSE IF (CMB\_WRELMAX < 0.7059119)  
THEN -0.573205 \* CMB\_WRELMAX<sup>0.7</sup> + 0.810122  
ELSE IF (CMB\_WRELMAX < 0.9231155)  
THEN - 5.22264 \* CMB\_WRELMAX<sup>0.06</sup> + 5.47514  
ELSE IF (CMB\_WRELMAX < 1.0860183)  
THEN - 2.02619 \* CMB\_WRELMAX<sup>0.15</sup> + 2.27963  
ELSE IF (CMB\_WRELMAX < 1.5204256)  
THEN 0.605192 \* EXP (-0.2 \* CMB\_WRELMAX) - 0.827158 \* EXP (-0.8 \* CMB\_WRELMAX)  
+ 1.52918 \* EXP (- 1.5 \* CMB\_WRELMAX) - 0.212269  
ELSE 0

CMB\_WAO3 = IF (CMB\_WRELMAX < 1.8462311)  
THEN 0.19139 \* EXP (-0.6 \* CMB\_WRELMAX) + 0.764408 \* EXP (- 1.8 \* CMB\_WRELMAX) + 0.0194903  
ELSE IF (CMB\_WRELMAX < 2.3077888)  
THEN 0.12964 \* EXP (-0.5 \* CMB\_WRELMAX) + 0.644861 \* EXP (- 1.5 \* CMB\_WRELMAX) + 0.0183343  
ELSE IF (CMB\_WRELMAX < 2.9865502)  
THEN 0.361318 \* EXP (-0.8 \* CMB\_WRELMAX) + 0.0219491  
ELSE IF (CMB\_WRELMAX < 4.3440731)  
THEN 0.193202 \* EXP (-0.45 \* CMB\_WRELMAX) + 0.00425171  
ELSE IF (CMB\_WRELMAX < 5.4300913)  
THEN 0.0560412 \* EXP (-0.25 \* CMB\_WRELMAX) + 0.311286 \* EXP (-0.8 \* CMB\_WRELMAX) +  
0.00297316  
ELSE 0

CMB\_WAO4 = IF (CMB\_WRELMAX < 13.5752283)  
THEN 0.0995677 \* EXP (-0.32 \* CMB\_WRELMAX) + 0.00355234  
ELSE IF (CMB\_WRELMAX < 21.7203653)  
THEN 0.041159 \* EXP (-0.19 \* CMB\_WRELMAX) + 0.00156765  
ELSE IF (CMB\_WRELMAX < 678.7614168)

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THEN 0.265022 * CMB_WRELMAX(-1.555)
ELSE 0

CMB_WAO = IF (CMB_WRELMAX < 0.3258055)
THEN CMB_WAO1
ELSE IF (CMB_WRELMAX < 1.5204256)
THEN CMB_WAO2
ELSE IF (CMB_WRELMAX < 5.4300913)
THEN CMB_WAO3
ELSE CMB_WAO4

CMB = (1 - (CMB_WAO - 0.019)) * CMB_TOT (350)
CSW = SEO + CMB (353)
SEOCMB_HI = 0.039 * (TEFC_N_N + TESL_N_N_HI)
SEO_HI = SEO - SEOCMB_HI (311)
CMB_HI = CMB_TOT + SEOCMB_HI (351)
CSW_TOT = SEO + CMB_TOT (352)
CSW_HI = SEO_HI + CMB_HI (354)

NIPA Wages

Private Residual Sector
WSDPB = WSDP - WSPH - WSPF - WSPRRB - TIPS_SR (327)
TIPS_SR = (0.000508328 * RTP - 0.000481700) * GDP * 1.26393 + TIPS_SR_ADD (326)

OASDI Wages

Covered Employment and Wages - Federal Civilian Government
TEFC = (TEFC.1 / EGGEFC.1) * EGGEFC (362)
TEFC_N = IF (CSRS.1 > 0) THEN TEFC_N.1 / CSRS.1 * CSRS - TEFC_N_SW ELSE 0
TEFC_N_N = HE_WOF_M (319)
TEFC_N_N_SE = HE_WOSF_M (302)
TEFC_N_O = (TEFC_N - TEFC_N_N) (365)
TEFC_O = (TEFC - TEFC_N) (364)
WEFC = (WEFC.1 / WSGGEFC.1) * WSGGEFC (331)
WEFC_O = (WEFC - WEFC_N) * ADJ_FSA_FC (332)

Covered Employment and Wages - State and Local Govt.
TESL = (TESL.1 / EGGESLMAX.1) * EGGESLMAX (280)
TESL_O = (TESL_O.1 / TESL.1) * TESL (281)
TESL_N = (TESL - TESL_O) (282)
TESL_N_O = (TESL_N_O_HI + TESL_N_O_NHI) (293)
TESL_N_O_HI = (TESL_N - TESL_N_O_NHI - TESL_N_N_NHI) * CER_MQGE_O (292)
TESL_N_O_NHI = (TESL_N_O_NHI_S + TESL_N_O_NHI_E + TESL_N_O_NHI_NS) (288)
TESL_N_S = TESL_N_S.1 * (NF1819 + NF2024 + NM1819 + NM2024) / (NF1819.1 + NF2024.1 + NM1819.1 +
NM2024.1) (355)
TESL_N_E = TESL_N_E.1 * (TESL / TESL.1) (285)
TESL_N_O_NHI_S = TESL_N_S * (TESL_N_O_NHI_S.1 / TESL_N_S.1) (284)
TESL_N_O_NHI_E = TESL_N_E * 0.6 (286)
TESL_N_O_NHI_NS = TESL_N_O_NHI_NS.1 * ESR_NS (287)
TESL_N_N = (TESL_N - TESL_N_O) (294)
TESL_N_N_HI = (TESL_N_N - TESL_N_N_NHI) (295)
TESL_N_N_HI_SE = (TESL_N_N_HI_SE.1 / TESL_N_N_HI.1) * TESL_N_N_HI (303)
TESL_N_N_NHI = (TESL_N_N_NHI_S + TESL_N_N_NHI_E + TESL_N_N_NHI_NS) (291)
TESL_N_N_NHI_S = (TESL_N_S - TESL_N_O_NHI_S) (283)
TESL_N_N_NHI_E = (TESL_N_E - TESL_N_O_NHI_E) (289)
TESL_N_N_NHI_NS = TESL_N_N_NHI_NS.1 * ESR_NS (290)
WESL = (WESL.1 / WSGGESL.1) * WSGGESL (297)
WESL_O = (WESL_O.1 / WSGGESL.1) * WSGGESL (298)
WESL_N = (WESL - WESL_O) (299)
WESL_N_HI = (WESL_N - WESL_N_NHI) (361)
WESL_N_NHI = (WESL_N_NHI_S + WESL_N_NHI_E + WESL_N_NHI_NS) (360)
WESL_N_NHI_S = WESL_N_NHI_S.1 * (TESL_N_S / TESL_N_S.1) * (AWSGGESL / AWSGGESL.1) (356)
WESL_N_NHI_E = WESL_N_NHI_E.1 * (TESL_N_E / TESL_N_E.1) * (AWSGGESL / AWSGGESL.1) (357)

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RAWR\_NS = IF (AWR\_NS = 0) THEN 0 ELSE AWR\_NS/AWR\_NS.1 (358)  
 WESL\_N\_NHI\_NS = IF (ESR\_NS = 0) THEN 0 ELSE WESL\_N\_NHI\_NS.1 \* (TESL\_N\_O\_NHI\_NS + TESL\_N\_N\_NHI\_NS) /  
 (TESL\_N\_O\_NHI\_NS.1 + TESL\_N\_N\_NHI\_NS.1) \* (AWSGGESL/AWSGGESL.1) \* RAWR\_NS (359)  
  
 WSW\_HIO\_OTH = 0 (296)  
 WSCA\_HIO\_OTH = WSW\_HIO\_OTH\*(WESL\_N/TESL\_N) (300)  
 WSW\_HIO\_OTH\_SE = 0 (301)  
  
 HE\_WOL\_M = TESL\_N\_N\_HI (304)  
 HE\_WOR\_M = 0 (305)  
 HE\_WOSL\_M = (HE\_WOSL\_M.1 / HE\_WOL\_M.1) \* HE\_WOL\_M (306)  
 HE\_WOSR\_M = 0 (307)

Self-Employed Earnings Sector

Covered SENE (366-374)  
 CSE\_TOT = (YF + YNF) / (YF.1 + YNF.1) \* CSE\_TOT.1  
 CSE\_CMB\_N = (CSE\_TOT / (CMB\_TOT + SEO)) / (CSE\_TOT.1 / (CMB\_TOT.1 + SEO.1)) \* (CSE\_CMB\_N.1 / (CMB\_TOT.1 -  
 CMB.1)) \* (CMB\_TOT - CMB)  
 CSE = CSE\_TOT - CSE\_CMB\_N  
 ACSE\_SEO = (CSE\_TOT / (SEO + 0.416488 \* CMB\_TOT))  
 ACSE\_CMB\_TOT = 0.416488 \* ACSE\_SEO  
 CSE\_SEO = ACSE\_SEO \* SEO  
 CSE\_CMB\_TOT = ACSE\_CMB\_TOT \* CMB\_TOT  
 CSE\_CMB = CSE\_CMB\_TOT - CSE\_CMB\_N  
 ACSE\_CMB = CSE\_CMB/CMB

Present Law OASDI and HI Covered Wages and Earnings

WSGMLC = CML \* WSGFM (334)  
 WSGFCA = WEFC\_O (333)  
 CFCA = WSGFCA/WSGGFCA (375)  
 CSLHI = (WESL\_O+WESL\_N\_HI)/WSGGESL (376)  
 WSGSLCA = WESL\_O (330)  
 WSPH\_O = CPH \* WSPH (323)  
 WSPF\_O = WSPF\_O.1 \* WSPF/WSPF.1 (324)  
 CPF = WSPF\_O/WSPF (377)  
 WSPRR\_O = CPRR \* WSPRRB (325)  
 WSPC = WSPH\_O + WSPF\_O + WSPRR\_O + TIPS\_SR + WSPB\_O (329)  
 CP = WSPC/WSDP (378)  
 WSCA = (WSPC + WSGSLCA + WSGFCA + WSGMLC) (335)  
 COVERNA = (WSCA + CSE) (379)  
 ACWA = WSCA/WSWA (336)  
 ASE = CSE/CSW (380)  
 ASEHI = CSE\_TOT/CSW\_HI (381)  
 ACEA = COVERNA/TCEA (382)  
 ACSLW = WESL\_O/TESL\_O \* MULTACSLW (383)  
 ACMW = ACMW.1 \* AWSGFM/AWSGFM.1 \* CML/CML.1 (384)  
 ACFCW = WEFC\_O/TEFC\_O (385)  
 ACFMW = ACFMW.1 \* (AIW.1/AIW.3)<sup>0.5</sup> (386)  
 TEPH\_N = ENAWPH \* (1 - CPH)  
 TEP\_N\_N\_S = TEP\_N\_N\_S.1 \* (NF1819 + NF2024 + NM1819 + NM2024) / (NF1819.1 + NF2024.1 + NM1819.1 + NM2024.1)  
 WSWA = (TCEA-SEO) (321)

Present Law HI Covered Wages and Earnings

WSCAHI\_ADD = WSCA \* WSCAHI\_ADD.1/WSCA.1  
 TCEAHI = HE\_M + TE\_S (318)  
 TCEA = TCEAHI - ((TESL\_N\_N\_HI + TEFC\_N\_N + WSW\_HIO\_OTH) -  
 (TESL\_N\_N\_HI\_SE + TEFC\_N\_N\_SE + WSW\_HIO\_OTH\_SE)) (320)  
 WSWAHI = TCEAHI - SEO\_HI  
 WSCAHI = WSCA + WEFC\_N + WESL\_N\_HI + WSCA\_HIO\_OTH (388)  
 ACWAHI = WSCAHI/WSWAHI  
 COVERNHI = WSCAHI + CSE\_TOT  
 ACEAHI = COVERNHI/TCEAHI

Complete Coverage concepts

WSWC = (WSWAHI + TEPH\_N + EPRRB + TEP\_N\_N\_S + TEPO\_N + TESL\_N\_N\_NHI) + LOST\_MF  
 ACWC = WSD/WSWC

```

AIW      = IF AIW_GR_YR = 0
           THEN AIW.1 * ACWC / ACWC.1 * MULTAIW
           ELSE AIW.1 * (1 + AIW_GR / 100)

```

Taxable Maximums

```

RAIW      = AIW.2 / AIWBASE (339)
TAXMAXB1 = RAIW * TMAXBASE * 1000 / 300 (340)
TAXMAXB2 = IF TAXMAXB1 - ROUND (TAXMAXB1) >= 0.5
           THEN ROUND (TAXMAXB1) + 1
           ELSE ROUND (TAXMAXB1) (341)
TAXMAXB3 = IF TAXMAXB2 < TAXMAX.1
           THEN TAXMAX.1 * 1000 / 300
           ELSE TAXMAXB2 (342)
TAXMAX    = IF BENINC.1 <= 0.001
           THEN TAXMAX.1
           ELSE 300 * TAXMAXB3 / 1000 (343)

```

Deemed Military Wage Credits

```

EDMILAF  = EDMIL * 1.1
EDMILT   = (2.00303 - 50.7517 / YEAR) * EDMILAF
EDMILR   = EDMILT - EDMILAF
MWC_ED_O = 1.2 * EDMILAF * 0.997
MWC_ED_HI = 1.2 * EDMILAF
AMWC_GO2 = MIN (1.2, AWSGFM * (2/52) * (1/3))
MWC_EDR_O = AMWC_GO2 * EDMILR * (1 - 0.017)
MWC_EDR_HI = MWC_EDR_O + ((1.2 + AMWC_GO2) * 0.5) * EDMILR * 0.017
MWC_O    = MWC_ED_O + MWC_EDR_O
MWC_HI   = MWC_ED_HI + MWC_EDR_HI

```



## 2-4 Effective Taxable Payroll (TAXPAY)

### 2-4.1 Ratio of taxable employee to total covered OASDI wages (RWTEE)

```
if (relmax > 9.74357861d0) then
  RWTEE = -(0.19406d0 / 0.733d0) * relmax**(-0.733d0) + &
    1.000096489d0
else if (relmax > 3.02059599d0) then
  RWTEE = -(0.00880d0 / 0.15d0) * exp(-0.15d0 * relmax) - &
    (0.05580d0 / 0.40d0) * exp(-0.40d0 * relmax) - &
    (0.79917d0 / 1.25d0) * exp(-1.25d0 * relmax) + &
    0.00065d0 * relmax + 0.960300963d0
else if (relmax > 1.82231527d0) then
  RWTEE = -(0.10007d0 / 0.30d0) * exp(-0.30d0 * relmax) - &
    (1.30310d0 / 1.55d0) * exp(-1.55d0 * relmax) - &
    0.01131d0 * relmax + 1.045378386d0
else if (relmax > 0.96762832d0) then
  RWTEE = (0.06774d0 / 0.25d0) * exp(-0.25d0 * relmax) - &
    (1.22605d0 / 1.3d0) * exp(-1.3d0 * relmax) + &
    0.05217d0 * relmax + 0.603167431d0
else if (relmax > 0.43034815d0) then
  RWTEE = (0.40291d0 / 1.5d0) * relmax**1.50d0 - &
    (1.825740d0 / 0.69d0) * exp(-0.69d0 * relmax) - &
    0.98402d0 * relmax + 2.651954653d0
else
  RWTEE = relmax - &
    (0.30150d0 / 1.5d0) * relmax**1.5d0 - &
    (0.38338d0 / 2.00d0) * relmax**2d0
end if
Where
  relmax = OASDI taxable maximum / average covered OASDI wage
  RWTEE = Ratio of OASDI taxable employee to covered wages
```

### 2-4.2 Taxable employee OASDI wages (WTEE)

WTEE = RWTEE \* WSC

Where

- RWTEE = Ratio of OASDI taxable employee to covered wages
- WSC = OASDI total covered wages
- WTEE = OASDI taxable employee wages

### 2-4.3 Ratio of multi-employer refund wages to total OASDI covered wages (RMER)

RMER = ( MER(-1) / WSC(-1) ) - 0.03217 \* ( RWTEE - RWTEE(-1) ) - 0.00024\*( RU - RU(-1) )

Where

- MER(-1) = Multi-employer refund wages in prior year
- RMER = Ratio of multi-employer refund wages to total OASDI covered wages
- RU = Annual average civilian unemployment rate
- RWTEE = Ratio of OASDI taxable employee to covered wages
- WSC(-1) = OASDI total covered wages in prior year

### 2-4.4 Multi-employer refund wages (MER)

MER = RMER \* WSC

Where

- MER = OASDI multi-employer refund wages
- RMER = Ratio of multi-employer refund wages to total OASDI covered wages
- WSC = OASDI total covered wages

### 2-4.5 Taxable employer OASDI wages (WTER)

WTER = WTEE + MER

Where

- MER = OASDI multi-employer refund wages
- WTEE = OASDI taxable employee wages

WTR = OASDI taxable employer wages

## 2-4.6 Ratio of taxable to covered self-employment earnings (RSET)

### Preliminary

BASECT = 74106.96  
BASECW = 57189.30  
BASEO = 36251.60

### Self-employed only

SECSEO = CSE - SECCMB  
ASESEO = SECSEO / SEO  
ASEO14 = ASESEO(2014)  
ASESEO = ASESEO \* BASEO / ASEO14  
O = TAXMAX / ASESEO

```
if ( O < 0.027584991d0 ) then
  OTR = O - (9.065975d0 / 2.5d0) * o**2.5d0
else if ( O < 0.110339964d0 ) then
  OTR = -(1.193247d0 / 1.5d0) * o**1.5d0 + (1.303923d0 / 2.15d0) * o**2.15d0 - &
    (6.126708d0 / 3.3d0) * o**3.3d0 + 1.129476d0 * O - 0.00064136d0
else if ( O < 0.220679929d0 ) then
  OTR = -(1.488812d0 / 1.3d0) * o**1.3d0 + (0.693659d0 / 1.75d0) * o**1.75d0 - &
    (0.855671d0 / 2.4d0) * o**2.4d0 + 1.473746d0 * O - 0.00511267d0
else if ( O < 0.49652984d0 ) then
  OTR = (7.606609d0 / 1.25d0) * o**1.25d0 - (0.362908d0 / 1.6d0) * o**1.6d0 - &
    (4.836158d0 / 2.4d0) * dexp(-2.4d0 * o) - 7.265212d0 * O + 2.067774776d0
else if ( O < 1.075814653d0 ) then
  OTR = -(1.110697d0 / 0.85d0) * dexp(-0.85d0 * o) + (1.205455d0 / 1.55d0) * &
    dexp(-1.55d0 * o) - (1.262542d0 / 3.1d0) * dexp(-3.1d0 * o) - &
    0.089381d0 * O + 0.939092697d0
else if ( O < 1.379249555d0 ) then
  OTR = -(0.779718d0 / 0.55d0) * dexp(-0.55 * o) + (1.671902d0 / 1.75d0) * &
    dexp(-1.75d0 * o) - (2.335616d0 / 2.6d0) * dexp(-2.6d0 * o) - &
    0.146447d0 * O + 1.303012246d0
else if ( O < 1.820609413d0 ) then
  OTR = (0.940350d0 / 0.3d0) * dexp(-0.3d0 * o) - (1.972391d0 / 1.15d0) * &
    dexp(-1.15d0 * o) + (2.270618d0 / 2.5d0) * dexp(-2.5d0 * o) + &
    0.423735d0 * O - 1.83689324d0
else if ( O < 2.289554262d0 ) then
  OTR = -(0.080185d0 / 0.55d0) * dexp(-0.55d0 * o) - (1.228334d0 / 1.85d0) * &
    dexp(-1.85d0 * o) + (1.588926d0 / 2.6d0) * dexp(-2.6d0 * o) + &
    0.040449d0 * O + 0.545577883d0
else if ( O < 3.227388789d0 ) then
  OTR = -(0.162947d0 / 0.2d0) * dexp(-0.2d0 * o) + (0.191691d0 / 1.9d0) * &
    dexp(-1.9d0 * o) - (4.840673d0 / 2.75d0) * dexp(-2.75d0 * o) - &
    0.03269d0 * O + 1.18097593d0
else if ( O < 55.169982211d0 ) then
  OTR = -(0.025559d0 / 0.1d0) * dexp(-0.1d0 * o) - (0.121258d0 / 0.4d0) * &
    dexp(-0.4d0 * o) + 0.000856d0 * O + 0.913882321d0
else if ( O < 599d0 ) then
  OTR = -(1.181349d0 / 0.85d0) * o**(-0.85d0) + 1.006054849d0
else
  OTR = 1d0
end if
```

SETSEO=OTR\*SECSEO

### OASDI taxable wages of workers with both wages and self-employment earnings

AWSCMB=WSCMB/CMBNT  
AWSCMB96=AWSCMB(2014)  
AWSCMB=AWSCMB\*BASECW/AWSCMB14  
CW=TAXMAX/AWSCMB  
if ( CW < 0.017485790d0 ) then  
 CWTR = CW - (1.382857d0 / 1.72d0) \* CW\*\*1.72d0  
else if ( CW < 0.061200264d0 ) then  
 CWTR = (0.549786d0 / 1.45d0) \* CW\*\*1.45d0 - (1.778351d0 / 1.6d0) \* CW\*\*1.6d0 + &

```

0.992433d0 * CW + 0.00001049d0
else if ( CW < 0.166115003d0 ) then
  CWTR = -(1.907583d0 / 1.8d0) * CW**1.8d0 + (1.972895d0 / 2.65d0) * CW**2.65d0 + &
    1.000556d0 * CW - 0.0001254d0
else if ( CW < 0.244801057d0 ) then
  CWTR = -(1.31146d0 / 1.3d0) * CW**1.3d0 + (0.291102d0 / 2.2d0) * CW**2.2d0 + &
    1.38039d0 * CW - 0.00344818d0
else if ( CW < 0.402173165d0 ) then
  CWTR = -(1.237171d0 / 1.2d0) * CW**1.2d0 - (0.529194d0 / 6.5d0) * CW**6.5d0 + &
    1.508203d0 * CW - 0.00018318d0
else if ( CW < 0.559545274d0 ) then
  CWTR = -(2.972542d0 / 1.2d0) * dexp(-1.2d0*CW) + (0.797265d0 / 1.55d0) * &
    dexp(-1.55d0 * CW) + 3.378586d0 * CW - 0.54365086d0
else if ( CW < 0.891775280d0 ) then
  CWTR = -(0.628763d0 / 0.35d0) * dexp(-0.35d0 * CW) - (0.415309d0 / 1.35d0) * &
    dexp(-1.35d0 * CW) - 0.315279d0 * CW + 2.12670341d0
else if ( CW < 1.119090547d0 ) then
  CWTR = -(0.564239d0 / 0.4d0) * dexp(-0.4d0 * CW) - (0.712562d0 / 2.9d0) * &
    dexp(-2.9d0 * CW) - 0.17935d0 * CW + 1.60425512d0
else if ( CW < 1.626178451d0 ) then
  CWTR = (0.732881d0 / 0.25d0) * dexp(-0.25d0 * CW) - (0.500876d0 / 0.55d0) * &
    dexp(-0.55d0 * CW) - (0.740109d0 / 1.3d0) * dexp(-1.3d0 * CW) + &
    0.320035d0 * CW - 1.45683143d0
else if ( CW < 3.322300062d0 ) then
  CWTR = (-0.09148d0 / 0.3d0) * dexp(-0.3d0 * CW) - (0.640943d0 / 1.4d0) * &
    dexp(-1.4d0 * CW) + 0.004344d0 * CW + 0.80189428d0
else if ( CW < 17.485789798d0 ) then
  CWTR = -(0.028438d0 / 0.15d0) * dexp(-0.15d0 * CW) - (0.215237d0 / 0.63d0) * &
    dexp(-0.63d0 * CW) + 0.000432d0 * CW + 0.85527753d0
else if ( CW < 1d3) then
  CWTR = -(0.161459d0 / 0.37d0) * CW**(-0.37d0) + 1.00044233d0
else
  CWTR = 1d0
end if
WSTCMB=CWTR*WSCCMB

```

#### OASDI taxable earnings of workers with both wages and self-employment earnings

```

TECCMB=SECCMB+WSCCMB
ATECMB=TECCMB/CMBNT
ATECMB14=ATECMB(2014)
ATECMB=ATECMB*BASECT/ATECMB14
CT=TAXMAX/ATECMB
if ( CT < 0.026988020d0 ) then
  CTTR = CT - (41.63187d0 / 3.3d0) * CT**3.3d0
else if ( CT < 0.053976039d0 ) then
  CTTR = -(0.006662d0 / 1.4d0) * CT**1.4d0 - (3.086338d0 / 2.5d0) * CT**2.5d0 + &
    1.004313d0 * CT - 0.00002231d0
else if ( CT < 0.101205073d0 ) then
  CTTR = -(1.889107d0 / 2.25d0) * CT**2.25d0 - (2.577198d0 / 4.3d0) * CT**4.3d0 + &
    1.013006d0 * CT - 0.00022589d0
else if ( CT < 0.242892176d0 ) then
  CTTR = -(3.390325d0 / 2.35d0) * CT**2.35d0 + (46.64034d0 / 5.5d0) * CT**5.5d0 + &
    1.062329d0 * CT - 0.00350007d0
else if ( CT < 0.391326284d0 ) then
  CTTR = -(17.4796d0 / 1.85d0) * CT**1.85d0 + (54.97179d0 / 0.34d0) * dexp(-0.34d0 * CT) + &
    56.50813d0 * CT - 161.6959229d0
else if ( CT < 0.539760392d0 ) then
  CTTR = (0.503679d0 / 0.65d0) * dexp(-0.65d0 * CT) - (1.283538d0 / 1.25d0) * &
    dexp(-1.25d0 * CT) + 0.114161d0 * CT + 0.275212359d0
else if ( CT < 0.728676529d0 ) then
  CTTR = (0.381258d0 / 0.45d0) * dexp(-0.45d0 * CT) - (1.14889d0 / 1.25d0) * &
    dexp(-1.25d0 * CT) + 0.127424d0 * CT + 0.094249206d0
else if ( CT < 0.904098656d0 ) then
  CTTR = -(2.823771d0 / 0.45d0) * dexp(-0.45d0 * CT) + (3.115654d0 / 1.35d0) * &
    dexp(-1.35d0 * CT) - (2.690356d0 / 2.45d0) * dexp(-2.45d0 * CT) - &
    1.005584d0 * CT + 5.002559942d0
else if ( CT < 1.120002813d0 ) then
  CTTR = (1.615272d0 / 0.35d0) * dexp(-0.35d0 * CT) - (2.575779d0 / 1.2d0) * &
    dexp(-1.2d0 * CT) + (0.956573d0 / 2.0d0) * dexp(-2.0d0 * CT) + &

```

```

0.712077d0 * CT - 2.88308308d0
else if ( CT < 6.747004899d0 ) then
  CTTR = -(0.104309d0 / 0.35d0) * dexp(-0.35d0 * CT) - (0.152237d0 / 1d0) * &
  dexp(-1d0 * CT) - (0.743361d0 / 2.15d0) * dexp(-2.15d0 * CT) + &
  0.003327d0 * CT + 0.802412901d0
else if ( CT < 40.482029395d0 ) then
  CTTR = -(0.033712d0 / 0.18d0) * dexp(-0.18d0 * CT) - (0.870759d0 / 0.9d0) * &
  dexp(-0.9d0 * CT) + 0.001132d0 * CT + 0.846776177d0
else if ( CT < 1d3 ) then
  CTTR = -(0.137526d0 / 0.35d0) * CT**(-0.35d0) + 1.000064387d0
else
  CTTR = 1d0
TETCMB=CTTR*TECCMB
SETCMB=TETCMB-WSTCMB

```

#### Ratio OASDI taxable to covered self-employment earnings

RSET = (SETCMB+SETSEO)/CSE

Where

ASEO2011 = Average self-employment earnings of workers with no OASDI taxable wages in 2011  
ATECMB = Average OASDI covered earnings of workers with both OASDI covered wages and self-employment earnings  
ATECMB2011 = Average OASDI covered earnings of workers with both OASDI covered wages and self-employment earnings in 2011  
AWSCMB = Average OASDI covered wage of workers with both wages and self-employment earnings  
AWSCMB2011 = Average OASDI covered wage of workers with both wages and self-employment earnings in 2011  
ASESEO = Average self-employment earnings of workers with no OASDI taxable wages  
AWSCMB = Average OASDI covered wage of workers with both wages and self-employment earnings  
BASECT = Average total earnings of workers with both self-employment earnings and wages in 1% sample data for 2011 used to produce equations  
BASECW = Average OASDI covered wages of workers with both self-employment earnings and wages in 1% sample data for 2011 used to produce equations  
BASEO = Average self-employment earnings of workers with no OASDI taxable wages in 1% sample data for 2011 used to produce equations  
CMBNT = Number of workers with both OASDI taxable wages and self-employment earnings  
CSE = OASDI covered self-employment earnings  
CT = Ratio OASDI taxable maximum to average earnings of workers with both self-employment earnings and OASDI taxable wages  
CW = Ratio OASDI taxable maximum to average self-employment earnings of workers with both self-employment earnings and OASDI taxable wages  
CTTR = Ratio of OASDI taxable to covered earnings for workers with both wages and self-employment earnings  
CWTR = Ratio of OASDI taxable to covered wages for workers with both wages and self-employment earnings  
O = Ratio OASDI taxable maximum to average self-employment earnings of workers with no OASDI taxable wages  
OTR = Ratio of OASDI taxable self-employment to covered earnings for workers with no OASDI taxable wages  
SECCMB = OASDI covered self-employment earnings of workers with both self-employment earnings and OASDI taxable wages  
SECSEO = OASDI covered self-employment earnings of workers with no OASDI taxable wages  
SEO = Number of workers with OASDI covered self-employment earnings and no OASDI taxable wages  
SETCMB = OASDI taxable self-employment earnings of workers with both OASDI taxable wages and self-employment earnings  
SETSEO = OASDI taxable self-employment earnings of workers with no OASDI taxable wages  
TAXMAX = OASDI taxable maximum  
TECCMB = OASDI covered earnings of workers with both wages and self-employed earnings  
TETCMB = OASDI taxable earnings of workers with both wages and self-employed earnings  
WSCCMB = OASDI covered wages of workers with both wages and self-employed earnings  
WSTCMB = OASDI taxable wages of workers with both wages and self-employed earnings

#### 2-4.7 OASDI taxable self-employment earnings (SET)

SET = RSET \* CSE

Where

CSE = OASDI covered self-employment earnings  
SET = OASDI taxable self-employment earnings  
RSET = Ratio of OASDI taxable to covered self-employment earnings

#### 2-4.8 OASDI effective taxable payroll (ETP)

ETP=WTER+SET-0.5\*MER

Where

ETP = OASDI effective taxable payroll  
MER = OASDI multi-employer refund wages  
SET = OASDI taxable self-employment earnings  
WTER = Annual OASDI taxable employer wages

## 2-5 Revenues (REVENUES)

### 2-5.1 OASDI taxable wage liability (WTL)

$$WTL = WTER * TRW$$

Where

TRW	=	OASDI combined employee-employer tax rate
WTL	=	Annual OASDI taxable wage liabilities
WTER	=	Annual OASDI taxable employer wages

### 2-5.2 OASDI taxable self-employment liability (SEL)

$$SEL = SET * TRSE$$

Where

SEL	=	OASDI taxable self-employment earnings liabilities
SET	=	OASDI taxable self-employment earnings
TRSE	=	OASDI self-employment tax rate

### 2-5.3 OASDI multi-employer refund wage liability (MERL)

$$MERL = MER * TRWEE$$

Where

MERL	=	OASDI multi-employer refund wage liabilities
MER	=	OASDI multi-employer refund wages
TRWEE	=	OASDI employee tax rate

### 2-5.4 OASDI quarterly taxable wage liability (WTLQ)

#### Federal Civilian

##### Annual total wages (OASDI + MQGE)

$$BAFCW = 34198.84$$

$$AWCFC = WCFC / ECFC * BAFCW / AWCFTOT97$$

$$T = \text{MAX} / \text{AWCFC}$$

IF(T.LT.0.014620379)THEN

$$FCTR = T - (1.04262 / 1.73) * T ** 1.73$$

ELSE IF(T.LT.0.292407578)THEN

$$FCTR = -(1.22471 / 1.6) * T ** 1.6 + (.826746 / 1.8) * \text{DEXP}(-1.8 * T) + 1.8535 * T - .459368449$$

ELSE IF(T.LT.0.760259704)THEN

$$FCTR = -(.635082 / 2D0) * T ** 2 + (.604884 / 2.9) * T ** 2.9 - (.403213 / 4.6) * T ** 4.6 + .910343 * T + .002291358$$

ELSE IF(T.LT.1.228111829)THEN

$$FCTR = -(1.62181 / 1.7) * T ** 1.7 + (.143632 / 2.7) * T ** 2.7 - (.312012 / 3.4) * T ** 3.4 + .841165 * T + .011332647$$

ELSE IF(T.LT.1.520519407)THEN

$$FCTR = -(1.34084 / 3.5) * T ** 3.5 + (1.09868 / 5D0) * T ** 5 - (.404253 / 5.8) * T ** 5.8 + 1.17397 * T - .222555715$$

ELSE IF(T.LT.2.339260627)THEN

$$FCTR = (.671304 / .5) * \text{DEXP}(-.5 * T) - (3.27076 / 1.4) * \text{DEXP}(-1.4 * T) + .126626 * T + .353367869$$

ELSE IF(T.LT.3.50889094)THEN

$$FCTR = (.0571643 / .95) * \text{DEXP}(-.95 * T) - (3.17633 / 1.8) * \text{DEXP}(-1.8 * T) + .000623031 * T + .996284293$$

ELSE IF(T.LT.4.970928832)THEN

$$FCTR = -(12.3148 / 2.25) * \text{DEXP}(-2.25 * T) + .0000698013 * T + .999222265$$

ELSE

$$FCTR = -(0.285502 / 2D0) * T ** (-2D0) + 1.00007094$$

END IF

$$WTFCTOT = FCTR * WCFC$$

Where

AWCFC	=	Average covered Federal Civilian wages (OASDI plus MQGE)
AWCFCTOT97	=	Average covered Federal Civilian wages (OASDI plus MQGE) for 1997
BAFCW	=	Average Federal Civilian wages (OASDI plus MQGE) in 1% sample data for 1997 used to produce equations
ECFC	=	Covered Federal Civilian employment (OASDI plus MQGE)
FCTR	=	Ratio of taxable to covered Federal Civilian wages (OASDI plus MQGE)
MAX	=	OASDI taxable maximum
T	=	Ratio of the OASDI taxable maximum to average covered Federal Civilian wages (OASDI plus MQGE)

WCFC = Covered Federal Civilian wages (OASDI plus MQGE)  
WTFCTOT = Taxable Federal Civilian wages (OASDI plus MQGE)

**Annual MQGE wages**

BAFCW = 50147.72  
AWCFC = WCFC / ECFC \* BAFCW / AWCFCO97  
T = MAX / AWCFC

```
IF(T.LT.0.019941085)THEN
  FCTR=T-(0.0450661/1.47)*T**1.47
ELSE IF(T.LT.0.099705424)THEN
  FCTR=(-.0518044/1.9)*T**1.9-(.0368056/2.3)*T**2.3+.99479*T+.0000248091
ELSE IF(T.LT.0.358939528)THEN
  FCTR=(-.05907/1.25)*T**1.25-(.0746657/2.9)*T**2.9+1.02092*T-.00032173
ELSE IF(T.LT.0.558350377)THEN
  FCTR=(-2.4664/1.4)*T**1.4+(4.82919/2.3)*T**2.3-(3.97473/3)*T**3+1.83998*T-.026694932
LSE IF(T.LT.0.797643395)THEN
  FCTR=(.609091/2.1)*T**2.1-(1.16086/4)*T**4+.788373*T+.043208139
ELSE IF(T.LT.1.196465093)THEN
  FCTR=(2.35647/4)*DEXP(-.4*T)-(3.87811/1.2)*DEXP(-1.2*T)-(1.1179/2.5)*DEXP(-2.5*T)+.738296*T-2.83402534
ELSE IF(T.LT.1.694992215)THEN
  FCTR=(-.422884/1.3)*DEXP(-1.3*T)-(6.90241/3D0)*DEXP(-3*T)-.0229917*T+1.068147457
ELSE IF(T.LT.2.592341034)THEN
  FCTR=(.557032/1.2)*DEXP(-1.2*T)-(5.40739/2.2)*DEXP(-2.2*T)+.0102014*T+.960037325
ELSE
  FCTR=(-(32.3187/3.5)*DEXP(-3.5*T)+1.000030482
END IF
```

WTFCHO=FCTR\*WCFC

Where

AWCFC = Average covered Federal Civilian MQGE wages  
AWCFCO97 = Average covered Federal Civilian MQGE wages for 1997  
BAFCW = Average Federal Civilian MQGE wages in 1% sample data for 1997 used to produce equations  
ECFC = Covered Federal Civilian MQGE employment  
FCTR = Ratio of taxable to covered Federal Civilian MQGE wages  
MAX = OASDI taxable maximum  
T = Ratio of the OASDI taxable maximum to average covered Federal Civilian MQGE wages  
WCFC = Covered Federal Civilian MQGE wages  
WTFCHO = Taxable Federal Civilian MQGE wages

**Annual OASDI taxable wages**

WTFC = WTFCTOT - WTFCHO

Where

WTFC = Annual OASDI taxable Federal Civilian wages  
WTFCHO = Taxable Federal Civilian MQGE wages  
WTFCTOT = Taxable Federal Civilian wages (OASDI plus MQGE)

**Quarterly OASDI covered wages**

CFCQD(1) = .98357 \* TCFCD(I,1) + FCPD(I,1)  
CFCQD(2) = .98909 \* TCFCD(I,2) + FCPD(I,2)  
CFCQD(3) = 1.01833 \* TCFCD(I,3) + FCPD(I,3)  
CFCQD(4) = 1.00814 \* TCFCD(I,4) + FCPD(I,4)

QWFCOD(J) = CFCQD(J) \* WTFC

Where

CFCQD = Proportion of annual OASDI covered Federal Civilian wages paid in each quarter  
FCPD = Payday variable for Federal Civilian wages based on calendar  
I = Calendar year  
J = Quarter  
TCFCD = Proportion of annual NIPA Federal Civilian wages paid in each quarter  
QWFCOD = Quarterly OASDI covered Federal Civilian wages  
WTFC = Annual OASDI taxable Federal Civilian wages

### Quarterly OASDI taxable wages

```
IF(FCTR.LE.0.928)FCQD(2)=FCQD(2)+.27522*(1.-FCTR)-.15127*(1.-FCTR)**2+.35146*(1.-FCTR)**3
IF(FCTR.LE.0.993)THEN
  FCQD(3)=FCQD(3)+.28047*(1.-FCTR)-4.73021*(1.-FCTR)**2+25.3606*(1.-FCTR)**3-58.1741*(1.-FCTR)**4+45.1465*(1.-FCTR)**5
  FCQD(4)=FCQD(4)-.75095*(1.-FCTR)+3.65109*(1.-FCTR)**2-16.9355*(1.-FCTR)**3+23.9578*(1.-FCTR)**4
END IF
First quarter is always 100 percent taxable.
QWTFC(I,1)=QWCFC(I,1)
IF(FCTR.LE.0.928)THEN
  Compute taxable for 2nd-4th quarter.
  FCQ=FCQD(2)+FCQD(3)+FCQD(4)
  WTFC2=WTFC-QWTFC(I,1)
  FCQD(2:4)=FCQD(2:4)/FCQ
  QWTFC(I,2:4)=FCQD(2:4)*WTFC2
ELSE IF(FCTR.LE.0.993)THEN
  Second quarter covered is completely taxable.
  QWTFC(I,2)=QWCFC(I,2)
  QWTFC(I,3)=FCQD(3)*WTFC
  QWTFC(I,4)=WTFC-QWTFC(I,1)-QWTFC(I,2)-QWTFC(I,3)
ELSE
  Second and third quarter covered is completely taxable.
  QWTFC(I,2)=QWCFC(I,2)
  QWTFC(I,3)=QWCFC(I,3)
  QWTFC(I,4)=WTFC-QWTFC(I,1)-QWTFC(I,2)-QWTFC(I,3)
END IF
```

Where

FCQD	=	Proportion of annual OASDI covered Federal Civilian wages paid in each quarter
FCQ	=	Sum of proportions of annual OASDI covered Federal Civilian wages paid in each quarter for quarters two to four
FCQD	=	Proportion of annual OASDI taxable Federal Civilian wages paid in each quarter
FCTR	=	Ratio annual OASDI taxable to covered Federal Civilian wages
I	=	Calendar year
TCFCD	=	Proportion of annual NIPA Federal Civilian wages paid in each quarter
QWCFC	=	Quarterly OASDI covered Federal Civilian wages
QWTFC	=	Quarterly OASDI taxable Federal Civilian wages
WTFC	=	Annual OASDI taxable Federal Civilian wages
WTFC2	=	Total OASDI taxable Federal Civilian wages paid in quarters two to four

### Quarterly OASDI taxable wage liabilities

```
WTLQFCEE(I, J) = QWTFC(I, J) * TRWEE(I)
WTLQFCER(I, J) = QWTFC(I, J) * TRWER(I)
WTLQFC(I, J) = WTLQFCEE(I, J) + WTLQFCER(I, J)
```

Where

I	=	Calendar year
J	=	Quarter
TRWEE	=	OASDI employee tax rate
TRWER	=	OASDI employer tax rate
WTLQFC	=	Quarterly OASDI taxable Federal Civilian combined employee-employer wage liabilities
WTLQFCEE	=	Quarterly OASDI taxable Federal Civilian employee wage liabilities
WTLQFCER	=	Quarterly OASDI taxable Federal Civilian employer wage liabilities

### Military wages

#### Annual OASDI taxable wages

```
BACMW = 16439.95
ACMW = AWCML * BACMW / AWCML97
T = MAX / ACMW
```

```
IF(T.LT.0.060827432)THEN
  MTR=T-(.712875/2)*T**2
ELSE IF(T.LT.0.182482295)THEN
  MTR=(.71197/1.8)*T**1.8-(1.59752/2D0)*T**2+.97587*T+0.000542413
ELSE IF(T.LT.0.608274315)THEN
  MTR=-(1.75026/2D0)*T**2+(2.86837/3D0)*T**3-(1.90346/4D0)*T**4+1.10056*T-.006441373
ELSE IF(T.LT.1.094893767)THEN
  MTR=-(.700864/1.4)*T**1.4-(.40042/3.3)*T**3.3+(.197091/4.1)*T**4.1+1.33615*T-.056637087
```



```

ELSE IF(T.LT.1.703168082)THEN
  MTR=(21.3527/.3)*DEXP(-.3*T)-(21.1277/0.5)*DEXP(-.5*T)+(2.73027/1.1)*DEXP(-1.1*T)+4.34833*T-31.56802874
ELSE IF(T.LT.2.311442397)THEN
  MTR=(33.3894/1.2)*T**1.2+(14.9436/1.6)*T**1.6-(2.58041/2.1)*T**2.1+21.3365*T-.872981629
ELSE IF(T.LT.3.163026438)THEN
  MTR=(-.076094/.3)*DEXP(-.3*T)-(1.59668/1.4)*DEXP(-1.4*T)-.0271355*T+1.182946986
ELSE IF(T.LT.4.257920205)THEN
  MTR=(.482918/1.5)*T**1.5-(9.21141/.9)*DEXP(-.9*T)+(25.93/1.5)*DEXP(-1.5*T)-1.14706*T+3.246003821
ELSE
  MTR=(-.9.00723/1.8)*DEXP(-1.8*T)+1.000285789
END IF
WTML=MTR*WCML

```

Where

ACMW	=	Average OASDI covered military wages adjusted for level used to produce equations
AWCML	=	Average OASDI covered military wages
AWCML97	=	Average OASDI covered military wages in 1997
BACMW	=	Average OASDI covered military wages in 1% sample data for 1997 used to produce equations
MAX	=	OASDI taxable maximum
MTR	=	Ratio of OASDI taxable to covered military wages
T	=	Ratio of the OASDI taxable maximum to average covered military wages
WCML	=	Annual OASDI covered military wages
WTML	=	Annual OASDI taxable military wages

#### Quarterly OASDI covered wages

CMLQD(1)	=	.97978*TCMLD(I,1)*MLPD(I,1)
CMLQD(2)	=	1.002*TCMLD(I,2)*MLPD(I,2)
CMLQD(3)	=	1.02145*TCMLD(I,3)*MLPD(I,3)
CMLQD(4)	=	.99689*TCMLD(I,4)*MLPD(I,4)
QWCML	=	CMLQD(J)*WCML

Where

CMLQD	=	Proportion of annual OASDI covered military wages paid in each quarter
I	=	Calendar year
J	=	Quarter
MLPD	=	Payday variable for military wages based on calendar
QWCML	=	Quarterly OASDI covered military wages
TCMLD	=	Proportion of annual NIPA military wages paid in each quarter
WCML	=	Annual OASDI covered military wages

#### Quarterly OASDI taxable wages

```

T=MAX/AWCML
IF(MLTR.LT.0.776)QML(1)=CMLQD(1)+.393565-.018307*T-3.44641/T+15.6381/T**2-40.0168/T**3+62.0449/T**4-
57.525/T**5+30.2498/T**6-7.8664/T**7+.674629/T**8
IF(MLTR.LT.0.952)QML(2)=CMLQD(2)+.844748-.0401062*T-7.24247/T+32.4957/T**2-83.3328/T**3+129.374/T**4-
122.526/T**5+68.2737/T**6-20.1479/T**7+2.34289/T**8
IF(MLTR.LT.0.985)QML(3)=CMLQD(3)-2.62266+.125592*T+22.5832/T-105.727/T**2+300.027/T**3-540.915/T**4+622.304/T**5-
441.658/T**6+175.722/T**7-29.8987/T**8
IF(MLTR.LT.1.)QML(4)=CMLQD(4)+2.37295-.111565*T-21.1954/T+106.049/T**2-330.637/T**3+658.869/T**4-
835.626/T**5+648.641/T**6-279.392/T**7+50.9246/T**8
IF(MLTR.LT.0.776)THEN
  QWTML(I,1:4)=QML(1:4)*WTML
ELSE IF(MLTR.LT.0.952)THEN
  QWTML(I,1)=QWCML(I,1)
  TOTWG1=WTML-QWTML(I,1)
  Q1=QML(2)+QML(3)+QML(4)
  QML(2:4)=QML(2:4)/Q1
  QWTML(I,2:4)=QML(2:4)*TOTWG1
ELSE IF(MLTR.LT.0.985)THEN
  QWTML(I,1)=QWCML(I,1)
  QWTML(I,2)=QWCML(I,2)
  TOTWG1=WTML-QWTML(I,1)-QWTML(I,2)
  Q1=QML(3)+QML(4)
  QML(2:4)=QML(2:4)/Q1
  QWTML(I,2:4)=QML(2:4)*TOTWG1
ELSE IF(MLTR.LT.1.)THEN
  QWTML(I,1)=QWCML(I,1)
  QWTML(I,2)=QWCML(I,2)

```

$QWTML(I,3)=QWCML(I,3)$   
 $QWTML(I,4)=WTML-QWTML(I,1)-QWTML(I,2)-QWTML(I,3)$   
 END IF

Where

AWCML = Average OASDI covered military wages  
 CMLQD = Proportion of annual OASDI covered military wages paid in each quarter  
 MLTR = Ratio of OASDI taxable to covered military wages  
 MAX = OASDI taxable maximum  
 I = Calendar year  
 Q1 = Sum of proportions of annual OASDI taxable military wages paid in each quarter for last three or two quarters in year  
 QML = Proportion of annual OASDI taxable military wages paid in each quarter  
 QWCML = Quarterly OASDI covered military wages  
 QWTML = Quarterly OASDI taxable military wages  
 T = Ratio of the OASDI taxable maximum to average covered military wages  
 TOTWG1 = Annual OASDI taxable military wages for all quarters except first or first and second  
 WTML = Annual OASDI taxable military wages

#### Quarterly OASDI taxable wage liabilities

$WTLQMLEE(I, J) = QWTML(I, J) * TRWEE(I)$   
 $WTLQMLER(I, J) = QWTML(I, J) * TRWER(I)$   
 $WTLQML(I, J) = WTLQMLEE(I, J) + WTLQMLER(I, J)$

Where

I = Calendar year  
 J = Quarter  
 TRWEE = OASDI employee tax rate  
 TRWER = OASDI employer tax rate  
 WTLQML = Quarterly OASDI taxable military combined employee-employer wage liabilities  
 WTLQMLEE = Quarterly OASDI taxable military employee wage liabilities  
 WTLQMLER = Quarterly OASDI taxable military employer wage liabilities

#### Federal

$WCF = WCFC + WCML$   
 $QWCF = QWCFC + QWCML$   
 $WTF = WTFC + WTML$   
 $QWTF = QWTFC + QWTML$   
 $WTLQFEE(I,J) = QWTF(I,J) * TRWEE(I)$   
 $WTLQFER(I,J) = QWTF(I,J) * TRWER(I)$   
 $WTLQF(I,J) = WTLQFEE(I,J) + WTLQFER(I,J)$

Where

I = Calendar year  
 J = Quarter  
 QWCF = Quarterly OASDI covered Federal wages  
 QWCF C = Quarterly OASDI covered Federal Civilian wages  
 QWCML = Quarterly OASDI covered military wages  
 QWTF = Quarterly OASDI taxable Federal wages  
 QWTFC = Quarterly OASDI taxable Federal Civilian wages  
 QWTML = Quarterly OASDI taxable military wages  
 WCF = Annual OASDI covered Federal wages  
 WCFC = Annual OASDI covered Federal Civilian wages  
 WCML = Annual OASDI covered military wages  
 WTF = Annual OASDI taxable Federal wages  
 WTFC = Annual OASDI taxable Federal Civilian wages  
 WTLQF = Quarterly OASDI taxable Federal combined employee-employer wage liabilities  
 WTLQFEE = Quarterly OASDI taxable Federal employee wage liabilities  
 WTLQFER = Quarterly OASDI taxable Federal employer wage liabilities  
 WTML = Annual OASDI taxable military wages

#### State and Local wages

##### Annual OASDI taxable wages

$BACW = 21583.61$   
 $AWCSL = WCSL / ESLC * BACW / AWCSLOD97$   
 $S = MAX / ASLC$   
 IF(S.LT.0.02316573)THEN

```

SLTR=S-(1.1803/1.71)*S**1.71
ELSE IF(S.LT.0.463314609)THEN
SLTR=(-1.54738/1.6)*S**1.6-(.421147/2.5)*S**2.5+(3.34881/.5)*DEXP(-.5*S)+4.39012*S-6.697774474
ELSE IF(S.LT.0.833966296)THEN
SLTR=(-.756943/1.8)*S**1.8+(.485982/2.3)*S**2.3-(.175681/3.2)*S**3.2+.88749*S+.004652169
ELSE IF(S.LT.1.945921357)THEN
SLTR=(3.4167/.3)*DEXP(-.3*S)-(7.26467/.9)*DEXP(-.9*S)+(4.57049/1.5)*DEXP(-1.5*S)+1.0378*S-6.245057503
ELSE IF(S.LT.3.243202261)THEN
SLTR=(-2.40293/.2)*DEXP(-.2*S)+(6.44952/.4)*DEXP(-.4*S)-(5.64852/.6)*DEXP(-.6*S)-.278204*S+5.099074279
ELSE IF(S.LT.5.559775305)THEN
SLTR=(-.0434955/.6)*DEXP(-.6*S)-(4.00403/1.7)*DEXP(-1.7*S)+.00006219*S+.997065459
ELSE IF(S.LT.18.532588435)THEN
SLTR=(-.0272758/.5)*DEXP(-.5*S)+.0000671826*S+.997657785
ELSE
SLTR=(-.00861948/.7)*S**(-.7)+1.000492941
END IF
WTSL=SLTR*WCSL

```

Where

AWCSL	=	Average OASDI covered State and Local wages adjusted for average wage used to produce equations
AWCSLOD97	=	Average OASDI covered State and Local wages for 1997
BACW	=	Average OASDI covered State and Local wages in 1% sample data for 1997 used to produce equations
ESLC	=	OASDI covered State and Local employment
MAX	=	OASDI taxable maximum
S	=	Ratio of the OASDI taxable maximum to average covered State and Local wages
SLTR	=	Ratio of OASDI taxable to covered State and Local wages
WCSL	=	OASDI covered State and Local wages
WTSL	=	OASDI taxable State and Local wages

#### Quarterly OASDI covered wages

```

CSLQD(1)=1.0131455*TCSLD(I,1)+SLPD(I,1)
CSLQD(2)=1.0431906*TCSLD(I,2)+SLPD(I,2)
CSLQD(3)=.9060524*TCSLD(I,3)+SLPD(I,3)
CSLQD(4)=1.0365866*TCSLD(I,4)+SLPD(I,4)
QWCSL=CSLQD(I,4)*WCSL

```

Where

CSLQD	=	Proportion of annual OASDI covered State and Local wages paid in each quarter
I	=	Calendar year
QWCSL	=	Quarterly OASDI covered State and Local wages
SLPD	=	Payday variable for State and Local wages based on calendar
TCSLD	=	Proportion of annual NIPA State and Local wages paid in each quarter
WCSL	=	Annual OASDI covered State and Local wages

#### Quarterly OASDI taxable wages

```

QSL(1)=(CSLQD(1)-.24087*(1.-1./SLTR))
QSL(2)=(CSLQD(2)-1.0492*(1.-1./SLTR)+.51259*(1.-1./SLTR**2)-.07643*(1.-1./SLTR**3))
QSL(3)=(CSLQD(3)-5.99032*(1.-SLTR**2)+13.238*(1.-SLTR**3)-11.3291*(1.-SLTR**4)+3.52237*(1.-SLTR**5))
QSL(4)=(CSLQD(4)+8.99897*(1.-SLTR**25)-5.48866*(1.-SLTR**5))
TQSL=QSL(2)+QSL(3)+QSL(4)
QSL(2:4)=QSL(2:4)/TQSL
QWTSL(I,1)=QSL(1)*WTSL
QWTSL(I,2:4)=QSL(2:4)*(WTSL- QWTSL(I,1))

```

Where

CSLQD	=	Proportion of annual OASDI covered State and Local wages paid in each quarter
I	=	Calendar year
QSL	=	Proportion of annual OASDI taxable State and Local wages paid in each quarter
QWTSL	=	Quarterly OASDI taxable State and Local wages
SLTR	=	Ratio of OASDI taxable to covered State and Local wages
WTSL	=	OASDI taxable State and Local wages

#### Quarterly OASDI taxable wage liabilities

```

WTLQSL(I,J) = QWTSL(I,J) * TRW(I)

```

Where

I	=	Calendar year
---	---	---------------

J = Quarter  
 TRW = OASDI combined employee-employer tax rate  
 WTLQSL = Quarterly OASDI taxable State and Local combined employee-employer wage liabilities

**Private household quarterly OASDI taxable wages and liabilities**

$QWTPHH(I,J) = WCPHH(I) * QDPHH(J)$   
 $WTLQPHH(I,J) = QWTPHH(I,J) * TRW(I)$

Where  
 I = Calendar year  
 J = Quarter  
 QDPHH = Proportion of annual OASDI taxable private household wages paid in each quarter  
 QWTPHH = Quarterly OASDI taxable private household wages  
 TRW = OASDI combined employee-employer tax rate  
 WCPHH = Annual OASDI covered private household wages  
 WTLQPHH = Quarterly OASDI taxable private household combined employee-employer wage liabilities

**Farm taxable wages**

**Annual OASDI**

BAFMW = 7467.91  
 AWCfm97 = ACFMW(1997)  
 $F = \text{MAX} / (\text{ACFMW} * \text{BAFMW} / \text{AWCFM97})$

IF(F.LT.0.066953142)THEN  
 FMTR=F- (1.30211/1.75)\*F\*\*1.75  
 ELSE IF(F.LT.0.401718855)THEN  
 FMTR=-(1.18244/1.35)\*F\*\*1.35+(.25412/1.75)\*F\*\*1.75+1.24681\*F-.001598087  
 ELSE IF(F.LT.0.669531425)THEN  
 FMTR=-(.508764/.6)\*DEXP(-.6\*F)-(1.300083/2.8)\*DEXP(-2.8\*F)+.0188542\*F+.966550312  
 ELSE IF(F.LT.1.87468799)THEN  
 FMTR=-(.638146/.6)\*DEXP(-.6\*F)-(1.0322774/1.5)\*DEXP(-1.5\*F)-.033706\*F+1.133974442  
 ELSE IF(F.LT.2.41031313)THEN  
 FMTR=-(2.64644/1.1)\*DEXP(-1.1\*F)+(17.4638/2)\*DEXP(-2\*F)-(26.4191/2.5)\*DEXP(-2.5\*F)+.00686748\*F+.909154345  
 ELSE IF(F.LT.4.82062626)THEN  
 FMTR=-(1.06567/1.3)\*F\*\*1.3+(-.073837/2.1)\*F\*\*2.1+1.31021\*F-.007628879  
 ELSE IF(F.LT.6.427501679)THEN  
 FMTR=-(1.178355/.5)\*DEXP(-.5\*F)-(1.70356/1.3)\*DEXP(-1.3\*F)+.00115171\*F+.959096096  
 ELSE IF(F.LT.10.7125028)THEN  
 FMTR=-(.0474377/0.35)\*DEXP(-.35\*F)-(1.32456/1)\*DEXP(-1\*F)+.0016146\*F+.957903052  
 ELSE IF(F.LT.11.38203422)THEN  
 FMTR=-(.0581938/.35)\*DEXP(-.35\*F)+.00130453\*F+.961918378  
 ELSE IF(F.LT.24.1031313)THEN  
 FMTR=-(.0492564/.3)\*DEXP(-.3\*F)+.000761577\*F+.97040299  
 ELSE  
 FMTR=-(.00304904/.06)\*DEXP(-.06\*F)+1.000606299  
 END IF  
 TFMW=FMTR\*WCFM

Where  
 ACFMW = Annual average OASDI covered farm wages  
 AWCfm97 = Annual average OASDI covered farm wages for 1997  
 BAFMW = Average farm wage in 1% sample data for 1997 used to produce equations  
 F = Ratio of taxable maximum to annual average OASDI covered farm wages adjusted for average wage used in equations  
 FMTR = Ratio of OASDI taxable to covered farm wages  
 MAX = OASDI taxable maximum  
 TFMW = Annual OASDI taxable farm wages

**Quarterly OASDI wages and liabilities**

$QWTFM(I,J) = TTFMD(I,J) * TFMW$   
 $WTLQFM(I,J) = QWTFM(I,J) * TRW(I)$

Where  
 I = Calendar year  
 J = Quarter  
 QWTFM = Quarterly OASDI taxable farm wages

TFMW = Annual OASDI taxable farm wages  
 TRW = OASDI com  
 TTFMD = Proportion of annual OASDI taxable farm wages paid in each quarter  
 WTLQFM = Quarterly OASDI taxable farm combined employee-employer wage liabilities

**Quarterly OASDI taxable employee tips**

QWTTIPSEE(L,J) = QDTIP(J) \* WTTIPSEE(I)  
 QWTTIPSEE(L,2) = QWTTIPSEE(L,1) + WTTIPSSR(I)  
 WTLQTIPSEE(L,J) = QWTTIPSEE(L,J) \* TRW(I)

Where

I = Calendar year  
 J = Quarter  
 QDTIP = Proportion of annual OASDI taxable tips received in each quarter  
 QWTTIPSEE = Quarterly OASDI taxable tips received by employees  
 WTLQTIPSEE = Quarterly OASDI combined employee-employer wage liabilities on taxable tips received by employees  
 TRW = OASDI combined employee-employer tax rate  
 WTTIPSEE = Annual OASDI taxable tips received by employees reported by employers  
 WTTIPSSR = Annual OASDI taxable tips received by employees self-reported on income tax returns

**Private nonfarm OASDI taxable wages and liabilities**

**Annual**

WTPNF = WTER - WTFC - WTML - WTSL - TFMW - WTTIPSEE - WTTIPSSR

Where

TFMW = Annual OASDI taxable farm wages  
 WTSL = Annual OASDI taxable State and Local wages  
 WTFC = Annual OASDI taxable Federal Civilian wages  
 WTPNF = Annual OASDI taxable private nonfarm wages excluding tips  
 WTTIPSEE = Annual OASDI taxable tips received by employees reported by employers  
 WTTIPSSR = Annual OASDI taxable tips received by employees self-reported on income tax returns  
 WTER = Annual OASDI taxable employer wages

**Quarterly**

BACW93 = 21912.00  
 NACW = BACW93 / ACW93 \* AWC  
 X = MAX / NACW  
 IF(X.LT.0.91274)THEN  
 TWTR=1D0+.990751\*DEXP(X)\*\*(-1)/(-1)-.013904602  
 ELSE IF(X.LT.2.05367)THEN  
 TWTR=1D0+(-.003129\*X+(1.167562\*DEXP(X)\*\*(-1.17)/(-1.17)))-.065747345  
 ELSE IF(X.LT.4.791895)THEN  
 TWTR=1D0+(.003962\*X+(.770093\*X\*\*(-1.85053))/(-1.85053))-0.06071106  
 ELSE  
 TWTR=1D0+(.267708\*X\*\*(-.94))/(-.94)+.00066  
 END IF  
 IF(TWTR.LT.0.70)THEN  
 QP(1)=-(-0.000575+0.18692\*DLOG(TWTR)-0.23133\*DLOG(TWTR)\*\*2-  
 0.10453\*DLOG(TWTR)\*\*3+0.04306\*DLOG(TWTR)\*\*4+0.01906\*DLOG(TWTR)\*\*5)-0.0325201+PD(1)+TCPD(I,1)  
 QP(2)=-(-0.00657+1.7015\*TWTR-8.60615\*TWTR\*\*2+14.444\*TWTR\*\*3-9.97171\*TWTR\*\*4+2.42519\*TWTR\*\*5)-  
 0.0080956+PD(2)+TCPD(I,2)  
 QP(3)=-(-0.12167+1.31142\*TWTR\*\*3-6.31672\*TWTR\*\*4+8.03785\*TWTR\*\*5-3.15412\*TWTR\*\*6)+0.019325+PD(3)+TCPD(I,3)  
 QP(4)=-(-0.1548-0.41354\*TWTR\*\*5+0.25874\*TWTR\*\*7)+0.0197767+PD(4)+TCPD(I,4)  
 ELSE IF(TWTR.LT.0.88)THEN  
 QP(1)=0.224763-0.237056\*TWTR+PD(1)+TCPD(I,1)  
 QP(2)=0.190385-0.209676\*TWTR+0.00176\*(TWTR-0.7)/(0.88-0.7)+PD(2)+TCPD(I,2)  
 QP(3)=-0.052523+0.05309\*TWTR+PD(3)+TCPD(I,3)  
 QP(4)=-0.354571+0.38249\*TWTR+PD(4)+TCPD(I,4)  
 ELSE  
 QP(1)=0.968092-1.877574\*TWTR+0.904348\*TWTR\*\*2+PD(1)+TCPD(I,1)  
 QP(2)=-0.468266+1.148107\*TWTR-0.690132\*TWTR\*\*2+PD(2)+TCPD(I,2)  
 QP(3)=-0.850885+1.824094\*TWTR-0.981557\*TWTR\*\*2+PD(3)+TCPD(I,3)  
 QP(4)=-0.350767-1.093966\*TWTR+0.766972\*TWTR\*\*2+PD(4)+TCPD(I,4)  
 END IF  
 IF(PTR.LT.0.86)THEN  
 QP(J)=QP(J)+ADJTP(J)

ELSE

IF((ADJCP(J)-ADJTP(J)).NE.0D0)QP(J)=QP(J)+ADJTP(J)+((PTR-BPTR)/(1.-BPTR))\*\*4\*(ADJCP(J)-ADJTP(J))

END IF

QWTPNF(I, J) = QP(J) \* WTPNF(I) + QWTTIPSEE(I, J) + QWTPHH(I, J)

QWTPNF(I, 2) = QWTPNF(I, 2) + WTTIPSSR(I)

Where

ACW93 = Annual average OASDI covered wage for 1993  
AWC = Annual average OASDI covered wage for current year  
BACW93 = Annual average OASDI covered wage for 1993 from actual data used to determine taxable to covered wage equations  
I = Calendar year  
J = Quarter  
MAX = Annual OASDI taxable maximum  
NACW = Annual average OASDI covered wage for current year adjusted for average from actual data used to determine equations  
PD = Payday variable for private nonfarm based on calendar  
QP = Proportion of annual OASDI taxable private nonfarm wages excluding taxable tips paid in each quarter  
QWTPNF = Quarterly OASDI taxable private nonfarm wages including tips  
TCPD = Proportion of annual NIPA private wages paid in each quarter  
TWTR = Ratio of OASDI taxable to covered wages computed using equations based on data for 1993  
X = Ratio of annual OASDI taxable maximum to adjusted annual average OASDI covered wage (NACW)

#### Quarterly OASDI wage liabilities

WTLQPNF(I,J) = (QWTPNF(I,J) – QWTPHH(I,J)) \* TRW(I)

Where

QWTPHH = Quarterly OASDI taxable private household wages  
QWTPNF = Quarterly OASDI taxable private nonfarm wages including tips  
TRW = OASDI combined employee-employer tax rate  
WTLQPNF = Quarterly OASDI tax liabilities from taxable private nonfarm wages including tips, excluding private household taxable wages

#### Total quarterly OASDI taxable wages and wage liabilities

QWT(I,J) = QWTPNF(I,J) + QWTF(I,J) + QWTSL(I,J) + QWTFM(I,J)

WTLQ(I,J) = QWT(I,J) \* TRW(I)

Where

I = Calendar year  
J = Quarter  
QWT = Quarterly OASDI taxable wages  
QWTF = Quarterly OASDI taxable Federal wages  
QWTFM = Quarterly OASDI taxable farm wages  
QWTPNF = Quarterly OASDI taxable private nonfarm wages including tips  
QWTSL = Quarterly OASDI taxable State and Local wages  
WTLQ = Quarterly OASDI taxable wage liabilities

### 2-5.5 OASDI quarterly taxable wage liability collections (WTLQC)

#### OASDI taxable private nonfarm wages by sub-quarterly periods

PTR = WTP/WCP  
MR = MAR(I) - .04346\*(1.-PTR) + .08497\*(1.-PTR)\*\*2  
JR = JUN(I) - .02627\*(1.-PTR) - .26844\*(1.-PTR)\*\*2  
SR = SEP(I) - .12321\*(1.-PTR) - .02344\*(1.-PTR)\*\*2  
DR = DEC(I) - .12468\*(1.-PTR) - .20710\*(1.-PTR)\*\*2  
MWTP(1) = QWTP(I,1)\*MR  
MWTP(2) = QWTP(I,1) - MWTP(1)  
MWTP(3) = QWTP(I,2)\*JR  
MWTP(4) = QWTP(I,2) - MWTP(3)  
MWTP(5) = QWTP(I,3)\*SR  
MWTP(6) = QWTP(I,3) - MWTP(5)  
MWTP(7) = QWTP(I,4)\*DR  
MWTP(8) = QWTP(I,4) - MWTP(7)

Where

DEC = Proportion of fourth quarter OASDI covered private nonfarm wages (excluding tips and household) paid in December  
DR = Proportion of fourth quarter OASDI taxable private nonfarm wages (excluding tips and household) paid in December

I = Calendar year  
 JR = Proportion of second quarter OASDI taxable private nonfarm wages (excluding tips and household) paid in June  
 JUN = Proportion of second quarter OASDI covered private nonfarm wages (excluding tips and household) paid in June  
 MAR = Proportion of first quarter OASDI covered private nonfarm wages (excluding tips and household) paid in March  
 MR = Proportion of first quarter OASDI taxable private nonfarm wages (excluding tips and household) paid in March  
 MWTP = OASDI taxable private nonfarm wages (excluding tips and household) paid in last month and in first two months of quarter  
 PTR = Ratio of annual OASDI taxable private nonfarm wages (excluding tips and household) to covered private nonfarm wages  
 QWTP = Quarterly OASDI taxable private nonfarm wages (excluding tips and household)  
 SEP = Proportion of third quarter OASDI covered private nonfarm wages (excluding tips and household) paid in September  
 SR = Proportion of third quarter OASDI taxable private nonfarm wages (excluding tips and household) paid in September  
 WCP = Annual OASDI covered private nonfarm wages  
 WTP = Annual OASDI taxable private nonfarm wages (excluding tips and household)

**OASDI taxable private nonfarm wages collected on in same quarter wages are paid**

```

TRAT =RATEE(I,5)
CA =.95
MWCP(1)=QWSCPNT(I,1)*MAR(I)
MWCP(2)=QWSCPNT(I,1)-MWCP(1)
MWCP(3)=QWSCPNT(I,2)*JUN(I)
MWCP(4)=QWSCPNT(I,2)-MWCP(3)
MWCP(5)=QWSCPNT(I,3)*SEP(I)
MWCP(6)=QWSCPNT(I,3)-MWCP(5)
MWCP(7)=QWSCPNT(I,4)*DEC(I)
MWCP(8)=QWSCPNT(I,4)-MWCP(7)
RCSM =.80
QRMREQ=750.
QRWREQ=11250.
RMF=70786.*WSP(I)/1001400.
CALL ITERNU(QRMREQ,MWTP(2),MWCP(2),TRAT,RMF,PWCS(1))
CALL ITERNU(QRWREQ,MWTP(1),MWCP(1),TRAT,RMF,PWCE(1))
CALL ITERNU(QRMREQ,MWTP(4),MWCP(4),TRAT,RMF,PWCS(2))
CALL ITERNU(QRWREQ,MWTP(3),MWCP(3),TRAT,RMF,PWCE(2))
CALL ITERNU(QRMREQ,MWTP(6),MWCP(6),TRAT,RMF,PWCS(3))
CALL ITERNU(QRWREQ,MWTP(5),MWCP(5),TRAT,RMF,PWCE(3))
CALL ITERNU(QRMREQ,MWTP(8),MWCP(8),TRAT,RMF,PWCS(4))
CALL ITERNU(QRWREQ,MWTP(7),MWCP(7),TRAT,RMF,PWCE(4))
DO J=1,4
  QWTPC(I,J)=PWCS(J)+PWCE(J)*RCSM*CA
  QWTPF(I,J)=QWSTXPHH(I,J)-QWTPC(I,J)
END DO
  
```

Where

AWSCODXSRT = Annual average OASDI covered private nonfarm wages (excluding household)  
 CA = Compliance allowance  
 DEC = Proportion of fourth quarter OASDI covered private nonfarm wages (excluding tips and household) paid in December  
 I = Calendar year  
 J = Quarter  
 JUN = Proportion of second quarter OASDI covered private nonfarm wages (excluding tips and household) paid in June  
 MAR = Proportion of first quarter OASDI covered private nonfarm wages (excluding tips and household) paid in March  
 MWCP = OASDI covered private nonfarm wages paid in third month and in first two months of each quarter  
 MWTP = OASDI taxable private nonfarm wages paid in third month and in first two months of each quarter  
 PWCE = OASDI taxable private nonfarm wages paid in the third month of each quarter  
 PWCS = OASDI taxable private nonfarm wages paid in the first two months of each quarter on which taxes are collected in that quarter  
 QWSCPNT = Quarterly OASDI covered private nonfarm wages  
 QRMREQ = Monthly deposit requirement  
 QRWREQ = Quarterly deposit requirement  
 QWSTXPHH = Quarterly OASDI taxable private nonfarm wages (excluding household)  
 QWTPC = Quarterly OASDI taxable private nonfarm wages on which employers deposit taxes in the quarter the wages were paid  
 QWTPF = Quarterly OASDI taxable private nonfarm wages on which employers deposit taxes in the quarter after the wages were paid  
 RATEE(I,5) = OASDHI employee tax rate  
 RCSM = Proportion of OASDI taxable private nonfarm wages wages paid in same quarter in which taxes are collected  
 RMF = Current year average wage size of firm  
 SEP = Proportion of third quarter OASDI covered private nonfarm wages (excluding tips and household) paid in September

TRAT = OASDHI employee tax rate  
WSP = Economy-wide (NIPA) private wages

```

SUBROUTINE ITERNU(A11,QPAR,QTOT,T,RMF,AMTOUT)
R=QPAR/QTOT
X=A11/(T*2+.10)
DO
IWH=X*(.16011+.01998*LOG(X/RMF)-.01)
FWH=T*2.*X*((-1.4402*LOG(1+X/RMF)+1.)*(1.-R)+R)
A1=IWH+FWH
D=A1/A1
N1=D*1000.
IF(N1.EQ.999.OR.N1.EQ.1000)THEN
RTAX=R+(1.-R)*(-1.07115*X/RMF+.38633*(X/RMF)**2+1)
TOD=177.16+1142.7*DEXP(-(X/RMF))+1181.26*DEXP(-3.*(X/RMF))-907.88*DEXP(-4.*(X/RMF))+646.49*DEXP(-5.*(X/RMF))-
165.09*DEXP(-6.*(X/RMF))-20.92*X/RMF-2906.07/(X/RMF+1.)*2+831.44/(X/RMF+1.)*3
AMTOUT=QPAR-RTAX*TOD*QTOT
RETURN
END IF
X=X*D
END DO
END SUBROUTINE ITERNU

```

Where

A1 = Total (income plus FICA) taxes withheld  
A11 = Deposit requirement  
AMTOUT = OASDI taxable private nonfarm wages paid in sub-quarterly period and collected on in same quarter  
D = Ratio of deposit requirement to total taxes withheld  
FWH = FICA taxes withheld  
IWH = Income taxes withheld  
N1 = Ratio of deposit requirement to total taxes withheld times 1000 (used to see how close we are to target)  
QPAR = OASDI taxable private nonfarm wages paid in sub-quarterly period  
QTOT = OASDI covered private nonfarm wages paid in sub-quarterly period  
R = Initial ratio of OASDI taxable to covered private nonfarm wages paid in sub-quarterly period  
RMF = Current year average wage size of firm  
RTAX = Ratio of OASDI taxable to covered private nonfarm wages paid in sub-quarterly period  
T = OASDHI employee tax rate  
TOD = Proportion of liabilities to be deposited in quarter after that in which wages paid  
X = Taxable wage amount needed to meet deposit requirement

**OASDI taxable private wages collected on in same quarter wages paid and in following quarter**

QWTPCQ(I,J)=QWTPC(I,J)+QWTPHHCQ(I,J)+QWTFM(I,J)  
QWTPFQ(I,J)=QWTPF(I,J)+QWTPHFFQ(I,J)

**OASDI taxable State and Local wages collected on in same quarter wages paid and in following quarter**

```

SLTR=WTSL/WCSL
LMPW(1)=MARSL(I)-.00329*(1.-SLTR**2)
LMPW(2)=JUNSL(I)-.68187*(1.-SLTR**3)+.52206*(1.-SLTR**4)
LMPW(3)=SEPSL(I)-1.33596*(1.-SLTR)+1.51187*(1.-SLTR**2)-.63523*(1.-SLTR**3)
LMPW(4)=DECSL(I)-2.03892*(1.-SLTR)+1.90430*(1.-SLTR**2)-.6633*(1.-SLTR**3)
DO J=1,4
SLCR(J)=(1.-LMPW(J))+LMPW(J)*LMCRPR(I-16,J)
QWTS LC(I,J)=SLCR(J)*QWTS L(I,J)
QWTS LF(I,J)=QWTS L(I,J)-QWTS LC(I,J)
END DO

```

Where

DECSL = Proportion of OASDI taxable State and Local wages paid in fourth quarter which are paid in December  
I = Calendar year  
J = Quarter  
JUNSL = Proportion of OASDI taxable State and Local wages paid in second quarter which are paid in June  
LMCRPR = Proportion of OASDI taxable State and Local wages paid in final month of quarter on which employers are to deposit taxes in the same quarter  
LMPW = Proportion of quarterly OASDI taxable State and Local wages paid in final month of quarter  
MARSL = Proportion of OASDI taxable State and Local wages paid in first quarter which are paid in March  
QWTS L = Quarterly OASDI taxable State and Local wages paid in quarter  
QWTS LC = Quarterly OASDI taxable State and Local wages paid in quarter on which taxes are deposited by the employer in the same quarter



QWTSLF	=	Quarterly OASDI taxable State and Local wages paid in quarter on which taxes are deposited by the employer in the following quarter
SEPSL	=	Proportion of OASDI taxable State and Local wages paid in third quarter which are paid in September
SLCR	=	Proportion of OASDI taxable State and Local wages paid in quarter on which taxes are deposited by the employer in the same quarter
SLTR	=	Ratio of OASDI taxable to covered State and Local wages
WCSL	=	Annual OASDI covered State and Local wages
WTSL	=	Annual OASDI taxable State and Local wages

**OASDI taxable wages collected on in same quarter wages paid and in following quarter**

WTQCQ(I,J)= QWTPCQ(I,J)+ QWTSLC(I,J)+QWTF(I,J)  
 WTQFQ(I,J)= QWTPFQ(I,J)+ QWTSLF(I,J)

Where

I	=	Calendar year
J	=	Quarter
QWTF	=	Quarterly OASDI taxable Federal wages
QWTPCQ	=	Quarterly OASDI taxable private wages collected on in same quarter wages paid
QWTPFQ	=	Quarterly OASDI taxable private wages collected on quarter following that in which wages paid
QWTSLCQ	=	Quarterly OASDI taxable State and Local wages collected on in same quarter wages paid
QWTSLFQ	=	Quarterly OASDI taxable State and Local wages collected on in quarter following that in which wages paid
WTQCQ	=	Quarterly OASDI taxable wages collected on in same quarter wages paid
WTQFQ	=	Quarterly OASDI taxable wages collected on in quarter following that in which wages paid

**Quarterly OASDI wage tax collections**

WTLQC(I,1) = TRW(I-1) \* WTQFQ(I-1,4) + TRW(I) \* WTQCQ(I,J)  
 DO J = 2, 4

WTLQC(I,J) = TRW(I) \* (WTQFQ(I,J-1) + WTQCQ(I,J))  
 END DO

Where

I	=	Calendar year
J	=	Quarter
TRW	=	OASDI combined employee-employer tax rate
WTLQC	=	Quarterly OASDI wage tax collections
WTQCQ	=	Quarterly OASDI taxable wages collected on in same quarter wages paid
WTQFQ	=	Quarterly OASDI taxable wages collected on in quarter following that in which wages paid

**2-5.6 Quarterly Self-Employed Net Income Tax Collections (SELQC)**

DO J = 1, 4

SELQC(I,J) = SECRPY(I,J) \* SEL(I) + SECRPY(I,J) \* SEL(I-1)  
 END DO

Where

I	=	Calendar year
J	=	Quarter
SECRPY	=	Proportion of OASDI taxable self-employment earnings collected on in same year earned
SECRPY	=	Proportion of OASDI taxable self-employment earnings collected on in year following that in which earned
SEL	=	OASDI taxable self-employment earnings liabilities
SELQC	=	Quarterly OASDI self-employed net income tax collections

## *Appendix 2-2*

### *Economic Acronyms*

<b>AA</b>	Appropriation adjustments
<b>ACE</b>	Average OASDI covered earnings
<b>ACSE</b>	Average OASDI covered self-employed income
<b>ACW</b>	Average OASDI covered wage
<b>ACWC</b>	Average economy-wide wage
<b>ADJ_FSA_FC</b>	Adjustment to lower federal civilian covered wages relative to NIPA wages due to a presumed increase in the relative amount placed into an FSA
<b>AWFEFC_N</b>	Average wage for Federal civilian employees not covered under OASDI
<b>AWI</b>	Average wage index calculated by SSA; based on the average wage of all workers with wages from Forms W-2
<b>AWSE</b>	Economy-wide average wage
<b>AWSGEFC</b>	Average wage for the Federal government enterprises
<b>AWSGFC</b>	Average wage for the Federal civilian government
<b>AWSGFM</b>	Average wage for the military
<b>AWSGGEFC</b>	Average wage for the Federal government & government enterprises
<b>AWSGGESL</b>	Average wage for State and local government and government enterprises
<b>AWSP</b>	Average wages, private sector
<b>AWSPH</b>	Average wage in private household sector
<b>AWSPL</b>	Average wages, private sector, 2-year moving average
<b>AWSSP</b>	Average compensation, private sector
<b>AWSSPBNFXGE</b>	Average compensation, private nonfarm business, excluding government enterprises
<b>AWSSPES</b>	Average compensation, private sector, educational services
<b>AWSSPF</b>	Average compensation, private farm, wage workers
<b>AWSSPHS</b>	Average compensation, private sector, health services
<b>AWSSPL</b>	Lagged average compensation for private sector workers
<b>AWSSPSS</b>	Average compensation, private sector, social services
<b>AWSUI</b>	Average wage of workers under UI
<b>AWS_MEF</b>	Average wage for employees with any wages (covered and noncovered) posted to the MEF
<b>AYF</b>	Average proprietor income, private farm
<b>AYF_K</b>	Ratio of average self-employment income to average wage-worker compensation for the agriculture sector
<b>AYNF</b>	Average proprietor income, private nonfarm business
<b>AYNF_K</b>	Ratio of average self-employment income to average wage-worker compensation for the nonagriculture sector
<b>BEA</b>	The Bureau of Economic Analysis
<b>BLS</b>	The Bureau of Labor Statistics
<b>CFCGEFC</b>	Compensation of fixed capital, Federal government enterprises
<b>CFCGESL</b>	Government consumption of fixed capital, Government enterprises, State & local
<b>CFCGFC</b>	Compensation of fixed capital, Federal civilian

<b>CFCGFM</b>	Federal Government Consumption Expenditures, Defense Consumption Expenditures
<b>CFCGSL</b>	State & Local Government consumption expenditures, Gross output of general government, Value added, consumption of general government fixed capital
<b>CMB_TOT</b>	Workers that have a combination of both OASDI covered wages and self-employed income.
<b>CML</b>	Ratio of Federal military OASDI covered wages to NIPA wages
<b>COV</b>	Economic Sub-Process: Covered Employment and Earnings
<b>CP</b>	Ratio of Private OASDI Covered to NIPA wages; OASDI private coverage ratio
<b>CPI</b>	The Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W) is an official measure of inflation in consumer prices, published by the BLS.
<b>CPS</b>	Current Population Survey, conducted monthly by the Bureau of Census for the Bureau of Labor Statistics. It is the source of historical monthly economic data (such as labor force, civilian noninstitutional population, and unemployment) used to project US employment.
<b>CR_UI</b>	
<b>CRAZI</b>	Civilian pay raise
<b>CSE_TOT</b>	Total OASDI covered self-employed income
<b>CSLA</b>	Ratio of State and Local OASDI Covered to NIPA wages
<b>CSRS</b>	Civil Service Retirement System
<b>CSW</b>	Self-employed only workers (SEO) plus combination workers (CMB_TOT)
<b>DNEDMIL</b>	Decreases in the military population (as shown by the difference over four quarters)
<b>DRTP, DRTPP, DRTPN, DRTP1Q, DNRT1Q, DPRTP1Q</b>	Dummy variables for positive and negative economic cycle trends
<b>E</b>	Total employment, CPS concept (i.e., average of monthly estimates of total wage and salary workers, plus self-employed, plus unpaid family workers)
<b>E_FE</b>	Civilian employment level at full employment (i.e., at potential GDP)
<b>EA</b>	Total agricultural employment
<b>EAS</b>	Civilian Employment Level, Self-employed workers: agriculture, SA
<b>EAW</b>	Employment by class of worker, agricultural wage workers
<b>EDMIL</b>	Total number serving in the US Armed Forces estimated by the Department of Defense and published by the Census Bureau
<b>EGFC</b>	Federal civilian government employment
<b>EGEFCPS</b>	Employment, Establishment Data, All Employees: Government, Federal Government Enterprises, U.S. Postal Service

<b>EGGEFC</b>	Employment, Establishment Data, All Employees: Government, Federal Government, SA
<b>EGGESL</b>	Employment, State & Local government enterprises
<b>EMPTRDI</b>	DI employer tax rate
<b>EMPTRHI</b>	HI employer tax rate
<b>EMPTROASI</b>	OASI employer tax rate
<b>ENA</b>	Civilian Employment Level, Nonagricultural industries, 16 years and over, SA
<b>ENAS</b>	Employment by class of worker, nonagricultural self-employed
<b>ENAU</b>	Employment by class of worker, nonagricultural unpaid family workers
<b>ENAW</b>	Employment by class of worker, nonagricultural wage workers
<b>ENAWPBXGE</b>	Employment for private nonfarm business
<b>ENAWPH</b>	Employment by class of worker, nonagricultural wage workers, private household workers
<b>ENAWSPBXGE</b>	Employment for private nonfarm business and nonagricultural self-employed
<b>EO</b>	Total employment in the other-than-LPR population
<b>EO_A</b>	Total employment in the other-than-LPR population who are temporarily authorized to reside or work in the US
<b>EO_ESF</b>	Total employment in the other-than-LPR population whose reported earnings are posted to the Earnings Suspense File
<b>EO_MEF</b>	Total employment in the other-than-LPR population whose earnings are reported and posted to the Master Earnings File
<b>EO_MEFC</b>	Total employment in the other-than-LPR population whose earnings are reported and posted to the Master Earnings File and are OASDI-covered
<b>EO_NA</b>	Total employment in the other-than-LPR population who have overstayed their authorization
<b>EO_NO</b>	Total employment in the other-than-LPR population who were never authorized to reside or work in the US
<b>EO_UND</b>	Total employment in the other-than-LPR population that is strictly in the underground economy (i.e., with no earnings reported)
<b>EP</b>	Employees in Private industries
<b>EPES_EST</b>	Employees by industry, Private industries, Educational services
<b>EPHS_EST</b>	Employment for private health services
<b>EPSS_EST</b>	Employees by industry, Private industries, Social Assistance
<b>ES</b>	Self-employed workers
<b>ETP</b>	Effective annual taxable payroll, equal to total employer taxable OASDI wages plus total self-employed taxable income minus one half of the multi-employer refund wages
<b>EU</b>	Unpaid family workers
<b>EW</b>	Wage and salaried workers
<b>FERS</b>	Federal Employee Retirement System
<b>GDP</b>	Gross domestic product

<b>GDP05</b>	GDP, 2005\$
<b>GDPG</b>	GDP, General Government
<b>GDPGE</b>	GDP, Federal and State & local government enterprises
<b>GDPGEFC</b>	GDP, Federal civilian government enterprises
<b>GDPGESL</b>	GDP, State & local government enterprises
<b>GDPGF</b>	GDP, General Government, Federal
<b>GDPGFC</b>	GDP, Federal civilian
<b>GDPGFM</b>	GDP, military
<b>GDPGGE</b>	GDP, Federal and State & local government enterprises
<b>GDPGGEFC</b>	GDP, Federal civilian government and government enterprises
<b>GDPGGESL</b>	GDP, State & local government and government enterprises
<b>GDPGSL</b>	GDP, General Government, State & Local
<b>GDPPBNFXGE</b>	GDP, private nonfarm business, excluding government enterprises
<b>GDPPF</b>	GDP, private business sector, farm
<b>GDPPH</b>	GDP, Private Households
<b>GDPPNI</b>	GDP, Nonprofit institutions serving households
<b>HI</b>	Hospital insurance
<b>HIFC_L</b>	HI Employer Liability, Federal Civilian
<b>HIFM_L</b>	HI Employer Liability, Federal Military
<b>HIP_L</b>	HI Employer Liability, Private
<b>HISL_L</b>	HI Employer Liability, State & Local
<b>KGDP05</b>	Potential real GDP, 2005\$
<b>LC</b>	US labor force, equal to the sum of number of persons employed and number of persons seeking employment
<b>LFPR</b>	Labor force participation rate, defined as the ratio of the number of persons in the US labor force to the number of persons in the US noninstitutional population.
<b>M</b>	Military population
<b>MER</b>	Multi-employer refund wages
<b>MRAZ</b>	Military pay raise
<b>N</b>	Civilian noninstitutional population
<b>NCE</b>	Total noncovered employment
<b>NIPA</b>	The National Income and Product Accounts, published by the BEA, providing historical estimates of quarterly earnings and output measures
<b>NRA</b>	Normal retirement age
<b>OASDI</b>	Old-Age, Survivors, and Disability Insurance
<b>OASDIFC_L</b>	OASDI Employer Liability, Federal Civilian
<b>OASDIFM_L</b>	OASDI Employer Liability, Federal Military
<b>OASDIP_L</b>	OASDI Employer Liability, Private
<b>OASDISL_L</b>	OASDI Employer Liability, State & Local
<b>OASDHI</b>	Old-Age, Survivors, Disability, and Health Insurance
<b>OLI</b>	Employer contributions for employee pension and insurance funds
<b>OLI_CSRS1</b>	Contributions for CSRS employees' pay
<b>OLI_FC</b>	Other labor income, Federal civilian

<b>OLI_FERS1</b>	Contributions for FERS employees' pay
<b>OLI_FERSFC</b>	Employer contributions to Thrift Savings Plan for FERS employees
<b>OLI_GGE</b>	Other labor income, government and government enterprises
<b>OLI_GHI</b>	Other labor income by type, Employer contributions to pension and welfare funds, private welfare funds, Group health insurance
<b>OLI_GHI_FC</b>	Employer contributions for employee pension & insurance funds, group health insurance, Federal civilian government sector
<b>OLI_GHI_P</b>	Employer contributions for employee pension & insurance funds, group health insurance, private sector
<b>OLI_GHI_SL</b>	Employer contributions for employee pension & insurance funds, group health insurance, State & local government sector
<b>OLI_GLI</b>	Employer contributions for employee pension and insurance funds, Group life insurance
<b>OLI_GLI_FC</b>	Employer contributions for employee pension & insurance funds, group life insurance, Federal civilian government sector
<b>OLI_GLI_P</b>	Employer contributions for employee pension & insurance funds, group life insurance, private sector
<b>OLI_GLI_SL</b>	Employer contributions for employee pension & insurance funds, group life insurance, State & local government sector
<b>OLI_P</b>	Employer contributions for employee pension and insurance funds, private industries
<b>OLI_PPPS</b>	Other Labor Income, Private Sector Pension and Profit Sharing
<b>OLI_PPS</b>	Employer contributions for employee pension and insurance funds, Pension & profit-sharing
<b>OLI_RETFC</b>	Employer contributions for employee pension and insurance funds, Publicly administered government employee retirement plans, Federal civilian
<b>OLI_RETFM</b>	Employer contributions for employee pension and insurance funds, Publicly administered government employee retirement plans, Federal military
<b>OLI_RETSL</b>	Employer contributions for employee pension and insurance funds, Publicly administered government employee retirement plans, State and local
<b>OLI_SL</b>	Other labor income, State and local
<b>OLI_SU</b>	Employer contributions for employee pension and insurance funds, Supplemental unemployment
<b>OLI_WC</b>	Employer contributions for employee pension and insurance funds, Workers' compensation
<b>OLI_WCP</b>	Private employer contribution to other labor income, total for workers' compensation
<b>OLI_WCSL</b>	Employer contributions to workers' compensation, State and local
<b>OLIF_RETFCO</b>	Other government contributions to Federal civilian retirement
<b>OOH</b>	Owner-occupied housing
<b>OP</b>	Other-than-LPR population
<b>OP_A</b>	Other-than-LPR population who are temporarily authorized to reside or work in the US

<b>OP_NA</b>	Other-than-LPR population who have overstayed their authorization
<b>OP_NO</b>	Other-than-LPR population who were never authorized to reside or work in the US
<b>PGDP</b>	Gross Domestic Product Price Index, Units: 2005=100
<b>PGDPAF</b>	Deflator for farm output
<b>PIA</b>	Primary insurance amount
<b>PIARR</b>	PIA replacement rate, defined as the ratio of a hypothetical medium scale worker's PIA to his/her career average indexed earnings.
<b>PGDP</b>	GDP price deflator
<b>PBNFXGE</b>	Private nonfarm business excluding government enterprises
<b>RCMB</b>	Proportion of wage workers who are also self-employed (CMB_TOT/WSW)
<b>RCSE</b>	Covered self-employed ratio, defined as the ratio of total covered self-employment income to total proprietor income (CSE_TOT/Y).
<b>RCWSF</b>	Ratio of compensation to wages in the Federal government
<b>RCWSM</b>	Ratio of compensation to wages in the military
<b>RCWSP</b>	Ratio of compensation to wages in the private sector
<b>RCWSSL</b>	Ratio of compensation to wages in the State and local sector
<b>RD</b>	Disability prevalence ratio, defined as the ratio of disabled worker beneficiaries to the disability-insured population.
<b>RELMAX</b>	Ratio of the TAXMAX to averaged covered earnings
<b>RELMAX_UI</b>	Ratio of the aggregate weighted average of the UI taxable maximum to the average UI wage
<b>RET</b>	Earnings test ratio, defined the ratio of the maximum amount of earnings before an OASDI benefit is reduced to the average wage index.
<b>RFS</b>	Family size ratio, defined as the ratio of the number of children under 6 to mothers of a certain age.
<b>RGR_GHI</b>	
<b>RHIP_L</b>	Product of HI tax rate, private coverage ratio, and the taxable ratio
<b>RM</b>	Military ratio, the ratio of the US armed forces to the noninstitutionalized population.
<b>RMER</b>	Multi-employer refund wage ratio, defined as the ratio of multi-employer refund wages to total OASDI wages.
<b>ROASDIP_L</b>	Product of OASDI tax rate, private coverage ratio, and the taxable ratio
<b>ROLI_PPPS</b>	Ratio of employer contributions to private pension and profit-sharing to private wages
<b>ROLI_SU</b>	Ratio of private employer contributions for employee pension and insurance funds, Supplemental unemployment to private wages
<b>ROLI_WCP</b>	Ratio of private employer contribution to other labor income, total for workers' compensation to private wages
<b>RSET</b>	Self-employed net income taxable ratio, defined as the ratio of total self-employed taxable income to total OASDI wages.
<b>RSOC_UIP</b>	Ratio of private employer contributions to social insurance, total for unemployment insurance, to private wages
<b>RSOC_WCP</b>	Ratio of private employer contributions to social insurance, total for workers' compensation to private wages

<b>RSOCF_PBG</b>	Ratio of private employer insurance contribution to the Pension Benefit Guaranty Trust Corporation to private wages
<b>RSOCSL_WC</b>	Ratio of combined Private and State & local sector employer contributions to social insurance for workers' compensation to the combined Private and State and local sector employer contributions to workers' compensation
<b>RTE</b>	Ratio of total employment to the sum of wage & salary, self-employed workers, and the military ( $TE/(EW + ES + \text{military})$ )
<b>RTP</b>	A summary measure of the economic cycle equal to the ratio of real GDP to potential GDP
<b>RU</b>	Civilian unemployment rate defined as the ratio of the unemployed US labor force to the total US labor force
<b>RUIWS</b>	Effective tax rate for employer contributions to unemployment insurance
<b>RWCWS</b>	Effective tax rate for employer contributions to workers' compensation
<b>RWSC</b>	Covered wage ratio, defined as the ratio of OASDI covered wages to total wage and salary disbursements ( $WSC/WSD$ )
<b>RWSD</b>	Earnings ratio, defined as the ratio of total wage and salary disbursements to total wage and worker compensation ( $WSD/WSS$ )
<b>RWSSPBNFXGE</b>	Ratio of compensation to GDP in private business nonfarm excluding government enterprises
<b>RWSSY</b>	Total compensation ratio, defined as the ratio of total compensation to gross domestic product ( $WSSY/GDP$ )
<b>RWTEE</b>	Employee taxable ratio, defined as the ratio total employee OASDI taxable wages to total OASDI covered wages.
<b>RY</b>	Income ratio, defined as the percentage of total compensation attributable to proprietor income ( $Y/WSSY$ ).
<b>S&amp;L</b>	State and Local government
<b>SEL</b>	Self-employment tax liabilities
<b>SELQC</b>	Quarterly self-employed net income tax collections
<b>SEO</b>	Workers that report only OASDI covered self-employed earnings
<b>SEPR</b>	Self-employed participation rate (the proportion of employed persons that are self-employed)
<b>SET</b>	Total self-employed taxable income
<b>SOC</b>	Employer contributions for government social insurance
<b>SOC_FC</b>	Employer contributions for social insurance, Federal civilian sector
<b>SOC_FM</b>	Employer contributions for government social insurance, Federal government, military sector
<b>SOC_GGE</b>	Employer contributions for social insurance, government and government enterprises
<b>SOC_P</b>	Employer contributions for social insurance, private industries
<b>SOC_SL</b>	Employer contributions for social insurance, State and local sector
<b>SOC_UIP</b>	Private employer contributions to social insurance, total for unemployment insurance
<b>SOC_UISL</b>	State and local government employer contributions to social insurance,



	total for unemployment insurance
<b>SOC_WCP</b>	Private employer contributions to social insurance, total for workers' compensation
<b>SOC_WCSL</b>	State and Local government employer contributions to social insurance, total for workers' compensation
<b>SOCF_HI</b>	Contributions for Government Social Insurance, Employer Contributions, Federal Social Insurance Funds, Hospital Insurance
<b>SOCF_MIFM</b>	Contributions for Government Social Insurance, Employer Contributions, Federal Social Insurance Funds, Military Medical Insurance
<b>SOCF_OASDI</b>	Contributions for Government Social Insurance, Employer Contributions, Federal Social Insurance Funds, Old-age, Survivors, And Disability Insurance
<b>SOCF_PBG</b>	Contributions for Government Social Insurance, Employer Contributions, Federal Social Insurance Funds, Pension Benefit Guaranty
<b>SOCF_RETRR</b>	Contributions for Government Social Insurance, Employer Contributions, Federal Social Insurance Funds, Railroad Retirement
<b>SOCF_UIF</b>	Contributions for Government Social Insurance, Employer Contributions, Federal Social Insurance Funds, Federal Unemployment Tax
<b>SOCF_UIFC</b>	Total federal civilian government employer contributions to unemployment insurance
<b>SOCF_UIFED</b>	Contributions for Government Social Insurance, Employer Contributions, Federal Social Insurance Funds, Federal Employees' Unemployment Insurance
<b>SOCF_UIFM</b>	Total federal government employer contributions to unemployment insurance, military
<b>SOCF_UIS</b>	Contributions for Government Social Insurance, Employer Contributions, Federal Social Insurance Funds, State Unemployment Insurance
<b>SOCF_WC</b>	Contributions for Government Social Insurance, Employer Contributions, Federal Social Insurance Funds, Worker's Compensation
<b>SOC_SL_WC</b>	Contributions for Government Social Insurance, Employer Contributions, State and Local Social Insurance Funds, Workers' Compensation
<b>SSA</b>	Social Security Administration
<b>TAXMAX</b>	OASDI contribution and benefit base
<b>TAXPAY</b>	Economic Sub-Process: Taxable Payroll
<b>TCE</b>	Total OASDI covered employment
<b>TE</b>	Total "at any time" employment
<b>TEFC_N</b>	Total "at any time" employment, Federal civilian, without Federal civilian OASDI
<b>TEO</b>	Total "at any time" employment in the other-than-LPR population
<b>TEO_ESF</b>	Total "at any time" employment in the other-than-LPR population

<b>TEO_MEF</b>	whose reported earnings are posted to the Earnings Suspense File Total “at any time” employment in the other-than-LPR population whose earnings are reported and posted to the Master Earnings File
<b>TEO_MEFC</b>	Total “at any time” employment in the other-than-LPR population whose earnings are reported and posted to the Master Earnings File and are OASDI-covered
<b>TEO_UND</b>	Total “at any time” employment in the other-than-LPR population that is strictly in the underground economy (i.e., with no earnings reported)
<b>TMAXUI_SL</b>	Taxable maximum for State & local unemployment insurance
<b>TRSE</b>	OASDI self-employed tax rate
<b>TRW</b>	Combined OASDI employee-employer tax rate
<b>TXRP</b>	OASDI private taxable ratio
<b>U</b>	The number of persons in the labor force who are unemployed
<b>MODSOL2</b>	Economic Sub-Process: U.S. Earnings
<b>USEMP</b>	Economic Sub-Process: U.S. Employment
<b>WEFC_N</b>	Wages for Federal civilian employees not covered under OASDI
<b>WS</b>	Compensation of Employees, Wage and Salary Accruals
<b>WSC</b>	Total OASDI covered wages
<b>WSD</b>	Total wage and salary disbursements
<b>WSDP</b>	Private wage and salary disbursements
<b>WSGEFC</b>	Government Wages and Salaries, Federal civilian, Government Enterprises
<b>WSGFC</b>	Wage and salary accruals by industry, Government, Federal civilian
<b>WSGFM</b>	Wage and salary accruals by industry, Government, Federal, Military
<b>WSGGEFC</b>	Wages for the Federal government & government enterprises
<b>WSGGESL</b>	Wages for State and local government and government enterprises
<b>WSP</b>	Compensation of Employees, Wage and Salary Accruals
<b>WSPF</b>	Wage and salary accruals by industry, Private industries, Farms
<b>WSPH</b>	Wage and salary accruals by industry, Private industries, Households
<b>WSPNI</b>	Wage and salary accruals by industry, Private industries, Nonprofit institutions serving households
<b>WSPRRB</b>	Wages covered by Railroad Retirement Act
<b>WS_MEF</b>	Total wages posted to the MEF
<b>WSS</b>	Total wage worker compensation
<b>WSSG</b>	Compensation for Federal and State & local government
<b>WSSGE</b>	Compensation for Federal and State & local government enterprises
<b>WSSGEFC</b>	Compensation of employees by industry, Government, Federal
<b>WSSGESL</b>	Compensation of employees by industry, Government, State and local government enterprises
<b>WSSGF</b>	Federal Government Consumption Expenditures, Compensation of General Government Employees
<b>WSSGFC</b>	Compensation of employees by industry, Government, Federal civilian
<b>WSSGFM</b>	Compensation of employees by industry, Government, Military
<b>WSSGGE</b>	National Income w/o Capital Consumption Adjustment, Government

<b>WSSGGESL</b>	Compensation for the State & local government and government enterprises
<b>WSSGSL</b>	State & Local Government Consumption Expenditures, Compensation of General Government Employees
<b>WSSP</b>	Compensation of employees by industry, Private industries
<b>WSSPBNFXGE</b>	Compensation in private business nonfarm excluding government enterprises
<b>WSSPES</b>	Compensation of employees by industry, Private industries, Educational services
<b>WSSPF</b>	Compensation of employees by industry, Private industries, Farms
<b>WSSPH</b>	Compensation of employees by industry, Private industries, Households
<b>WSSPHS</b>	Compensation of employees by industry, Private industries, Health services
<b>WSSPNI</b>	Compensation of employees by industry, Private industries, Nonprofit institutions serving households
<b>WSSPSS</b>	Compensation of employees by industry, Private industries, Social assistance
<b>WSSY</b>	Total compensation for wage and salary workers and proprietors
<b>WSW</b>	Wage and salary workers that report some OASDI covered earnings
<b>WSW_MEF</b>	Total number of employees with any wages posted to the MEF
<b>WTEE</b>	Total employee OASDI taxable wages
<b>WTER</b>	Total employer OASDI taxable wages
<b>WTL</b>	Annual OASDI wage tax liabilities
<b>WTLQ</b>	Quarterly OASDI wage tax liabilities
<b>WTLQC</b>	Quarterly OASDI wage tax collections
<b>Y</b>	Total proprietor income
<b>YF</b>	National Income, Proprietors' income with Inventory Valuation (IVA) and Capital Consumption Adjustment (CCAdj): farm sector
<b>YNF</b>	National Income, Proprietors' income with IVA and CCAdj: nonfarm

# **Process 3:**

# **Beneficiaries**

### 3. Beneficiaries

OACT uses the Beneficiaries process to project the fully insured and disability insured population, the number of disabled workers and their dependent beneficiaries, the number of retired workers and their dependent beneficiaries, and the number of dependent beneficiaries of deceased workers. The Beneficiaries process receives input data from the Demography and Economics processes along with data received from the Social Security Administration and other government agencies. Output data is provided to the Economics and Trust Fund Operations and Actuarial Status processes.

The Beneficiaries Process is composed of three subprocesses: INSURED, DISABILITY, and OLD-AGE AND SURVIVORS. As a rough overview, INSURED projects the number of people in the Social Security area population that have sufficient work histories for disability and retirement benefit eligibility. DISABILITY projects the number of disabled workers and their dependent beneficiaries. OLD-AGE AND SURVIVORS projects the number of retired workers, their dependent beneficiaries, and the dependent beneficiaries of deceased workers.

All programs output data on an annual basis.

#### 3.1. INSURED

##### 3.1.a. Overview

Insured status is a critical requirement for a worker, who has participated in the covered economy, to receive Social Security benefits upon retirement or disability. The requirement for insured status depends on the age of a worker and his or her accumulation of quarters of coverage (QC).

INSURED is a simulation model that estimates the percentage of the population that is fully insured (FPRO) and disability insured (DPRO) throughout the projection period. These estimates are used in conjunction with estimates of the Social Security area population (SSAPOP) to estimate the number of people that are fully insured (FINPOP) and disability insured (DINPOP). FINPOP is then used by the OLD-AGE AND SURVIVORS INSURANCE subprocess, and both FINPOP and DINPOP are used by the DISABILITY subprocess. FINPOP and DINPOP are projected by age, sex, and cohort.

For each sex and birth cohort, INSURED simulates 30,000 work histories that represent the non-other-than-LPR (lawful permanent resident) immigration population (LEGPOP). These histories are constructed from past and projected cover worker rates of the non-other-than-LPR immigration population, median earnings, and amounts required for crediting QC.

The equations for this subprocess are given below:

$$\text{FPRO} = \text{FPRO}(\cdot) \tag{3.1.1}$$

$$\text{DPRO} = \text{DPRO}(\cdot) \quad (3.1.2)$$

$$\text{FINPOP} = \text{FPRO} * \text{SSAPOP} \quad (3.1.3)$$

$$\text{DINPOP} = \text{DPRO} * \text{SSAPOP} \quad (3.1.4)$$

### 3.1.b. *Input Data*

All data are updated annually, except those that are noted.

#### *Long-Range OCACT Data*

##### Demography

1. Social Security area population as end of year (1940 – 2095) by age (0 -100, age 100 including age 100 and older), marital status (single, married, widowed, divorced) and sex (M, F).
2. “Other-than-LPR immigrant” population as end of year (1963 – 2095) by age (0 -100, age 100 including age 100 and older) and sex (M, F).
3. Number of new “net LPR immigrants” (LPR immigrants – estimated legal emigrants) entering the Social Security area each year (1940 – 2095) by age (14 – 100, age 100 including age 100 and older) and sex (M, F).
4. The population granted deferred action for childhood arrivals (DACAs) as end of year (2012-2095) by age (0 -100, age 100 including age 100 and older) and sex (M, F).
5. The population granted deferred action for parental arrivals (DAPAs) as end of year (2016-2095) by age (0 -100, age 100 including age 100 and older) and sex (M, F).
6. The population that attain deferred action for childhood arrivals status (DACAATT) each year (2012-2095) by age (-1-100, age 100 including age 100 and older) and sex (M, F).
7. The population that attain deferred action for parental arrivals status (DAPAATT) each year (2016-2095) by age (-1-100, age 100 including age 100 and older) and sex (M, F).

##### Economics

8. Annual estimates of covered workers posted to the Master Earnings File (MEF) by sex (M, F) and age (0 – 100) for years (1937 – 2095).
9. Annual projection (2014 – 2095) of average wage index and median covered earnings.
10. “Other-than-LPR immigrant” workers with earnings posted to the (MEF) by sex (M, F), age (16 – 100), and for years (1964 – 2095).

##### Beneficiaries

11. Disabled-worker beneficiaries at year end (2016 – 2095) by age (15 – 66), sex (M, F) and duration (0 – 10, duration 10 including duration 10 and above) from the previous

year's Trustees Report. These data are read in from files that are generated annually from the Beneficiaries/DISABILITY (#3.2) area.

*Short-Range OCACT data*

12. FINPOP by age (14 – 95, age 95 including age 95 and older) and sex (M, F) from the end of year 1969 to the end of Short-Range projection period (2027) (EOY 1969-2030 is provided).
13. DINPOP by age (15 – 66) and sex (M, F) from the end of year 1969 to the end of Short-Range projection period (2027) (EOY 1969-2030 is provided).

*Other input data*

14. Historical series of annual median earnings of covered workers by age group (<20, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74, 75-79, 80-84) and sex (M, F) for years 1937-2014. Data are updated using the CWHS file from the mainframe.
15. Number of disabled workers by age (20-69) and sex (M, F) for years 1958-2016. Ages 66-69 are zeros. Data are updated using the data from the historical disability file "wkrben".
16. The amount required for crediting one quarter of coverage for years 1937-2014 from an OCACT web site.
17. Historical series of annual median earnings of all covered workers for years 1937-2014. Data are updated using the data in the most recent Social Security Annual Statistical Supplement Table 4.B6.
18. The number of all covered workers (wage/salary workers, self-employed workers) by sex and amount of earnings for 2014 in the most recent Social Security Annual Statistical Supplement Table 4.B7 & 4.B9. These are used to produce the input data for the distribution of earnings (FRACMOD.f90). **(No Change for the 2018 TR)**
19. ANNUAL factor (comparability factor between quarterly and annual reporting of earnings) by age (13-84) and sex (M, F) for years prior to 1978. **(No Change for the 2018 TR)**
20. SLCT factor (adjustment factor to bring simulated fully insured rate in line with historical fully insured rate) by age (13-84) and sex (M, F). These data were updated for the 2018 TR.
21. SRCH factor (adjustment factor to bring simulated fully insured rate in line with historical fully insured rate) by age (13-84) and sex (M, F). These data were updated for the 2018 TR.
22. DIADJ factor (adjustment factor to bring simulated disability insured rate in line with historical disability insured rate) by age (13-69) and sex (M, F). These data were updated for the 2018 TR.

**3.1.c. Development of Output**

*Equation 3.1.1 & 3.1.2 -*

## Determining the QC distribution

There are three variables playing important roles in the simulation process starting from age 13 through 84 of a birth cohort by sex. They include historical and projected covered worker rates of the non-other-than-LPR population<sup>1</sup> by age and sex, the amounts required for crediting QC, and a cumulative worker distribution by earnings level.

Covered worker rates of the non-other-than-LPR population (CPRO) are the ratio of the non-other-than-LPR covered workers to the non-other-than-LPR Social Security area population. A non-other-than-LPR population is its total population minus its other-than-LPR immigrant population. Historical and projected (total and other-than-LPR immigrant) numbers of covered workers and the Social Security area population, which are provided by the Economics and Demography sections respectively, are used to calculate the rates for ages 13 through 84.

The law specifies the amount of earnings needed to earn one QC for each year of the historical period. Its projection assumes the same growth rate as the Social Security average wage index.

The cumulative worker distribution by earnings level is 'FRAC'. It is a function of covered earnings relative to median earnings. For a given ratio of covered earnings relative to median earnings, FRAC returns the percentage of covered workers whose earnings relative to median earnings are less than the given ratio. It is constructed based on the latest historical data. It is used for each age and sex and is assumed to remain constant throughout the projection period. The program uses FRAC to estimate the percentage of covered workers that earn 0, 1, 2, 3 or 4 QC in a given year. Thus, for a particular age and sex, the percentage of covered workers earning at least  $n$  QC is defined as:

$$\text{QCDis}t = 1 - \text{FRAC} \left[ \frac{n * \text{QC amount}}{\text{median earnings}} \right], \quad \text{for } n = 1, 2, 3, 4$$

where *median earnings* is for that age and sex.

## Simulation process – assigning QC to records

Once the QCDis is known, the simulation process begins with 30,000 records for each sex and birth cohort. Starting with the QC distribution at age 13, INSURED randomly assigns a number of QC (1, 2, 3 or 4) to these records based on QCDis.

For ages 14 to 84, INSURED begins the simulation process by randomly selecting records to represent new net LPR immigrants and the other-than-LPR immigrant population that attain DACA status prior to 2018 from the covered worker portion of 30,000 records. For each record, a number of QC (0, 1, 2, 3 or 4) is assigned on a uniform basis. Once a record is assigned a number of QC, INSURED nullifies the previous earnings of the record. In 2013, the initial year of eligibility for DACAs, we assume that 10 percent of DACAs will retain covered earnings

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<sup>1</sup> The insured model treats those given legal work authorization through President Obama's 2012 immigration Deferred Action for Childhood Arrivals (DACA) program like LPR immigrants. For the 2018 Trustees Report, we assume the DACA program will not be renewed in 2018.



made prior to attaining LPR status.

After the records for new immigrants are selected, the rest of the records for ages 14 to 84 are either non-covered workers or covered workers. The total number of records assigned as non-covered workers is set equal to  $(1 - \text{covered worker rate}) * 30,000$ . These records receive no QC. To identify records as non-covered workers, INSURED uses two parameters (SRCH, SLCT), which vary by age and sex.

SRCH sets a limit on the number of consecutive records to be searched for a non-covered worker. In general, the younger age groups have lower SRCH values. SLCT is the number of consecutive prior years in which no QC were earned that is required in order for a simulated record to be assigned as a non-covered worker. Lower SLCT values are set for the very young age groups. Sensitivity analyses show that insured percentages are negatively correlated with these two parameters. When the female covered worker rates approach the male rates, the female SRCH and SLCT values are graded toward the male values<sup>2</sup>.

For each sex and birth cohort, the simulation process of assigning records as non-covered workers uses the following approach. This approach is repeated until the targeted number of non-covered workers is achieved.

1. One of the records, which is designated as one for LPR immigrants, is randomly selected as the starting record.
2. Beginning with the starting record, each record is examined until a record that matches the SLCT criterion is found.
3. However, if the number of records examined equals the value of SRCH and no record matches the SLCT criterion, then the record closest to the SLCT criterion is assigned no QC as a non-covered worker.

Initially, values for SRCH and SLCT are the same as those used in the prior Trustees Report. Adjustments to these values are only made when the results are not consistent with historical data.

The final step of the simulation process is to use QCDis to randomly assign QC of 0, 1, 2, 3 or 4 to the remaining covered worker records, which are not new net LPR immigrants, for ages 14-84.

### Determining Insured Status

Once the simulation process is complete, the insured status for each record at any age can be determined based on the total QC assigned up to that age. The simulated non-other-than-LPR fully insured percentage (FSIM\_LEG) is calculated as the percentage of the 30,000 simulated records meeting the QC requirements for insured status. The same calculation is applied to the

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<sup>2</sup> This occurs when the female covered worker rate is greater than 90 percent of the male rate. When the female rate is equal to or greater than the male rate, the female SLCT and SRCH parameters are set equal to the male parameters. The parameters are linearly interpolated when the female covered worker rate is between 90 and 100 percent of the male rate.

disability-insured percentage (DSIM\_LEG).

For each sex and cohort, FSIM\_LEG is determined at ages 13 to 84. DSIM\_LEG is determined at ages 13 to 69.

An adjustment, DINADD, is made to DSIM\_LEG. This additive adjustment accounts for workers who fail to meet the requirement for disability-insured status solely because of having no earnings while receiving disability benefits. INSURED assumes that workers who have been on the disability rolls for more than 3 years would be in this situation<sup>3</sup>. Thus, DINADD is

$$\frac{\text{\# of workers on the disability rolls more than 3 years}}{\text{Social Security Area population}} \quad \text{by age, sex, and cohort.}$$

A small proportion of the other-than-LPR immigrant population, OTLPOP, is added to calculate the simulated fully insured rate of the Social Security Area population, FSIM. We assume that other-than-LPR immigrants who have their earnings posted to the MEF (CW\_Other) are three-fourths as likely to be insured as the non-other-than-LPR population. We project FSIM as

$$\frac{FSIM\_LEG * (LEGPOP + ALPHA * (CW\_OTHER/CPRO))}{SSAPOP}$$

by age, sex, and cohort, where ALPHA is equal to 0.75.

Hence, the simulated fully insured rate of the other-than-LPR immigrant population FSIM\_OTL is

$$\frac{FSIM\_LEG * ALPHA * CW\_OTHER/CPRO}{OTLPOP}$$

by age, sex, and cohort.

FSIM\_LEG is assumed to remain the same beyond age 84. FSIM\_OTL is assumed to remain the same beyond age 69. For ages 70 and older, FSIM is projected by multiplying the non-other-than-LPR and other-than-LPR fully insured rates to their respective populations and dividing the sum by the Social Security Area population.

DSIM and DSIM\_OTL are projected in a similar manner by using DSIM\_LEG. If the simulated results for DSIM are not consistent with historical data, an additional age-sex-specific additive adjustment (DIADJ) is used to bring the simulated results in line with the historical estimates.

Finally, incorporation of Short-Range projections produces FPRO and DPRO. For the first 10

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<sup>3</sup> Those who are on the rolls for less than 4 years are assumed to meet the requirement for disability-insured status based on their earnings histories.

years, FPRO and DPRO are calculated by dividing the Short-Range estimates by the Social Security area population. The difference in terms of the percentage between the Long-Range (FSIM and DSIM) and Short-Range projections at the end of 10<sup>th</sup> year is linearly phased out during the next ten years by cohort and sex. The Long-Range projections are assumed thereafter.

#### Number of Fully Insured and Disability Insured Workers

The numbers of Fully Insured and Disability Insured workers are obtained by applying FPRO and DPRO, respectively, to the Social Security area population. The result is an estimate of the number of people that are fully insured (FINPOP) and disability insured (DINPOP) by single year of age and sex, respectively. For a given age and sex, the proportion of the Social Security area population that is insured (FPRO) is assumed to be the same for each marital status.

## 3.2. DISABILITY

### 3.2.a. Overview

The Social Security Administration pays monthly disability benefits to disability-insured workers who meet the definition of “disability”. If they meet certain requirements, spouses and children of disabled-worker beneficiaries may also receive monthly benefits.

DISABILITY projects the number of disabled-worker beneficiaries in current-payment status (DIB) at the end of each year by age at entitlement, sex, and duration from entitlement. We base the number of DIB at the end of each year on the number of disabled-worker beneficiaries who are currently entitled to benefits (CE). We calculate the number of CE at the end of year by adding the number of newly entitled CE (New Entitlements) during the year and subtracting the number of CE who leave the disability rolls (Exits) during the year to the number of CE at the end of the prior year. Disabled-worker beneficiaries who leave the disability rolls (Exits) do so by recovering from disabilities (Recoveries), by dying (Deaths), or by converting to retired worker status (Conversions). A disabled-worker beneficiary converts to retired worker status upon reaching Normal Retirement Age (NRA), the age at which a person first becomes entitled to unreduced retirement benefit.

DISABILITY also projects the number of future dependent beneficiaries of DIB by category, age, and sex. The six categories are minor child, student child, disabled adult child, young spouse, married aged spouse and divorced aged spouse. We generate the numbers of dependent beneficiaries of DIB by multiplying the relevant subset of the SSA area population (Exposures) by a series of probabilities that relate to the regulations and requirements for obtaining benefits (Linkages).

$$\text{New Entitlements}(\text{year}) = \text{Exposure}_{\text{BOY}} \times \text{Incidence Rate}(\text{year}) \quad (3.2.1)$$

where BOY is beginning of year.

$$\text{Exits}(\text{year}) = \text{Recoveries}(\text{year}) + \text{Deaths}(\text{year}) + \text{Conversions}(\text{year}) \quad (3.2.2)$$

where Recoveries(year) =  $\text{CE}_{\text{BOY}} \times \text{Recovery Rate}(\text{year})$   
where Deaths(year) =  $\text{CE}_{\text{BOY}} \times \text{Death Rate}(\text{year})$ .

$$\text{CE}_{\text{EOY}} = \text{CE}_{\text{EOY-1}} + \text{New Entitlements}(\text{year}) - \text{Exits}(\text{year}), \quad (3.2.3)$$

where EOY is end of year, EOY-1 is end of prior year.

$$\text{Dependent Beneficiaries of DIB}_{\text{EOY}} = \text{Exposures}_{\text{EOY}} \times \text{Linkages}_{\text{EOY}} \quad (3.2.4)$$

### 3.2.b. Input Data

#### *Trustees Assumptions*

Each year, the Trustees set the assumption for the ultimate incidence rates and the ultimate recovery rates for the twentieth year of the projection period. The following chart shows our targeted ultimate incidence rate by age group and sex. We further adjust these rates with a 0.6%

load for the removal of closure of the record and a 0.8% discount for the physician review requirement mandated by the Bipartisan Budget Act of 2015.

	Age Group										
	<20	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69
Male	2.46	2.58	1.66	2.49	3.34	4.52	5.96	9.89	15.72	19.02	9.00
Female	1.90	2.02	1.62	2.82	3.54	4.78	6.39	10.10	14.16	14.72	8.34

Using a standard population of disability insured who are not in current pay as of December 1999, the age-sex-adjusted incidence rate (on an entitlement rate basis) for the 2018 Trustees Report is 5.7 per 1,000. Using a standard population of DIBs as of December 1999, the age-sex-adjusted recovery rate (on an entitlement rate basis) for the 2018 Trustees Report is 9.3 per 1,000.

### *Long-Range OCACT Data*

All data is updated annually except those noted otherwise. Population data are as of December 31. We assume data as of December 31 of year  $z-1$  is equal to data as of January 1 of year  $z$ .

#### Demography

1. Social Security area population by age, sex, and marital status<sup>1</sup> (dimensioned (0:100,1:2,1:4)) for years 1970-2095.
2. Probabilities of death by sex, age and year (1:2,15:148,2016:2095).
3. Total children by sex of parent, age of parent and age of child (dimensioned (1:2,19:71,0:18)) for years 1970-2095.
4. Total married lives by age of husband crossed with age of wife (dimensioned (14:100,14:100)) for years 1970-2095.
5. Average number of children under 18 per couple with children by age group (<25, 25-29,...,60-64) of head of household (dimensioned (1:9)) for years 1970-2095.

#### Economics

6. Unemployment rates by age group (16-19, 20-24,...,60-64), sex and year (1990:2029).

#### Beneficiaries

INSURED subprocess #3.1

7. Disability-insured population by age, sex and year (15:69,1:2,1969:2095) from the 2018 Trustees Report.
8. Disability-insured population by age, sex and year (15:69,1:2,1969:2095) from the 2017 Trustees Report.
9. Fully insured population by age, sex and marital status (14:95,1:2,1:4) for years 1970-2095.
10. Lawful Permanent Resident (LPR) fully insured percentage by age, sex and year (15:69,1:2,1969:2095) from the 2018 Trustees Report

<sup>1</sup> Single, married, widowed, divorced.

2017 Trustees Report DISABILITY subprocess #3.2

11. Death rate projection factors from the 2017 Trustees Report by age group (15-19,20-24,...,60-64), sex and year (1:2,1:10,2017:2095).
12. Recovery rate projection factors and recovery rates from the 2017 Trustees Report by age group (15-19,20-24,...,60-64), sex and year (1:2,1:10,2017:2095) and (1:2,1:10,1970:2095), respectively.

*Other input data*

We update only the most recent year data annually for this category except as noted otherwise below:

13. The December 2017 data from the Master Beneficiary Record (MBR) containing the number of DIB by duration of entitlement, age of entitlement, sex and time of year (BOY or EOY) (0:55,15:66,1:2,1:2).
14. December 2017 and December 2016 data from the MBR containing the number of disabled workers in current-payment status by age, sex and year (15:66,1:2,1969:2017).
15. December 2017 data from the MBR containing the number of disabled workers in withheld or suspended status by age, sex and year (15:66,1:2,1969:2017).
16. December data from the MBR containing the number of dependent beneficiaries by age, sex of the account holder, and year for the following beneficiary categories.
  - Minor child (0:17,1:2,1970:2017)
  - Student child (18:21,1:2,1970:2017)
  - Disabled adult child (age group1:9<sup>2</sup>,1:2,1970:2017)
  - Young spouse (19:64,1:2,1970:2017)
  - Married aged spouse (62:100,1:2,1970:2017)
  - Divorced aged spouse (62:100,1:2,1970:2017)

We also read totals for each category.

17. December data from the MBR containing the number of DIB awards by age, sex and year (15:67,1:2,1970:2017).
18. December data from the MBR containing (1) the number of DIB total terminations (recoveries and deaths) and (2) the number of conversions<sup>3</sup>. These data are by sex and year (1:2,1970:2017).
19. December data from the MBR containing the number of DIB deaths by age, sex and year (15:67,1:2,1975:2017).
20. December data from the MBR containing the number of estimated DIB recoveries by age, sex and year (15:67,1:2,1975:2017).
21. December data from the MBR containing the number of old-age beneficiaries who at some point in time were converted to retired worker status. This data is by age, sex and year: (65:95+,1:2,1970:2017)
22. December data from the MBR containing the number of DIB entitled to the Hospital Insurance portion of Medicare by age group (<25,25-29,...,60-64,65+), sex and year

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<sup>2</sup> Age groups 1 through 9 are 18-19, 20-24, 25-29, ..., 55-59.

<sup>3</sup> Conversions are DIB beneficiaries who become eligible for old-age benefits due to reaching the normal retirement age.

- (2:11,1:2,1973:2017). This file is not used for the SOSI.
23. December data from the MBR containing the number of DIB awards by duration, age, sex and year (0:5,0:65,1:2,1993:2016). 2016 Awards were retrieved for this year's TR, 1993-2015 Awards have not been updated.
  24. Retroactive factors<sup>4</sup> by year (1969:2016). These values are estimated using OCACT beneficiary data. This file is not used for the SOSI.

All numbers in the following categories are updated annually unless otherwise noted.

25. Average incidence rates by age and sex (15:65,1:2) for the base period 2002-2011 based on awards data from 2002-2016 (also known as the base incidence rates). We update these values when time and data are available. Note that rates for ages 60 through NRA are from the 2011 TR.
26. Probability of death for DIB's – in a multiple-decrement environment by duration, age and sex (0:10,15:65,1:2) for the base period 2006-2010. These numbers (also known as the base probabilities of death) are from Actuarial Study No. 123. We update these values when time and data are available.
27. Probability of recovery for DIB's – in a multiple-decrement environment by duration, age and sex (0:10,15:65,1:2) for the base period 2006-2010. These numbers (also known as the base probabilities of recovery) are from Actuarial Study No. 123. We update these values when time and data are available.
28. Initial Incurred but not reported (IBNR)<sup>5</sup> factors by duration, age and sex (0:10, 15:69, 1:2) based on 2002 entitlements (awards data from 2002-2007). (Not Updated)
29. Ultimate IBNR factors by duration, age and sex (0:10, 15:69, 1:2) based on 2002-2011 entitlements (awards data from 2002-2016). We update these values when time and data are available. The IBNR calculation linearly grades between the initial and ultimate IBNR factors during the ten years from 2008-2017. The ultimate IBNR factor table applies for all years after 2017.
30. For each year 2000-2105, (1) the Normal Retirement Age (NRA), (2) the proportion of DIBs who stay on the DI roll for that age, and (3) the proportion of DIBs who convert to an old-age benefit during that year for that age. We update these values only when there is a change in the NRA or in the present law.
31. The following linkages for the calculations of auxiliary beneficiaries; the probability that student is in an eligible school, the probability that adult child is disabled, the probability that beneficiary is not subject to the earnings test, and the probability that beneficiary was married 10 or more years are estimated and are updated when time and data are available.
32. Short-Range/Long-Range adjustment (APROJ) factors by auxiliary beneficiary category (1:7) for years 2018-2095. These seven categories are; minor child, student child, disabled adult child, young wife, young husband, age wife and aged husband. We calculate these values by comparing Short-Range and Long- Range numbers for auxiliary beneficiaries.

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<sup>4</sup> Retroactive factors for each calendar year are the ratio of the total monthly payments to DIBs to the monthly DIBs in current payment status times the average DIB monthly benefit.

<sup>5</sup> IBNR factors reflect the proportion of DIBs entitled to benefits who have been awarded since the year of their entitlement.

33. IPROJG, DPROJG and RPROJG adjustment factors used to adjust incidence, death and recovery rates to reconcile between the long-range model and the short-range model. IPROJG (1:11, 2, 2018-2095) and DPROJG (1:10, 2, 2018-2095) adjustment factors are by age group, sex and year. RPROJG (2, 2018-2027) adjustment factors are by sex and year.
34. Ultimate RPROJG values by sex and age group (1:2, 1:10) calculated to reach a target value. We update these values when the probabilities of recovery for DIB's are updated.

### **3.2.c. Development of Output**

#### *Equation 3.2.1 – New Entitlements*

We calculate new entitlements by multiplying age-sex-specific incidence rates to the exposed population at the beginning of the year. The exposed population is the disability-insured population less the currently entitled population. We calculate future age-sex-specific incidence rates by multiplying the base incidence rates by the incidence rate projection factors (IPROJGs). For the first ten years of the projection (short-range period), IPROJGs by 5-year age group and sex are obtained by using regression equations with the change in unemployment in the two prior years as the independent variables. We describe the regression equations in detail in Appendix 3.2-1. Then, we run the IPROJGs through the main model and analyze the resulting incidence rates by age group and sex. We adjust the IPROJGs by age and sex to reach “target” incidence rates in the twentieth year of the projection period. These “target” incidence rates were determined based on a recent review of historical and projected award rates by age group and sex. For projection periods between the tenth and twentieth years, we linearly interpolate the IPROJGs between the ultimate IPROJGs values and the IPROJGs values at the end of short-range period. Additional adjustments to the IPROJGs during the short-range period may be necessary for reconciliation between the long-range model and the short-range model. For the 2018 Trustees Report, we made IPROJG adjustments in the short-range period to better project the higher claims expected due to the hiring of more Administrative Law Judges (ALJs) and the backlog of pending ALJ claims.

#### *Equation 3.2.2 – Exits*

The long-range model projects three types of exits from the disability rolls; death, recovery and conversion to an old-age beneficiary upon reaching normal retirement age (NRA). Deaths and recoveries are projected by multiplying the beginning currently entitled population by the probabilities of death only and recovery only,  $(q_x^{(d)})$  and  $(q_x^{(r)})$ , respectively. Projected  $(q_x^{(d)})$  and  $(q_x^{(r)})$  by age, sex, and duration are calculated by multiplying the base probabilities by the respective projection factors by age group and sex for that year.

For the first ten years, we derive the recovery projection factors (RPROJGs) by age group and sex from linear interpolation between an estimated starting level for the RPROJGs and an estimated tenth-year projection target level for the RPROJGs. For each age group and sex, we calculate the starting RPROJGs the following way:



$$\text{RPROJG}^{\text{TR18}}(2017) = \text{RPROJG}^{\text{TR17}}(2017) \times \text{actual recovery rate}(2017) / \text{estimated recovery rate}^{\text{TR17}}(2017)$$

Because there is no apparent upward or downward trend, we use the average recovery rates for the last ten historical years as the target values for the 10<sup>th</sup> year (2027). Then, for each age group and sex, we calculate the tenth year's RPROJGs as follows:

$$\text{RPROJG}^{\text{TR18}}(2027) = \text{RPROJG}^{\text{TR18}}(2017) \times \text{target value recovery rate}(2027) / \text{actual recovery rate}(2017)$$

For the second 10 years of the projection period, we linearly interpolate between the ultimate RPROJG value and the RPROJG value at the end of short-range period (2027). We assume attainment of ultimate recovery rates in the twentieth year of the projection period. Ultimate recovery rates by age group and sex are determined by analyzing historical recovery rates. We may make additional adjustments to the RPROJGs to reconcile with the short-range model.

For the first year of the projection period, the death projection factors (DPROJGs) by age group and sex are determined so that they achieve a targeted death rate. The targeted death rate is determined by fitting an exponential curve to historical death rates for DIBs by age group and sex (see Appendix 3.2-1). For the rest of the projection period, we assume the DPROJGs improve at the same rate as the general population for that age group and sex. We calculate the DPROJGs for each year by 5-year age group and sex the following way:

$$\text{DPROJG}(\text{year}) = \text{DPROJG}(\text{year}-1) \times \left( \frac{\sum_{\text{age}=x}^{x+4} \text{year} \times \text{DIB}_{\text{age}}^{1999}}{\sum_{\text{age}=x}^{x+4} \text{year}-1 \times \text{DIB}_{\text{age}}^{1999}} \right)$$

*Equation 3.2.3 – Disabled-Worker Beneficiaries*

The projection begins with the latest data available from the mainframe of disabled-worker beneficiaries in current-payment status. This data is from a 100 percent sample of the Master Beneficiary Record (MBR) at the end of the year. We split up disabled-worker beneficiaries by age at entitlement, sex and duration of entitlement. We convert this population to a currently entitled population by dividing each age, sex and duration cell by the appropriate duration-age-sex-year-specific IBNR factor. An iterative process begins with new entitlements added to and exits subtracted from the previous year's currently entitled population to get the following year's currently entitled population with advancement of duration within the age of entitlement. We reduce this currently entitled population by multiplying by the appropriate duration-age-sex-year-specific IBNR factor. The result is the following year's disabled-worker beneficiaries in current-payment status. The process repeats over each sex, age of entitlement and duration of entitlement throughout the projection period.

*Equation 3.2.4 – Dependent Beneficiary of Disabled Workers*

There are six dependent-beneficiary categories; minor child, student child, disabled adult child,

young spouse, married aged spouse and divorced aged spouse. We disaggregate projections by age of the beneficiary and sex of the account holder. We detail below the linkages and exposures used in each category of dependent beneficiaries.

#### Minor Child

Exposure:	Single SSA population by single ages 0-17	
Linkages:	pMCAGA	= Probability that parent is under NRA
	pMCDIA	= Probability that parent is disability insured given that the parent is under NRA
	pMCDPA	= Probability that disability insured parent under NRA is disabled
	MCRES	= Residual Factor

#### Student Child

Exposure:	Single SSA population by single ages 18-19	
Linkages:	pSCAGA	= Probability that parent is under NRA
	pSCDIA	= Probability that parent is disability insured given that the parent is under NRA
	pSCDPA	= Probability that disability insured parent under NRA is disabled
	pSCDPC	= Probability that student is in an eligible school
	SCRES	= Residual Factor

#### Disabled Adult Child

Exposure:	Total SSA population by age groups 18-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59	
Linkages:	pDCAGA	= Probability that parent is under NRA
	pDCDIA	= Probability that parent is disability insured given that the parent is under NRA
	pDCDPA	= Probability that disability insured parent under NRA is disabled
	pDCDPC	= Probability that adult child is disabled
	DCRES	= Residual Factor

#### Young Spouse

Exposure:	Married SSA population by sex and by single ages 20-64	
Linkages:	pYSAGA	= Probability that account holder is under NRA
	pYSDIA	= Probability that account holder is disability insured given that the account holder is under NRA
	pYSDPA	= Probability that disability insured account holder under NRA is disabled
	pYSETB	= Probability that young spouse is not subject to earnings test
	pYSMCB	= Probability that young spouse has a minor child beneficiary in his/her care
	pYSDCB	= Probability that young spouse has a disabled child beneficiary in his/her care
	YSRES	= Residual Factor

### Married Aged Spouse

Exposure: Married SSA population by sex and by single ages 62-100

Linkages: pMSAGA	= Probability that account holder is under NRA
pMSDIA	= Probability that account holder is disability insured given that the account holder is under NRA
pMSDPA	= Probability that disability insured account holder under NRA is disabled
pMSFIB	= Probability that beneficiary is not insured
MSRES	= Residual Factor

### Divorced Aged Spouse

Exposure: Divorced SSA population by sex and by single ages 62-100

Linkages: pDSDEA	= Probability that account holder is living
pDSAGA	= Probability that account holder is under NRA
pDSDIA	= Probability that account holder is disability insured given that the account holder is under NRA
pDSDPA	= Probability that disability insured account holder under NRA is disabled
pDSFIB	= Probability that beneficiary is not insured
pDSDMB	= Probability that beneficiary was married 10 or more years

We estimate the residual factors for each of the dependent categories using a 10-year Least Squares regression formula. We then hold these residual factor values constant for the duration of the long-range period. If the 10-year Least Squares method results in a negative residual factor, we hold the last historical residual factor instead.

We develop factors for a dependent beneficiary category to match short-range results during the first 10 years of the projection period. We phase these factors out linearly over the second ten years of the projection period.

### ***Appendix: 3.2-1***

The following information provides details about the regression equations used in determining incidence rates and IPROJG values by age group and sex for the first ten years of the projection period.

**Male**

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 16-19  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 16-19  
Dependent Variable: 15-19 incidence rates  
Observation Period: 1994-2014  
Adjusted R square: 0.13890330  
Standard Deviation: 0.54523436  
Coefficient Intercept: 2.24942170  
Coefficient Slope1: 0.11890705  
Coefficient Slope2: 0.01048405

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 20-24  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 20-24  
Dependent Variable: 20-24 incidence rates  
Observation Period: 1994-2014  
Adjusted R square: 0.32114501  
Standard Deviation: 0.35797768  
Coefficient Intercept: 2.22024474  
Coefficient Slope1: 0.14246116  
Coefficient Slope2: 0.03351166

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 25-29  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 25-29  
Dependent Variable: 25-29 incidence rates  
Observation Period: 1994-2014  
Adjusted R square: 0.58760904  
Standard Deviation: 0.18177401  
Coefficient Intercept: 1.97591901  
Coefficient Slope1: 0.10822941  
Coefficient Slope2: 0.07958108

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 30-34  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 30-34  
Dependent Variable: 30-34 incidence rates

Observation Period: 1994-2014  
Adjusted R square: 0.22371150  
Standard Deviation: 0.25098857  
Coefficient Intercept: 2.46211089  
Coefficient Slope1: 0.07815206  
Coefficient Slope2: 0.06362436

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 35-39  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 35-39  
Dependent Variable: 35-39 incidence rates  
Observation Period: 1994-2014  
Adjusted R square: 0.26443907  
Standard Deviation: 0.34339257  
Coefficient Intercept: 3.22204844  
Coefficient Slope1: 0.13221066  
Coefficient Slope2: 0.10894175

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 40-44  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 40-44  
Dependent Variable: 40-44 incidence rates  
Observation Period: 1994-2014  
Adjusted R square: 0.41012944  
Standard Deviation: 0.39823705  
Coefficient Intercept: 4.29221360  
Coefficient Slope1: 0.20042328  
Coefficient Slope2: 0.17213367

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 45-49  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 45-49  
Dependent Variable: 45-49 incidence rates  
Observation Period: 1994-2014  
Adjusted R square: 0.50085439  
Standard Deviation: 0.45699057  
Coefficient Intercept: 5.79835494  
Coefficient Slope1: 0.26305305  
Coefficient Slope2: 0.24651573

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 50-54  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 50-54  
Dependent Variable: 50-54 incidence rates  
Observation Period: 1994-2014

Adjusted R square: 0.45160250  
Standard Deviation: 0.68911547  
Coefficient Intercept: 9.72847499  
Coefficient Slope1: 0.24157191  
Coefficient Slope2: 0.45105094

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 55-59  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 55-59  
Dependent Variable: 55-59 incidence rates  
Observation Period: 1994-2014  
Adjusted R square: 0.29864022  
Standard Deviation: 0.93229099  
Coefficient Intercept: 15.90670231  
Coefficient Slope1: 0.24102021  
Coefficient Slope2: 0.56048713

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 60-64  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 60-64  
Dependent Variable: 60-64 incidence rates  
Observation Period: 1994-2014  
Adjusted R square: 0.19565793  
Standard Deviation: 0.81586763  
Coefficient Intercept: 16.52909162  
Coefficient Slope1: 0.19945944  
Coefficient Slope2: 0.34034827

### **Female**

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 16-19  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 16-19  
Dependent Variable: 15-19 incidence rates  
Observation Period: 1994-2014  
Adjusted R square: 0.13608134  
Standard Deviation: 0.37064810  
Coefficient Intercept: 1.52576133  
Coefficient Slope1: 0.09410038  
Coefficient Slope2: 0.03561926

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 20-24  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 20-24  
Dependent Variable: 20-24 incidence rates  
Observation Period: 1994-2014

Adjusted R square: 0.24797118  
Standard Deviation: 0.30443749  
Coefficient Intercept: 1.65662497  
Coefficient Slope1: 0.16038769  
Coefficient Slope2: 0.03651247

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 25-29  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 25-29  
Dependent Variable: 25-29 incidence rates  
Observation Period: 1994-2014  
Adjusted R square: 0.50250126  
Standard Deviation: 0.23253316  
Coefficient Intercept: 1.83610381  
Coefficient Slope1: 0.17741730  
Coefficient Slope2: 0.11298042

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 30-34  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 30-34  
Dependent Variable: 30-34 incidence rates  
Observation Period: 1994-2014  
Adjusted R square: 0.55047181  
Standard Deviation: 0.24239133  
Coefficient Intercept: 2.57873693  
Coefficient Slope1: 0.18638170  
Coefficient Slope2: 0.20010263

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 35-39  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 35-39  
Dependent Variable: 35-39 incidence rates  
Observation Period: 1994-2014  
Adjusted R square: 0.61272791  
Standard Deviation: 0.29105549  
Coefficient Intercept: 3.65339331  
Coefficient Slope1: 0.31719511  
Coefficient Slope2: 0.20525313

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 40-44  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 40-44  
Dependent Variable: 40-44 incidence rates  
Observation Period: 1994-2014  
Adjusted R square: 0.42805945

Standard Deviation: 0.43112989  
Coefficient Intercept: 4.93809714  
Coefficient Slope1: 0.32599935  
Coefficient Slope2: 0.28323424

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 45-49  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 45-49  
Dependent Variable: 45-49 incidence rates  
Observation Period: 1994-2014  
Adjusted R square: 0.65010281  
Standard Deviation: 0.38283565  
Coefficient Intercept: 6.41648225  
Coefficient Slope1: 0.48378765  
Coefficient Slope2: 0.40856932

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 50-54  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 50-54  
Dependent Variable: 50-54 incidence rates  
Observation Period: 1994-2014  
Adjusted R square: 0.57079569  
Standard Deviation: 0.46847618  
Coefficient Intercept: 10.10007006  
Coefficient Slope1: 0.24595968  
Coefficient Slope2: 0.66545870

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 55-59  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 55-59  
Dependent Variable: 55-59 incidence rates  
Observation Period: 1994-2014  
Adjusted R square: 0.22687292  
Standard Deviation: 0.64098345  
Coefficient Intercept: 14.54268214  
Coefficient Slope1: -0.04846018  
Coefficient Slope2: 0.66846331

Independent Variable: Unemp Rate(t)-Unemp Rate(t-1) for ages 60-64  
Independent Variable: Unemp Rate(t-1)-Unemp Rate(t-2) for ages 60-64  
Dependent Variable: 60-64 incidence rates  
Observation Period: 1994-2014  
Adjusted R square: 0.37353160  
Standard Deviation: 0.46673583



Coefficient Intercept: 13.08336151  
Coefficient Slope1: 0.19804129  
Coefficient Slope2: 0.43090817

The following information provides details about the exponentially fitted equations used in determining death rates by age group and sex for the first year of the projection period.

**Male**

Independent Variable: Year  
Independent Variable: 15-19 death rates  
Observation Period: 2008-2017  
Adjusted R square: -0.12388  
Standard Deviation: 1.00096  
Coefficient Intercept: -17.43399  
Coefficient Slope1: 0.00982

Independent Variable: Year  
Independent Variable: 20-24 death rates  
Observation Period: 2008-2017  
Adjusted R square: 0.04965  
Standard Deviation: 0.10108  
Coefficient Intercept: -24.61933  
Coefficient Slope1: 0.01349

Independent Variable: Year  
Independent Variable: 25-29 death rates  
Observation Period: 2008-2017  
Adjusted R square: -0.09382  
Standard Deviation: 0.06217  
Coefficient Intercept: 8.94347  
Coefficient Slope1: -0.00327

Independent Variable: Year  
Independent Variable: 30-34 death rates  
Observation Period: 2008-2017  
Adjusted R square: -0.05483  
Standard Deviation: 0.02622  
Coefficient Intercept: 6.72864  
Coefficient Slope1: -0.00211

Independent Variable: Year

Independent Variable: 35-39 death rates  
Observation Period: 2008-2017  
Adjusted R square: 0.64192  
Standard Deviation: 0.02404  
Coefficient Intercept: 24.74669  
Coefficient Slope1: -0.01095

Independent Variable: Year  
Independent Variable: 40-44 death rates  
Observation Period: 2008-2017  
Adjusted R square: 0.38321  
Standard Deviation: 0.02734  
Coefficient Intercept: 18.48749  
Coefficient Slope1: -0.00773

Independent Variable: Year  
Independent Variable: 45-49 death rates  
Observation Period: 2008-2017  
Adjusted R square: 0.75328  
Standard Deviation: 0.01979  
Coefficient Intercept: 26.58237  
Coefficient Slope1: -0.01162

Independent Variable: Year  
Independent Variable: 50-54 death rates  
Observation Period: 2008-2017  
Adjusted R square: 0.87501  
Standard Deviation: 0.01576  
Coefficient Intercept: 31.34491  
Coefficient Slope1: -0.01388

Independent Variable: Year  
Independent Variable: 55-59 death rates  
Observation Period: 2008-2017  
Adjusted R square: 0.94779  
Standard Deviation: 0.00870  
Coefficient Intercept: 28.29733  
Coefficient Slope1: -0.01228

Independent Variable: Year  
Independent Variable: 60-64 death rates

Observation Period: 2008-2017  
Adjusted R square: 0.44490  
Standard Deviation: 0.01354  
Coefficient Intercept: 12.30082  
Coefficient Slope1: -0.00427

**Female**

Independent Variable: Year  
Independent Variable: 15-19 death rates  
Observation Period: 2008-2017  
Adjusted R square: -0.12413  
Standard Deviation: 1.17362  
Coefficient Intercept: -18.00934  
Coefficient Slope1: 0.01019

Independent Variable: Year  
Independent Variable: 20-24 death rates  
Observation Period: 2008-2017  
Adjusted R square: 0.24246  
Standard Deviation: 0.10900  
Coefficient Intercept: -45.06144  
Coefficient Slope1: 0.02364

Independent Variable: Year  
Independent Variable: 25-29 death rates  
Observation Period: 2008-2017  
Adjusted R square: 0.11478  
Standard Deviation: 0.06852  
Coefficient Intercept: -20.02456  
Coefficient Slope1: 0.01110

Independent Variable: Year  
Independent Variable: 30-34 death rates  
Observation Period: 2008-2017  
Adjusted R square: 0.63036  
Standard Deviation: 0.03076  
Coefficient Intercept: -25.13135  
Coefficient Slope1: 0.01369

Independent Variable: Year  
Independent Variable: 35-39 death rates

Observation Period: 2008-2017  
Adjusted R square: -0.06603  
Standard Deviation: 0.01492  
Coefficient Intercept: 0.38248  
Coefficient Slope1: 0.00109

Independent Variable: Year  
Independent Variable: 40-44 death rates  
Observation Period: 2008-2017  
Adjusted R square: 0.27781  
Standard Deviation: 0.02117  
Coefficient Intercept: 12.66352  
Coefficient Slope1: -0.00492

Independent Variable: Year  
Independent Variable: 45-49 death rates  
Observation Period: 2008-2017  
Adjusted R square: 0.61737  
Standard Deviation: 0.02116  
Coefficient Intercept: 21.41514  
Coefficient Slope1: -0.00918

Independent Variable: Year  
Independent Variable: 50-54 death rates  
Observation Period: 2008-2017  
Adjusted R square: 0.87917  
Standard Deviation: 0.01215  
Coefficient Intercept: 25.05955  
Coefficient Slope1: -0.01091

Independent Variable: Year  
Independent Variable: 55-59 death rates  
Observation Period: 2008-2017  
Adjusted R square: 0.80381  
Standard Deviation: 0.01272  
Coefficient Intercept: 20.56324  
Coefficient Slope1: -0.00862

Independent Variable: Year  
Independent Variable: 60-64 death rates  
Observation Period: 2008-2017

Adjusted R square: 0.81403  
Standard Deviation: 0.01471  
Coefficient Intercept: 24.07083  
Coefficient Slope1: -0.01029

### 3.3. Old-Age and Survivors Insurance

#### 3.3.a. Overview

Every month, the Social Security program pays benefits to retired workers and their dependents. It also provides benefits to eligible dependents of deceased workers. The OLD-AGE AND SURVIVORS subprocess projects the number of people expected to receive benefits over the next 75 years. The projection method is very similar to the method used for dependent beneficiaries of disabled workers in the DISABILITY subprocess. We compute the projection of beneficiaries by multiplying a subset of the Social Security area population by a series of probabilities of the conditions that a person must meet to receive benefits. The main program receives all necessary input data and performs all preliminary calculations. It then calls each individual beneficiary type subroutine where it makes all beneficiary calculations.

We categorize retired workers and their dependent beneficiaries as follows:

- retired workers (*RWN*) by age (62-95+), sex, and marital status (single, married, widowed, divorced)
- aged spouses of retired workers (*ASRWN*), by age (62-95+), sex of the account holder, and marital status of the beneficiary (married, divorced)
- young spouses of retired workers (*YSRWN*) by age-group (under 25, 25-29, ..., 65-69) and sex of the account holder
- minor, student, and disabled adult children of retired workers (*MCRWN*, *SCRWN*, and *DCRWN*, respectively) by age of the child (0-17 for minor, 18-19 for student, age groups 18-19, 20-24, ..., 55-59, 60+ for disabled adult) and sex of the account holder

Dependent beneficiaries of deceased workers include:

- aged spouses of deceased workers, *ASDWN*, by age (60-95+), sex of the account holder, marital status (widowed, divorced) and insured status (insured, uninsured)
- disabled spouses of deceased workers (*DSDWN*) by age (50-69), sex of the account holder and marital status (widowed, divorced)
- young spouses of deceased workers (*YSDWN*) by age-group (under 25, 25-29, ..., 65-69), sex of the account holder and marital status of the beneficiary (widowed, divorced)
- minor, student, and disabled adult children of deceased workers (*MCDWN*, *SCDWN*, and *DCDWN*, respectively) by age of the child (0-17 for minor, 18-19 for student, age groups 18-19, 20-24, ..., 55-59, 60+ for disabled adult) and sex of the account holder

Lastly, we estimate the number of deaths of insured workers (*LUMSUM*) by 5-year age group (20-24, 25-29, ..., 80-84, 85+) and sex.

Equations 3.3.1-13 indicates the flow of calculations of beneficiaries.

$$\begin{aligned}
 ASDWN &= ASDWN(\cdot) & (3.3.1) \\
 RWN &= RWN(\cdot) & (3.3.2) \\
 ASRWN &= ASRWN(\cdot) & (3.3.3) \\
 DSDWN &= DSDWN(\cdot) & (3.3.4) \\
 MCRWN &= MCRWN(\cdot) & (3.3.5) \\
 MCDWN &= MCDWN(\cdot) & (3.3.6) \\
 SCRWN &= SCRWN(\cdot) & (3.3.7) \\
 SCDWN &= SCDWN(\cdot) & (3.3.8) \\
 DCRWN &= DCRWN(\cdot) & (3.3.9) \\
 DCDWN &= DCDWN(\cdot) & (3.3.10) \\
 YSRWN &= YSRWN(\cdot) & (3.3.11) \\
 YSDWN &= YSDWN(\cdot) & (3.3.12) \\
 LUMSUM &= LUMSUM(\cdot) & (3.3.13)
 \end{aligned}$$

The appendix 3.3-1 at the end of this section provides a listing with explanation of the acronyms used in this documentation.

### 3.3.b. *Input Data*

We update all data annually unless otherwise noted. Timing of data received is denoted ‘BOY’ (beginning of year) or ‘EOY’ (end of year).

#### *Long-Range OCACT Data*

##### Demography

1. Social Security area population by year (EOY 1970-2095), single year of age (0-100+), sex, and marital status (single, married, widowed, divorced)
2. Deaths by year (during years 2017-2095), age group (20-24, ..., 80-84, 85+) and sex
3. Average number of children per family by year (EOY 1970-2095), and age group of the householder (20-24, ..., 60-64)
4. Children by year (EOY 1970-2095), single year of age (0-18), sex of primary account holder (parent), status of primary (62+ or deceased), and age of the other parent (15-19, 20-24, ..., 65-69, 70+, total ages)
5. Married couples by year (EOY 1970-2095), age of husband (62-95+) and age of wife (62-95+)
6. Persons with an aged spouse by year (EOY 1970-2095), age group (15-24, 25-29, ..., 65-69) and sex
7. Probabilities of death by year (EOY 1941-2100), single year of age (-1,100), and sex

### Economics

8. Covered wages and employment in the Federal Civilian and State and Local Sectors (during years 1998-2095)
9. Labor force participation rates for age 62 by year (during years 1970-2095) and sex

### Beneficiaries

10. Fully insured persons by year (EOY 1969-2095), age (14-95+), sex, and marital status (single, married, widowed, divorced)
11. Lawful permanent resident (LPR) fully insured rate by year (EOY 1969-2095), age (14-95+), and sex
12. Disabled-worker beneficiaries in current pay by year (EOY 1970-2095), age (62-66) and sex
13. Converted DI to OAI beneficiaries by year (EOY 1970-2095), age(65-95+) and sex
14. Disability prevalence rates by year (EOY 1970-2095), age (50-69) and sex

### *Short-Range OCACT Data*

15. Insured aged spouses of deceased workers by year (EOY 1974-2017), age (60-95+) and sex
16. Retired worker beneficiaries in-current-pay status by age (62-70, 70+) and sex for EOY 2016-2027
17. We receive the following for EOY 2017:
  - a. Aged spouses of deceased workers by age (60-95+), sex and marital status (widowed, divorced)
  - b. Retired workers by age (62-95+) and sex
  - c. Aged spouses of retired workers by age (62-95+), sex and marital status (married, divorced)
  - d. Disabled widow(er)s by age (50-65), sex and marital status (widowed, divorced)
  - e. Minor children by age (0-17), sex of parent and status of parent (retired, deceased)
  - f. Student children by age (18-21), sex of parent and status of parent (retired, deceased)
  - g. Disabled adult children by age group (18-19, 20-24, ..., 55-59, 60+), sex of parent and status of parent (retired, deceased)
  - h. Young spouses of retired workers by age group (under 25, 25-29, ..., 60-64, 65-69) and sex
  - i. Young spouses of deceased workers by age group (under 25, 25-29, ..., 65-69), sex and marital status (widowed, divorced)
  - j. Total parent beneficiaries
18. We receive the following for EOY 2027:
  - a. Retired workers by age group (62-64, 65-69) and sex
  - b. Insured widows by age group (60-64, ..., 80-84, 85+)
  - c. Uninsured widows by age group (60-64, 65+)
  - d. Total disabled widows
  - e. Female young spouses of deceased workers



- f. Female aged spouses of retired workers by age group (62-64, 65-67, 68-70, 71+)
  - g. Female young spouses of retired workers
  - h. Minor children by status of parent
  - i. Student children by status of parent
  - j. Disabled adult children by status of parent
19. Total amount of lump-sum death payments during 2016
20. Insured aged spouses in current pay by single year of age as of the end of the year for years 1974-2017.

*Other Input Data*

21. For EOY 1970-2004, obtained from the MBR10PER dataset on the mainframe:
- a. Aged spouses of deceased workers by age (60-95+), sex and marital status (widowed, divorced)
  - b. Retired workers by age (62-95+) and sex
  - c. Aged spouses of retired workers by age (62-95+), sex and marital status (married, divorced)
  - d. Disabled widow(er)s by age (50-64), sex and marital status (widowed, divorced)
  - e. Minor children by age (0-17), sex of parent and status of parent (retired, deceased)
  - f. Student children by age (18-19), sex of parent and status of parent (retired, deceased)
  - g. Disabled adult children by age (20-95+), sex of parent and status of parent (retired, deceased)
  - h. Young spouses of retired workers by age group (under 25, 25-29, ..., 60-64) and sex
  - i. Young spouses of deceased workers by age group (under 25, 25-29, ..., 65-69), sex and marital status (widowed, divorced)
  - j. Total parent beneficiaries
- Note: We will not update this data.
22. Number of beneficiaries with benefits withheld due to receipt of a significant government pension by sex and marital status (married, widowed) for EOY 2016 from the 2017 Annual Statistical Supplement
23. Age distribution of beneficiaries with benefits withheld due to receipt of a significant government pension by age (60-95+) and sex, computed as an average from the 2013 through 2017 WEP 100-percent sample
24. Proportions of disabled adult children of retired and deceased workers (proportioned by age and sex of the child) from the 2003 MBR ten-percent sample. (Note: The RSB program calculates disabled adult children by sex of the primary account holder, not by sex of the child. The RSB program outputs a file, which we use for Annual Update #9, which calculates beneficiaries by sex. Therefore, we apply the 2003 proportions to estimate the breakdown of disabled adult children by sex of the child. We will not update this input.). Not used for SOSI.

25. Schedule of normal retirement age (*NRA*), delayed retirement credit, and actuarial reduction factors for ages more than 3 years below *NRA* and less than 3 years below *NRA* for years 1970-2095 from the Social Security website (Note: these values are only updated when there is a Social Security law change regarding the *NRA*)
26. Prevalence rate regression coefficients (slopes and y-intercept value by sex)
27. Regressed prevalence rate by sex for the most recent historical year
28. Adjustment factors which account for the difference between estimated and actual historical retired worker prevalence rates by year (EOY 2018-2095), age (63-69) and sex
29. Adjustment factors which account for the difference between projected beneficiary values for the 10<sup>th</sup> year of the projection period made by the Long-Range and Short-Range offices. Factors are computed for:
  - a. Retired workers by age group (62-64, 65-69) and sex
  - b. Insured widows by age group (60-64,...,80-84,85+)
  - c. Uninsured widows by age group (60-64, 65+)
  - d. Total disabled widows
  - e. Female young spouses of deceased workers
  - f. Female aged spouses of retired workers by age group (62-64, 65+)
  - g. Female young spouses of retired workers
  - h. Minor children by status of parent
  - i. Student children by status of parent
  - j. Disabled adult children by status of parent
30. Adjustment factors to auxiliary beneficiary categories for demographic assumption changes increasing the other-than-LPR population by sex for years 2018-2095. Factors are computed for:
  - a. Aged spouses of deceased workers (widow(er)s)
  - b. Aged spouses of retired workers
  - c. Disabled adult children of retired workers
  - d. Minor children of deceased workers
  - e. Disabled adult children of deceased workers
  - f. Young spouses of deceased workers

Note: Starting with the 2017 TR, these factors are all set to 1 due to the change to using LPR fully insured rates versus total fully insured for calculating FIB factors.
31. Number of one-earner couples by year of birth of the spouse where the primary account holder files for and suspends their retirement worker benefit and their spouse receives a spousal benefit for years 2008-2017 from a 1 percent MBR sample.
32. Number of one-earner couples by year of birth of the primary account holder where the primary account holder files for and suspends their retirement worker benefit and their spouse receives a spousal benefit for years 2008-2015 from a 1 percent MBR sample.  
Note: We will not update this data.

### 3.3.c. Development of Output

We use several acronyms to describe the equations presented below. Acronyms not preceded by a subscript generally refer to the number of beneficiaries. For example, RWN refers to the number of retired workers. Acronyms preceded with a ‘*p*’ refer to probabilities. For example,  $pRW_{FIA}$  refers to the probability that a person is fully insured.

#### Equation 3.3.1 – Aged Spouses of Deceased Workers (ASDWN)

##### Aged Spouses of Deceased Workers

Exposures: SSA population by age (60-95+), sex and marital status (widowed and divorced)

Linkages:  $pASDW_{DEA}$  = probability that the primary account holder (PAH) is deceased  
 $pASDW_{FIA}$  = probability that the PAH was fully insured at death  
 $pASDW_{MBB}$  = probability that the widow(er) is not receiving a young-spouse benefit for the care of a child  
 $pASDW_{FIB}$  = probability that the aged-widow(er) is or is not fully insured  
 $pASDW_{GPB}$  = probability that the aged-widow(er)’s benefits are not withheld or offset totally because of receipt of a significant government pension based on earnings in non-covered employment  
 $pASDW_{RES}$  = probability that a widow(er) eligible to receive his/her own retired-worker benefits would instead apply for and receive widow(er) benefits

We project the number of aged spouses of deceased workers (widow(er)s), along with all linkage factors, by age, sex of the account holder ( $sa = 1$  for male,  $sa = 2$  for female), marital status and insured status. Age ranges from 60 to 95+, marital status includes widowed ( $mb = 1$ ) and divorced ( $mb = 2$ ), and insured status includes insured ( $in = 1$ ) and uninsured ( $in = 2$ ). Note that all variables preceded by the letter *p* refer to calculated probabilities. We calculate the projected number of insured aged spouses of deceased workers age 60 to 70, and uninsured aged spouses of deceased workers age 60 to 95+ as follows:

$$ASDWN = ASDW_{POP} \times pASDW_{DEA} \times pASDW_{FIA} \times pASDW_{MBB} \times pASDW_{FIB} \times pASDW_{GPB} \times pASDW_{RES} \quad (3.3.1)$$

For each sex we calculate the projected number of insured aged spouses of deceased workers over age 70 by applying mortality rates to the population already receiving such benefits:

$$ASDWN_{N,YEAR} = ASDWN_{N-1,YEAR-1} \times (1 - qx_{N-1,YEAR})$$

Where N is the age, and  $qx_{N-1,YEAR}$  is the death rate for age N-1 in the given year.

$ASDW_{POP}$  represents the subset of the population from which we draw these beneficiaries. We set this equal to the Social Security area population ( $SSAPOP_{mb}$ ) for each possible marital status.

$$ASDW_{POP} = SSAPOP_{mb}$$

$pASDW_{DEA}$  represents the probability that the primary account holder (PAH) is deceased. For the widowed population, we set this factor equal to one. For the divorced population, we set this factor equal to the portion of the total widowed ( $SSAPOP_{wid}$ ) and married ( $SSAPOP_{mar}$ ) population who are widowed.

$$pASDW_{DEA} = \begin{cases} 1, & mb = 1 \text{ (widowed)} \\ \frac{SSAPOP_{wid}}{SSAPOP_{mar} + SSAPOP_{wid}}, & mb = 2 \text{ (divorced)} \end{cases}$$

$pASDW_{FIA}$  represents the probability that the PAH was fully insured at death. For a given age of widow,  $AW$ , we assume that the age of her deceased husband,  $AH$ , ranges from  $AW-6$  to  $AW+12$  with a lower and upper bound of 60 and 95+. Further, we assume that the more likely age of the husband is  $AW+3$ . For each age, we calculate  $pASDW_{FIA}$  as a weighted average of the portion of the Social Security area population who are fully insured at each possible age of the husband ( $FINS_{AH}$ ). For example, for a widow age 70, we assume that the age of her husband is between 64 and 82, therefore we calculate the weighted average of the portion of the population who are fully insured males, applying the highest weight of 10 to age 73, and a linearly reduced weight to zero for each age above and below 73. We use the same concept for widow(er)s with the assumption that the age of his deceased wife ranges from  $AH-12$  to  $AH+6$ , with a greater likelihood of her age being  $AH-3$ . Let  $WEIGHT$  represent the specific weight applied to each potential age of the spouse.

$$WEIGHT_{AH} = 10 - |AW + 3 - AH|$$

$$WEIGHT_{AW} = 10 - |AH - 3 - AW|$$

$$pASDW_{FIA} = \begin{cases} \frac{\sum_{AH=AW-6}^{AW+12} WEIGHT_{AH} \times FINS_{AH}}{\sum_{AH=AW-6}^{AW+12} WEIGHT_{AH}}, & sa = 1 \\ \frac{\sum_{AW=AH-12}^{AH+6} WEIGHT_{AW} \times FINS_{AW}}{\sum_{AW=AH-12}^{AH+6} WEIGHT_{AW}}, & sa = 2 \end{cases}$$

$pASDW_{MBB}$  represents the probability that the widow(er) is not receiving a young-spouse benefit for the care of a child. A widow(er) can receive a young-spouse benefit up to age 69 if he/she meets all other eligibility requirements. Since the minimum age requirement to receive a widow(er) benefit is 60, it is necessary to remove those receiving a young-spouse benefit ( $YSDWN^{ab}$ ), where  $ab$  represents the 5-year age bracket<sup>1</sup>. We assume a uniform breakdown to divide the age groups into single-age estimates.

<sup>1</sup> There are no young spouses at NRA or above.

For  $in = 1$  (insured):

$$pASDW_{MBB} = 1$$

For  $in = 2$  (uninsured):

$$FACTOR_{AGE} = \begin{cases} 1, & 65 \leq age \text{ and } NRA \geq age + 1 \\ NRA - age, & age < NRA < age + 1 \\ 0, & elsewhere \end{cases}$$

$$pASDW_{MBB} = \begin{cases} 1 - \frac{0.2 \times YSDWN^{60-64}}{ASDW_{POP} \times pASDW_{DEA} \times pASDW_{FIA}}, & age = 60 - 64 \\ 1 - \frac{YSDWN^{65-69}}{ASDW_{POP} \times pASDW_{DEA} \times pASDW_{FIA}} \times \frac{FACTOR_{age}}{\sum_{65}^{69} FACTOR_{age}}, & 65 \leq age \leq NRA \\ 1, & age > NRA \end{cases}$$

$pASDW_{FIB}$  represents the probability that the aged widow(er) is fully insured. For insured widow(er)s,  $pASDW_{FIB}$  is equal to the LPR fully insured rate ( $FILEG$ ) at each age and sex. For uninsured widow(er)s,  $pASDW_{FIB}$  is simply one minus the probability for insured widow(er)s.

$$pASDW_{FIB} = \begin{cases} FILEG, & in = 1 \\ 1 - FILEG, & in = 2 \end{cases}$$

Where  $in$  represents the insured status of the account holder.

$pASDW_{GPB}$  represents the probability that the aged-widow(er)'s benefits are not withheld or completely offset because of receipt of a significant government pension based on earnings in non-covered employment. According to the 1977 amendments, Social Security benefits are subject to reduction by up to two-thirds of non-covered government pension.  $GPWHLD$  represents the total number of widow(er) beneficiaries (for all ages) expected to receive a significant government pension.  $rGPOAGE$  represents the ratio of the total for each given age. If a person is insured, this implies that he/she is eligible to receive Social Security benefits based on his/her own earnings regardless of a government pension. Therefore, we do not apply a factor.

For  $in = 1$  (insured):

$$pASDW_{GPB} = 1$$

For  $in = 2$  (uninsured):

$$pASDW_{GPB} = \begin{cases} 1, & year \leq 1978 \\ 1 - \frac{rGPOAGE \times GPWHL D}{ASDW_{POP} \times pASDW_{DEA} \times pASDW_{FIA} \times pASDW_{MBB} \times pASDW_{FIB}}, & year > 1978 \end{cases}$$

$pASDW_{RES}$  represents the probability that a widow(er), who is eligible to receive widow(er)'s benefits, will actually receive benefits. In particular, for  $in = 1$ , this factor is equivalent to the probability that a widow(er) eligible to receive his/her own retired-worker benefits would instead apply for and receive widow(er) benefits. For all historical years, we calculate  $pASDW_{RES}^{year}$  as the ratio of  $ASDWN$ , the actual number of widow(er)s, to the number of persons meeting all previously mentioned requirements by age, sex, insured status, and marital status.

$$pASDW_{RES}^{year} = \frac{ASDWN}{ASDW_{POP} \times pASDW_{DEA} \times pASDW_{FIA} \times pASDW_{MBB} \times pASDW_{FIB} \times pASDW_{GPB}}, \quad year < TRYR$$

Where TRYR is the Trustees Report year.

For each age, sex, insured status, and marital status, we use a least squares regression over the last ten years of historical data to determine a starting value in TRYR-1 for  $pASDW_{RES}^{year}$  from which we project future values. In addition, for each sex, insured status, and marital status, we graduate the regressed values of  $pASDW_{RES}^{TRYR-1}$  over age using a weighted minimized third-difference formula to produce  $ESTRES^{ASDW}$ .  $ESTRES^{ASDW}$  are the preliminary estimates of  $pASDW_{RES}^{TRYR+9}$ , the values in the 10<sup>th</sup> year of the projection period. In addition, we apply adjustments to the widows ( $sa = 1$ ) by age group (60-64, 65-69 for insured; 60-64, 65+ for uninsured),  $SRADJ^{ASDW}$ , to the 10<sup>th</sup> year of the projection period in order to match the projections made by the Short-Range office. We linearly interpolate the values of  $pASDW_{RES}^{year}$  for intermediate years between  $pASDW_{RES}^{TRYR-1}$  and  $pASDW_{RES}^{TRYR+9}$  (equal to  $ESTRES^{ASDW} \times SRADJ^{ASDW}$ ). After the 10<sup>th</sup> year, we linearly grade these adjustment factors to one over the 10 years beyond the end of the short-range period, thus gradually eliminating the effect of the short-range adjustment factors, so that we ultimately return to long-range projections.

We also apply adjustments to the 70+ insured widows by age group (70-74, 75-79, 80-84, 85+). The adjustments for the intermediate years between the TRYR and TRYR + 9 are applied on a cohort basis to the number of aged spouses of deceased workers ( $ASDWN$ ) using the following formula:

$$ASDWN_{N,YEAR} = ASDWN_{N,YEAR} \times SRADJ\left(\frac{1}{h}\right)$$

Where  $h$  is the number of years the adjustment is applied for the cohort. For age 70, we linearly grade these adjustment factors to one over the 10 years beyond the end of the short-range period, thus gradually eliminating the effect of the short-range adjustment factors, so that we ultimately return to long-range projections.

Equation 3.3.2 – Retired Workers (RWN)

Retired Workers

- Exposure: SSA population by age (62-95+), sex and marital status (single, married, widowed and divorced)
- Linkages:  $pRW_{FIA}$  = probability that the primary account holder (PAH) is insured  
 $pRW_{DBB}$  = probability that the PAH is not receiving a disabled-worker benefit  
 $pRW_{WBB}$  = probability that the PAH is not receiving a widow(er) benefit  
 $pRW_{RES}$  = retirement prevalence rate; probability that a fully insured worker not receiving disability or widow(er)'s benefits would receive a retired-worker benefit

We project the numbers of retired-worker beneficiaries, along with all linkage factors, by age, sex, and marital status. Age ranges from 62 to 95+, and marital status includes single, married, widowed, and divorced ( $ms = 1-4$ ). We calculate the projected number of retired-worker beneficiaries as follows:

$$RWN = RW_{POP} \times pRW_{FIA} \times pRW_{DBB} \times pRW_{WBB} \times pRW_{RES} \quad (3.3.2)$$

$RW_{POP}$  represents the subset of the population from which we draw these beneficiaries. We set this equal to the Social Security area population ( $SSAPOP_{ms}$ ) for  $ms = 1-4$ .

$$RW_{POP} = SSAPOP_{ms}$$

$pRW_{FIA}$  represents the probability that the primary account holder (PAH) is insured. We set this factor equal to the portion of the Social Security area population that is fully insured ( $FINS$ ) for  $ms = 1-4$ .

$$pRW_{FIA} = \frac{FINS}{RW_{POP}}$$

$pRW_{DBB}$  represents the probability that the PAH is not receiving a disabled-worker or disability-conversion benefit. We set this factor equal to the portion of fully insured workers who are neither disabled-worker beneficiaries nor converted from disabled-worker beneficiaries ( $DIBCON$ ).  $ASDWN$  represents the number of aged spouses of deceased workers.

$$pRW_{DBB} = \begin{cases} 1 - \frac{DIBCON}{RW_{POP} \times pRW_{FIA}}, & ms = 1, 2 \\ \left(1 - \frac{DIBCON + ASDWN}{RW_{POP} \times pRW_{FIA}}\right) \left(\frac{DIBCON}{DIBCON + ASDWN}\right), & ms = 3, 4 \end{cases}$$

$pRW_{WBB}$  represents the probability that the PAH is not receiving a widow(er) benefit. We set this factor equal to the portion of fully insured workers that is not aged spouses of deceased workers.

$$pRW_{WBB} = \begin{cases} 1, & ms = 1, 2 \\ \left(1 - \frac{DIBCON + ASDWN}{RW_{POP} \times pRW_{FIA}}\right) \left(\frac{ASDWN}{DIBCON + ASDWN}\right), & ms = 3, 4 \end{cases}$$

$pRW_{RES}^{N,year}$  represents the retirement prevalence rate, which is the probability that a fully insured worker not receiving disability or widow(er)'s benefits would receive retired-worker benefits as of the given age,  $N$ , for the given year. In order to estimate the future prevalence rate, the program first calculates the historical values of  $pRW_{RES}^{N,year}$ .

For each historical year and sex, we calculate  $pRW_{RES}^{N,year}$  as the ratio of  $RWN$ , the actual number of retired workers, to the number of persons meeting all previously mentioned requirements by age, sex, and marital status.

$$pRW_{RES}^{N,year} = \frac{RWN}{RW_{POP} \times pRW_{FIA} \times pRW_{DBB} \times pRW_{WBB}}, \quad N = 62-95+ \text{ and } year < \text{TRYR}$$

Historical prevalence rates at age 62 follow an inverse relationship with (1) labor force participation rates ( $LFPR^{year}$ ) at age 62, by sex, and (2) increases in the normal retirement age over the historical period. We assume this relationship holds in the projection period, and therefore we used it to calculate  $REGPR^{year}$ , the regressed prevalence rate based on the projected  $LFPR^{year}$  at age 62 for each year and sex, and the number of months from age 62 to the normal retirement age ( $monthNRA^{year}$ ). Note that we calculate prevalence rates on a cohort basis<sup>2</sup>. The regression equation used to estimate the prevalence rates is:

$$\begin{aligned} REGPR^{year} &= -1.04580 \times LFPR^{year} + -0.00441 \times monthNRA^{year} + 1.12548 \text{ for male with} \\ &\quad \text{an } R^2 \text{ value of } 0.88994, \\ &\quad \text{and} \\ REGPR^{year} &= -0.64071 \times LFPR^{year} + -0.00695 \times monthNRA^{year} + 0.97973 \text{ for female with} \\ &\quad \text{an } R^2 \text{ value of } 0.88722 \end{aligned}$$

We then set the future prevalence rate at age 62,  $pRW_{RES}^{62,year}$ , equal to the sum of the regressed prevalence rate ( $REGPR^{year}$ ) and  $ERROR$ , the difference between the actual prevalence rate and the regressed prevalence rate in the most recent historical year, which we phase out linearly over 10 years.

$$pRW_{RES}^{62,year} = REGPR^{year} + (ERROR) \times \max\left(0, \frac{\text{TRYR} + 9 - year}{10}\right), \quad N = 62 \text{ and } year \geq \text{TRYR} - 1$$

To compute  $pRW_{RES}^{N,year}$  for ages 63 through 69 in the projection period, we must calculate several preliminary variables. These include:

- $MBAPIA_N$ , for  $N = 62-70$  (same for both sexes),

<sup>2</sup>For example, to calculate the projected number of 65 year olds in a given year, the prevalence rate at age 62 is needed. This is actually the prevalence rate that occurred three years ago at age 62.



- $ESTPR_N^{year}$ , for  $N = 63-69$  and by sex, and
- $DIFFADJ_N$ , for  $N = 63-69$  and by sex.

$MBAPIA_N$  is the ratio of the monthly benefit amount (MBA) to the primary insurance amount (PIA) at age  $N$  and is calculated on a cohort basis for  $N = 62-70$ . We base the calculation of  $MBAPIA_N$  on the normal retirement age ( $NRA$ ), delayed retirement credits ( $DRC$ ), and actuarial reduction factors,  $ARFLE3$  when the difference between  $NRA$  and age at retirement is less than 3, and  $ARFGT3$  when the difference is greater than 3 within each cohort. If a person retires after  $NRA$ , his/her benefits are increased by  $DRC$  for each year the age exceeds  $NRA$ . If a person retires before  $NRA$ , his/her benefits are decreased by  $ARFLE3$  for each of the first three years that  $NRA$  exceeds the age, and further decreased by  $ARFGT3$  for any remaining years.

$$MBAPIA_N = \begin{cases} 1 + (N - NRA) \times DRC, & N \geq NRA \\ 1 - (NRA - N) \times ARFLE3, & NRA - 3 \leq N \leq NRA \\ 1 - 3 \times ARFLE3 - (NRA - 3 - N) \times ARFGT3, & N < NRA - 3 \end{cases}$$

$ESTPR_N^{year}$ , the estimated prevalence rate at age  $N$ , is then calculated as the prevalence rate at age 62 ( $pRW_{RES}^{62,year-(N-62)}$ ) plus an estimate on the expected portion of the remaining probability ( $1 - pRW_{RES}^{62,year-(N-62)}$ ), that a potential retired worker will actually retire by that given age. We base this estimate on  $MBAPIA_N$ , assuming that the retirement decision by a worker is totally and completely influenced by the expected change in the portion of PIA that is payable at each age relative to the potential change after the initial eligibility.

$$ESTPR_N^{year} = pRW_{RES}^{62,year-(N-62)} + (1 - pRW_{RES}^{62,year-(N-62)}) \times \frac{MBAPIA_N - MBAPIA_{62}}{MBAPIA_{70} - MBAPIA_{62}}, \quad N = 63-69$$

In the first year of the projection period, an adjustment ( $DIFFADJ_N$ ) is made which accounts for the difference between the actual and estimated prevalence rate at each age in the most recent historical years. For ages 63 to 69, the value used beginning in TRYR is the average of the last 5 years' differences between the actual and estimated PR. With the exception of age 66, we hold this value constant throughout the projection period.

For years in which the  $NRA$  increases,  $DIFFADJ_N$  is greater for a period of time both before and after the  $NRA$  transitions to a new age. This affects  $DIFFADJ_{66}$  due to the increase in  $NRA$  from age 65 to age 66 between the years 2000-2005, and the scheduled increase from age 66 to 67 over the years 2017-2022. Thus for the years preceding the change in  $NRA$  from age 66 to 67, we use the average from the last five historical years, which includes the increase in the difference between actual and estimated prevalence rates from when the  $NRA$  changed from age 65 to 66, in order to calculate  $DIFFADJ_{66}$ . We assume that the effects on age 66 prevalence rates after the  $NRA$  change from 66 to 67 will be similar to the effects on age 65 prevalence rates after the  $NRA$  change from 65 to 66. Thus we set  $DIFFADJ_{66}$  to the average difference between actual and estimated prevalence rates for age 65 during the five years after the  $NRA$  changed from 65 to 66. Then after the  $NRA$  increases to age 67, we

use  $DIFFADJ2_{66}$  to decrease age 66 prevalence rates to the level that age 65 prevalence rates dropped to after the NRA increase to 66. In the years during which the NRA transitions to age 67 we use a linear interpolation based on the number of months that the NRA has increased in order to phase out  $DIFFADJ_{66}$  and phase in  $DIFFADJ2_{66}$ . It will remain at  $DIFFADJ2_{66}$  for the rest of the projection period.

$$pRW_{RES}^{N,year} = ESTPR_N + DIFFADJ_N$$

For age 70, we assume that the values of the latest actual  $pRW_{RES}^{N,year}$  by sex, change linearly to the ultimate level of 0.995 over the first 20 years of the projection period.

For  $year \geq TRYR$ :

$$pRW_{RES}^{70,year} = 0.995 - [0.995 - pRW_{RES}^{70,TRYR-1}] \times \max\left(0, \frac{TRYR + 19 - year}{20}\right), \quad sa = 1, 2$$

For ages 71 and older, we assume  $pRW_{RES}^{N,year}$  stays constant at the level when the age was 70 because there is no incentive to delay applying for benefits beyond age 70.

$$pRW_{RES}^{N,year} = pRW_{RES}^{70,year-(N-70)}, \quad \text{for } N = 71-95+ \text{ and } year \geq TRYR$$

In addition, we apply adjustments by age group (62-64, 65-69) and sex,  $SRADJ^{RW}$ , to the 10<sup>th</sup> year of the projection period in order to match the projections made by the Short-Range office. We also apply these adjustments to  $pRW_{RES}^{N,year}$  for all years after  $TRYR+9$ . The values of  $pRW_{RES}^{N,year}$  for intermediate years are linearly interpolated between  $pRW_{RES}^{N,TRYR-1}$  and  $pRW_{RES}^{N,TRYR+9}$ .

In response to the elimination of the file and suspend and deemed filing claiming strategies for aged spouses by the Bipartisan Budget Act of 2015 (BBA), we expect that the married and divorced retired workers who would have delayed receiving their worker benefits will instead file for benefits earlier. As such, we use the  $unsuspRW(ag)$  factor to increase the projected number of married workers for those who would have suspended their benefits but will now begin receiving them earlier.

$$unsuspRW(ag) = \frac{suspRW(ag) + RWN_{ag,M,Mar} + RWN_{ag,F,Mar}}{RWN_{ag,M,Mar} + RWN_{ag,F,Mar}} - 1$$

Where  $suspRW(ag)$  is the number of retired workers who would have suspended their benefits for the file and suspend strategy. Since the utilization of this filing strategy had been expected to continue to grow in popularity had it not been eliminated, we apply a behavioral increase factor,  $RWBehavioralInc(ag)$ , to  $unsuspRW(ag)$  to reflect the increasing number of retired workers who will no longer delay their benefits now that the filing strategy is no longer available.

$$RWBehavioralInc(ag) = \begin{cases} 1.5, & \text{for those born in 1947} \\ 1.03, & \text{for those born in 1948} \\ 1.0, & \text{for those born after 1948} \end{cases}$$

We use the  $DFRetWrkr(ag, sx)$  factor to increase the number of married and divorced retired workers for the insured aged spouses who will no longer be able to delay receiving their worker benefit while receiving their aged spouse benefit. We calculate these factors as:

$$DFRetWrkr(ag, sx) = \frac{DeemdFiler(ag, sx) + RWN_{ag, sx, Mar} + RWN_{ag, sx, Div}}{RWN_{ag, sx, Mar} + RWN_{ag, sx, Div}} - 1$$

Where  $DeemdFiler(ag, sx)$  is the number of insured aged spouses who would have used the deemed filing strategy. We assume that 50 percent of these deemed filers will file for worker benefits earlier now that the strategy is no longer available, with 1/3 claiming at age 66, and 2/9 at each age 67 through 69.

As the NRA transitions from 66 to 67, we reduce both the  $unsuspRW(66)$  and  $DFRetWrkr(66, sx)$  by one minus the increase in NRA expressed as a fraction of a year with each factor being set to zero once the NRA is 67.

For each age, retired workers are further broken down by age at entitlement,  $AE$ , by multiplying the number of retired workers at age  $N$  by the ratio of the incidence rate at  $AE$  ( $N - AE$  years prior) to the prevalence rate at age  $N$ .

$${}^N_{AE}RWN^{year} = {}^NRWN^{year} \times \frac{{}_{AE}INCRATE^{year-(N-AE)}}{pRW_{RES}^{N, year}}, \quad AE \leq N$$

where we calculate the incidence rate for a given  $AE = N$  and year as the change in the prevalence rate at age  $N$  to the prevalence rate at age  $N-1$  in the previous year.

$${}_{AE}INCRATE^{year} = \begin{cases} pRW_{RES}^{N, year}, & N = AE = 62 \\ pRW_{RES}^{N, year} - pRW_{RES}^{N-1, year-1}, & 63 \leq N = AE \leq 69 \\ 1 - pRW_{RES}^{N-1, year-1}, & N = AE = 70 \end{cases}$$

Additional adjustments are applied to the incidence rates in order to account for the increase in retired worker beneficiaries due to the elimination of the deemed filing and file and suspend strategies. Since many of the beneficiaries utilizing these strategies delayed receiving their worker benefit until age 70, we assume that the retired workers added through the  $unsuspRW(ag)$  and  $DFRetWrkr(ag, sx)$  factors will survive until age 70. As such, our incidence rate calculations are adjusted to reflect the age at which the new retired workers claim benefits and to ensure that they remained on the rolls until age 70.

Equation 3.3.3 – Aged Spouses of Retired Workers (ASRWN)

Aged Spouses of Retired Workers

Exposures: SSA population by age (62-95+, sex, and marital status (married and divorced))

Linkages:  $pASRW_{DEA}$  = probability that the primary account holder (PAH) is not deceased  
 $pASRW_{AGA}$  = probability that the PAH is of the required age  
 $pASRW_{FIA}$  = probability that the PAH is fully insured  
 $pASRW_{CPA}$  = probability that the PAH is receiving benefits  
 $pASRW_{MBB}$  = probability that the beneficiary is not receiving a young-spouse benefit  
 $pASRW_{FIB}$  = probability that the aged-spouse is not fully insured  
 $pASRW_{GPB}$  = probability that the aged-spouse's benefits are not withheld because of receipt of a significant government pension based on earnings in non-covered employment  
 $pASRW_{FS1}$  = probability that a couple will engage in a filing strategy in which the PAH files for and suspends their benefit and an uninsured spouse receives an aged spouse benefit  
 $pASRW_{FS2}$  = probability that a couple will engage in a filing strategy in which the PAH files for and may or may not suspend their benefit and the fully insured spouse files only for their aged spouse benefit.  
 $pASRW_{RES}$  = probability that a person who is eligible to receive aged-spouse benefits actually receives the benefits

We project the number of aged spouses of retired workers, along with all linkage factors, by age, sex of the account holder ( $sa = 1, 2$ ), and marital status of the beneficiary. Age ranges from 62 to 95+, and marital status includes married ( $mb = 1$ ) and divorced ( $mb = 2$ ). We calculate the projected number of aged spouses of retired workers as follows:

$$ASRWN = ASRW_{POP} \times pASRW_{DEA} \times pASRW_{AGA} \times pASRW_{FIA} \times pASRW_{CPA} \times pASRW_{MBB} \times pASRW_{FIB} \times pASRW_{GPB} \times pASRW_{FS1} \times pASRW_{FS2} \times pASRW_{RES} \quad (3.3.3)$$

$ASRW_{POP}$  represents the subset of the population from which these beneficiaries are drawn, and we set it equal to the Social Security area population ( $SSAPOP_{mb}$ ) for  $mb = 1, 2$ .

$$ASRW_{POP} = SSAPOP_{mb}$$

$pASRW_{DEA}$  represents the probability that the PAH is not deceased. For the married population, we do not apply a factor. For the divorced population, we set the factor equal to the portion of the total married and widowed population who are married.

$$pASRW_{DEA} = \begin{cases} 1, & mb = 1 \text{ (married)} \\ \frac{SSAPOP_{mar}}{SSAPOP_{mar} + SSAPOP_{wid}}, & mb = 2 \text{ (divorced)} \end{cases}$$

$pASRW_{AGA}$  represents the probability that the PAH is of the required age, and we set it equal to the portion of the married population with a spouse (PAH) at least age 62.

$$pASRW_{AGA} = \frac{\sum_{AA=62}^{95} mar(AA, AS)}{SSAPOP_{AS,mar}}$$

Where  $mar(AA,AS)$  is the number of married couples where the age of the account holder is AA and the spouse of the account holder is age AS.

$pASRW_{FIA}$  represents the probability that the PAH is fully insured, and we set it equal to the portion of married couples of the required age where the PAH is fully insured ( $FI\_PAH$ ). For example, when the program estimates the number of female aged spouse of retired workers, this factor will find the portion where their spouse, the male PAH, is fully insured.

$$pASRW_{FIA} = \frac{\sum_{AA=62}^{95} [mar(AA, AS) \times FI\_PAH_{AA,mar}]}{\sum_{AA=62}^{95} mar(AA, AS)}$$

$pASRW_{CPA}$  represents the probability that the PAH is receiving benefits. We set this factor equal to the portion of eligible married couples where the PAH is receiving benefits ( $RETIRED$ ). If the beneficiary is divorced, we do not apply a factor, since it is not required for the retired worker to be receiving benefits for the divorced aged spouse to receive benefits.

$$pASRW_{CPA} = \begin{cases} 1, & \text{year} \geq 1985 \text{ and} \\ & mb = 2 \\ \frac{\sum_{AA=62}^{95} [mar(AA, AS) \times FI\_PAH_{AA,mar} \times RETIRED]}{\sum_{AA=62}^{95} mar(AA, AS) \times FI\_PAH_{AA,mar}}, & \text{elsewhere} \end{cases}$$

$pASRW_{MBS}$  represents the probability that the beneficiary is not receiving a young-spouse benefit. If the beneficiary is age 70 or older or if the beneficiary is divorced, we do not apply a factor. Otherwise, we set this factor equal to the portion of potentially eligible widow(er)s where the spouse of the PAH is not receiving a young-spouse benefit ( $YSRWN^{ab}$ ), where  $ab$  represents the 5-year age group.<sup>3</sup>

For  $mb = 1$  (married):

<sup>3</sup> There are no young spouses at NRA or above.

$$FACTOR_{AGE} = \begin{cases} 1, & 65 \leq age \text{ and } NRA \geq age + 1 \\ NRA - age, & age < NRA < age + 1 \\ 0, & elsewhere \end{cases}$$

$$pASRW_{MBB} = \begin{cases} 1 - \frac{0.2 \times YSRWN^{60-64}}{ASRW_{POP} \times pASRW_{DEA} \times pASRW_{AGA} \times pASRW_{FIA} \times pASRW_{CPA}}, & age = 62 - 64 \\ 1 - \frac{YSRWN^{65-69}}{ASRW_{POP} \times pASRW_{DEA} \times pASRW_{AGA} \times pASRW_{FIA} \times pASRW_{CPA}} \times \frac{FACTOR_{ag}}{\sum_{65}^{69} FACTOR_{ag}}, & 65 \leq age \leq NRA \\ 1, & elsewhere \end{cases}$$

For  $mb = 2$  (divorced):

$$pASRW_{MBB} = 1$$

$pASRW_{FIB}$  represents the probability that the aged spouse is not fully insured, and is therefore not receiving a retired-worker benefit based on his/her own earnings. We set this factor equal to one minus the LPR fully insured rate (*FILEG*) at each age and sex.

$$pASRW_{FIB} = 1 - FILEG$$

$pASRW_{GPB}$  represents the probability that the aged-spouse's benefits are not withheld because of receipt of a significant government pension based on earnings in non-covered employment. *GPWHL D* represents the total number of aged spouse of retired-worker beneficiaries (for all ages) expected to receive a significant government pension. *rGPOAGE* represents the ratio of the total for each given age.

$$pASRW_{GPB} = \begin{cases} 1, & year \leq 1978 \\ 1 - \frac{rGPOAGE \times GPWHL D}{ASRW_{POP} \times pASRW_{DEA} \times pASRW_{AGA} \times pASRW_{FIA} \times pASRW_{CPA} \times pASRW_{MBB} \times pASRW_{FIB}}, & elsewhere \end{cases}$$

$pASRW_{FSI}$  represents the probability that a couple engages in a filing strategy in which the PAH files for and suspends their worker benefit and the uninsured aged spouse files for a spousal benefit. Due to the Bipartisan Budget Act of 2015 (BBA), this filing strategy is no longer available to married couples if the worker files and suspends their worker benefits after April 29, 2016. We assume that any couple with a worker age 66 and older who was planning on using this strategy will do so before it is eliminated. For the couples where the worker reaches age 66 after April 29, 2016, we assume that the worker will instead opt to receive their worker benefit when they would have suspended so that their spouse can receive the aged spouse benefit.

For  $mb = 1$  (married):

Since we assume the one-earner couples will begin receiving benefits at the same time regardless of whether the file and suspend strategy is available, we expect that the projected prevalence rate,  $pASRW_{RES}$ , will be similar to that in the historical period. Thus, we set the  $pASRW_{FS1}$  to 1 for all years less than TRYR.

Additionally, we set the factor to 1 for all ages in the year 2020, the year in which the last group of workers able to make use of this strategy would reach age 70, and later. For the years prior to 2020, we calculate  $pASRW_{FS1}$  as the percent of new couples engaging in this strategy over the total number of married aged spouses receiving benefits in the last historical year.

$$pASRW_{FS1}^{year} = 1 + \max\left(\frac{FSCouple1(ag) - lastyrFSCouple1(ag)}{ASRWN_{ag,M,Mar} + ASRWN_{ag,F,Mar}}, 0\right)$$

Where  $FSCouple1(ag)$  is the number of one-earner couples expected to use the file and suspend strategy, and  $lastyrFSCouple1(ag)$  is the number of one-earner couples using this strategy in the last historical year. We then phase out  $pASRW_{FS1}$  for those who turn 66 after April 29, 2016, based upon the age distribution of the workers newly suspending their benefits in order make use of this strategy.

For  $mb = 2$  (divorced):

$$pASRW_{FS1}^{year} = 1$$

$pASRW_{FS2}$  represents the probability that a couple engages in a filing strategy in which the PAH files for and may or may not suspend their worker benefit and their fully insured spouse receives only a spousal benefit thus delaying receiving their worker benefit. For historical years 2006 to TRYR-1, we set this equal to 1 plus the ratio of couples ages NRA to 70 where the PAH has filed for benefits and their fully insured spouse is receiving only a spousal benefit ( $FSCouple2(ag, sa, mb)$ ) to the actual number of aged spouse beneficiaries. Due to the BBA, those turning 62 in 2016 or later will no longer be able to use this filing strategy. For the projection period prior to the elimination of this filing strategy, we set  $pASRW_{FS2}^{year}$  equal to  $pASRW_{FS2}^{year-1}$  multiplied by a behavioral increase factor ( $BehaviorInc(ag, sa)$ ). This factor accounts for the increase in the number of couples engaging in this filing strategy due to knowledge of the strategy becoming more widespread as well as the growth in the age 62 LPR fully insured married and divorced population ( $filpop62$ ). We set  $pASRW_{FS2}$  to 1 in the projection period as those age 62 in 2016 reach NRA and above.

For  $year < TRYR$ :

$$pASRW_{FS2}^{year} = \begin{cases} 1 + \frac{FSCouple2(ag, sa, mb)}{ASRWN_{ag,sa,mb}^{year}}, & 2006 \leq year \text{ and } NRA \leq ag \leq 70 \\ 1, & elsewhere \end{cases}$$

For  $year \geq TRYR$ :

$$BehaviorInc(ag, sa) = \begin{cases} 1.3 \times filpop62, & \text{for those born in 1949} \\ 1.15 \times filpop62, & \text{for those born in 1950} \\ 1.0 \times filpop62, & \text{for those born after 1950} \end{cases}$$

$$pASRW_{FS2}^{year} = \begin{cases} 1 + (pASRW_{FS2}^{year-1} - 1) \times BehaviorInc(ag, sa), & NRA \leq ag \leq 70 \text{ and} \\ & year - 2016 + 62 < ag \\ 1, & \text{elsewhere} \end{cases}$$

$pASRW_{RES}$  represents the probability that a person who is eligible to receive aged-spouse benefits actually receive the benefits. For all historical years, we calculate  $pASRW_{RES}^{year}$  as the ratio of  $ASRWN$ , the actual number of aged spouses receiving benefits, to the number of persons meeting all previously mentioned requirements by age, sex, and marital status.

For  $year < TRYR$ :

$$pASRW_{RES}^{year} =$$

$ASRWN$

---


$$ASRW_{POP} \times pASRW_{DEA} \times pASRW_{AGA} \times pASRW_{FIA} \times pASRW_{CPA} \times pASRW_{MBB} \times pASRW_{FIB} \times pASRW_{GPB} \times pASRW_{FS1} \times pASRW_{FS2}$$

For each age, sex, and marital status, we use a least squares regression over the last ten years of historical data to determine a starting value in TR-1 for  $pASRW_{RES}^{year}$  from which we project future values. In addition, for each sex and marital status, we graduate the regressed values of  $pASRW_{RES}^{TRYR-1}$  over age using a weighted minimized third-difference formula to compute  $ESTRES^{ASRW}$ .  $ESTRES^{ASRW}$  are the preliminary estimates of  $pASRW_{RES}^{TRYR+9}$ , the values in the 10<sup>th</sup> year of the projection period. For female spouses, we apply additional adjustments by age group (62-64, 65+),  $SRADJ^{ASRW}$ , to the 10<sup>th</sup> year of the projection period in order to match the projections made by the Short-Range office. We linearly interpolate the values of  $pASRW_{RES}^{year}$  for intermediate years interpolated between  $pASRW_{RES}^{TRYR-1}$  and  $pASRW_{RES}^{TRYR+9}$  (equal to  $ESTRES^{ASRW} \times SRADJ^{ASRW}$ ). After the 10<sup>th</sup> year of the projection period, we linearly grade these adjustment factors to one over the 10 years beyond the end of the short-range period, thus gradually eliminating the effect of the short-range adjustment factors, so that we ultimately return to the long-range projections.

*Equation 3.3.4 – Disabled Spouses of Deceased Workers (DSDWN)*

Disabled Spouses of Deceased Workers

Exposure: SSA population by age (50-69), sex and marital status (widowed and divorced)

- Linkages:  $pDSDW_{DEA}$  = probability that the primary account holder (PAH) is deceased
- $pDADW_{FIA}$  = probability that the PAH was fully insured at death
- $pDSDW_{SSB}$  = probability that the spouse is indeed disabled
- $pDSDW_{DEB}$  = probability that the disabled spouse is not receiving another type of benefit



$pDSDW_{RES}$  = probability that a person who is eligible to receive disabled-spouse benefits actually receive the benefits

We project the number of disabled spouses of deceased workers, along with all linkage factors, by age, sex of the account holder ( $sa = 1$  for male,  $sa = 2$  for female), and marital status. Age ranges from 50 to 69, and marital status includes widowed ( $mb = 1$ ) and divorced ( $mb = 2$ ). We calculate the projected number of disabled spouses of deceased workers as follows:

$$DSDWN = DSDW_{POP} \times pDSDW_{DEA} \times pDSDW_{FIA} \times pDSDW_{SSB} \times pDSDW_{DEB} \times pDSDW_{RES} \quad (3.3.4)$$

$DSDW_{POP}$  represents the subset of the population from which we draw these beneficiaries, and we set it equal to the Social Security area population ( $SSAPOP_{mb}$ ) for  $mb = 1, 2$ .

$$DSDW_{POP} = SSAPOP_{mb}$$

$pDSDW_{DEA}$  represents the probability that the primary account holder is deceased. For the widowed population, we do not apply a factor. For the divorced population, we set this factor equal to the portion of the total widowed and married population that is widowed.

$$pDSDW_{DEA} = \begin{cases} 1, & mb = 1 \text{ (widowed)} \\ \frac{SSAPOP_{wid}}{SSAPOP_{wid} + SSAPOP_{mar}}, & mb = 2 \text{ (divorced)} \end{cases}$$

$pDSDW_{FIA}$  represents the probability that the PAH was fully insured at death. Given the age of the widow,  $AW$ , we assume that the age of her deceased husband,  $AH$ , ranges from  $AW-6$  to  $AW+12$  with a lower and upper bound of 50 and 95+. Further, we assume that the more likely age of the husband is  $AW+3$ . For each age, we calculate  $pDSDW_{FIA}$  as a weighted average of the portion of the Social Security area population that is fully insured ( $FINS$ ), at each possible age of the husband. For example, if the widow is age 65, we assume that the age of the husband is between 59 and 77. Therefore, when we calculate the weighted average of the portion of the population who are fully insured males, we apply the highest weight of ten to age 68 and linearly reduce the weight to zero for each age above and below 68. We use the same concept for widow(er)s with the assumption that the age of his deceased wife ranges from  $AH-12$  to  $AH+6$ , with a greater likelihood of her age being  $AH-3$ . Let  $WEIGHT$  represent the specific weight applied to each age.

$$WEIGHT_{AH} = 10 - |AW + 3 - AH|$$

$$WEIGHT_{AW} = 10 - |AH - 3 - AW|$$

$$pDSDW_{FIA} = \begin{cases} \frac{\sum_{AH=AW-6}^{AW+12} WEIGHT_{AH} \times FINS_{AH}}{\sum_{AH=AW-6}^{AW+12} WEIGHT_{AH}}, & sa = 1 \\ \frac{\sum_{AW=AH-12}^{AH+6} WEIGHT_{AW} \times FINS_{AW}}{\sum_{AW=AH-12}^{AH+6} WEIGHT_{AW}}, & sa = 2 \end{cases}$$

$pDSDW_{SSB}$  represents the probability that the spouse is indeed disabled. We set this factor equal to the disability prevalence rates ( $DISPREV$ ) by age and sex received from the DISABILITY subprocess.

$$pDSDW_{SSB} = DISPREV$$

$pDSDW_{DEB}$  represents the probability that the disabled spouse is not dually eligible for another type of benefit. We assume this factor remains at a constant level by sex.

$$pDSDW_{DEB} = \begin{cases} 0.85, & sa = 1 \\ 0.06, & sa = 2 \end{cases}$$

$pDSDW_{RES}$  represents the probability that a person who is eligible to receive disabled-spouse benefits actually receive the benefits. For all historical years, we calculate  $pDSDW_{RES}^{year}$  as the ratio of  $DSDWN$ , the actual number of disabled spouses of deceased workers receiving benefits, to the number of persons meeting all previously mentioned requirements by age, sex, and marital status.

$$pDSDW_{RES}^{year} = \frac{DSDWN}{DSDW_{POP} \times pDSDW_{DEA} \times pDSDW_{FIA} \times pDSDW_{SSB} \times pDSDW_{DEB}}, \quad year < TRYR$$

For ages 50 to 64, and each sex, and marital status, we use the average  $pDSDW_{RES}^{year}$  over the last five years of historical data to determine starting values for  $pDSDW_{RES}^{year}$  from which we project future values. We phase in these averages over five years using a linear interpolation between the five-year averages and  $pDSDW_{RES}^{TRYR-1}$ . For female disabled spouses, we apply an adjustment,  $SRADJ^{DSDW}$ , to the 10<sup>th</sup> year of the projection period in order to match the projections made by the Short-Range office. We exponentially interpolate the values of  $pDSDW_{RES}^{year}$  for intermediate years between  $pDSDW_{RES}^{TRYR-1}$  and  $pDSDW_{RES}^{TRYR+9}$  (equal to  $pDSDW_{RES}^{year} \times SRADJ^{DSDW}$ ). After the 10<sup>th</sup> year of the projection period, we linearly grade the adjustment factors to one over the 10 years beyond the end of the short-range period, thus gradually eliminating the effect of the short-range adjustment factors, so that we ultimately return to the long-range projections.

For the projection period, for ages 65 to 69 where age is less than the NRA when the beneficiary was age 60,  $pDSDW_{RES}^{year}$  is equal to  $pDSDW_{RES}^{year}$  at age 64 times an adjustment that accounts for the additional ages as NRA changes.

$$FACTOR_{age} = \begin{cases} 1, & NRA \text{ at age } 60 \geq age + 1 \\ NRA \text{ at age } 60 - age, & age < NRA \text{ at age } 60 < age + 1 \end{cases}$$

$$pDSDW_{RES}^{year} = pDSDW_{RES}^{year,64} \times \left( \frac{pDSDW_{RES}^{year,64}}{pDSDW_{RES}^{year,63}} \right)^{(age-64)} \times FACTOR_{age}, \quad \begin{matrix} 65 \leq age \leq 69 \text{ and} \\ age < NRA \text{ at age } 60 \end{matrix}$$

Equation 3.3.5 – Minor Children of Retired Workers (MCRWN)

We project the number of minor children of retired workers,  $MCRWN$ , by age of the minor ( $am = 0-17$ ) and sex of the account holder ( $sa = 1$  for male,  $sa = 2$  for female).

For children of male retired workers:

$$MCRWN_{M,sa}^{year} = mcrwChi_{M,am}^{year} \times \frac{rw\_sum_{year}}{pop\_sum_{year}} \times pMCRW_{RES}^{year} \quad (3.3.5.1)$$

For the number of minor children of male retired workers, we multiply the number of children under the age of 18 with a father who is at least 62 years old and who's other parent is not deceased ( $mcrwChi_{M,am}^{year}$ ) by the total number of male retired workers ages 62 to 71 ( $rw\_sum_{year}$ ) divided by the total number of males in the population ages 62 to 71 ( $pop\_sum_{year}$ ).

$pMCRW_{RES}$  represents the probability that a child who is eligible to receive minor-child benefits actually receives them. In the historical period, we calculate this as the ratio of the total number of minor children of retired workers actually receiving benefits to the total eligible to receive benefits.

$$pMCRW_{RES}^{year} = \frac{MCRWN_M^{year}}{mcrwChi_{M,am}^{year} \times \frac{rw\_sum_{year}}{pop\_sum_{year}}}$$

For the projection period, we take the average of these ratios over the last ten historical years and phase it in using a linear interpolation between the average and  $pMCRW_{RES}^{TRYR-1}$ . We apply an adjustment,  $SRADJ^{MCRW}$ , to the 10<sup>th</sup> year of the projection period in order to match the projections made by the Short-Range office. The adjustment factor is phased in over the first 10 years of the projection period with the full factor applied in the 10<sup>th</sup> year. After the 10th year of the projection period, we linearly grade these adjustment factors to one over the 10 years beyond the end of the short-range period, thus gradually eliminating the effect of the short-range adjustment factors, so that we ultimately return to the long-range projections.

For children of female retired workers:

$$MCRWN_{F,sa}^{year} = \frac{MCRWN_{Total,M}^{year} \times mcrwPrctFem}{1 - mcrwPrctFem} \times \frac{MCRWN_{an,F}^{TRYR-1}}{MCRWN_{Total,F}^{TRYR-1}} \quad (3.3.5.2)$$

$mcrwPrctFem$  represents the average over the last five historical years of the percentage of the total number of minor children of female retired workers, ages 0 to 17, to the total number of minor children for both male and female retired workers.

$$\frac{MCRWN_{Total,F}^{year}}{MCRWN_{Total,F}^{year} \times MCRWN_{Total,M}^{year}}$$

We maintain the total  $MCRWN_{0-17,F}^{YR}$  at this percentage over the entire projection period by

multiplying our estimate of  $MCRWN_{0-17,M}^{YR}$  by  $mcrwPrcntFem$  divided by its complement.

$$MCRWN_{0-17,F}^{YR} = \frac{MCRWN_{0-17,M}^{YR} \times mcrwPrcntFem}{1 - mcrwPrcntFem}$$

In order to distribute  $MCRWN_{0-17,F}^{YR}$  among the ages 0 to 17, we multiply  $MCRWN_{0-17,F}^{YR}$  by the proportion of beneficiaries at each age in the last historical year.

*Equation 3.3.6 – Minor Children of Deceased Workers (MCDWN)*

Minor Children of Deceased Workers

Exposure: SSA population by age (0-17) and sex of the account holder

- Linkages:  $pMCDW_{DEA}$  = probability that the parent is either retired or deceased  
 $pMCDW_{FIA}$  = probability that the primary account holder (PAH) is fully insured  
 $pMCDW_{RES}$  = probability that a child who is eligible to receive minor-child benefits actually receive the benefits

We project the number of minor children of deceased workers, along with all linkage factors, by age of the minor ( $am = 0-17$ ) and sex of the account holder ( $sa = 1$  for male,  $sa = 2$  for female). We calculate it as follows:

$$MCDWN = MCDW_{POP} \times pMCDW_{DEA} \times pMCDW_{FIA} \times pMCDW_{RES} \quad (3.3.6)$$

$MCDW_{POP}$  represents the subset of the population from which we draw these beneficiaries, and we set it equal to the Social Security area population ( $SSAPOP$ ).

$$MCDW_{POP} = SSAPOP$$

$pMCDW_{DEA}$  represents the status of the parent (PAH). This is set equal to the portion of the minor population where at least one parent is deceased.  $CHI_{DEA}$  represents the number of children having at least one deceased parent.

$$pMCDW_{DEA} = \frac{CHI_{DEA}}{MCDW_{POP}}$$

$pMCDW_{FIA}$  represents the probability that the parent (PAH) is fully insured. We set this equal to the portion of the population aged  $25+am$  to  $35+am$  where the PAH is fully insured ( $FI_{PAH}$ ).

$$pMCDW_{FIA} = \frac{\sum_{25+am}^{35+am} [SSAPOP \times FI_{PAH}]}{\sum_{25+am}^{35+am} SSAPOP}$$

$pMCDW_{RES}$  represents the probability that a child who is eligible to receive minor-child benefits actually receive the benefits. For all historical years, we calculate  $pMCDW_{RES}^{year}$  as the ratio of  $MCDWN$ , the actual number of minor children of deceased workers receiving benefits, to the number of persons meeting all previously mentioned requirements by age and

sex of the parent.

$$pMCDW_{RES}^{year} = \frac{MCDWN}{MCDW_{POP} \times pMCDW_{DEA} \times pMCDW_{FIA}}, \quad year < TRYR$$

For each age and sex of parent, we use a least squares regression over the last ten years of historical data to determine a starting value in TR-1 for  $pMCDW_{RES}^{year}$  from which we project future values. We apply an adjustment,  $SRADJ^{MCDW}$ , to the 10<sup>th</sup> year of the projection period in order to match the projections made by the Short-Range office. We linearly interpolate the values of  $pMCDW_{RES}^{year}$  for intermediate years between the regressed values for  $pMCDW_{RES}^{TRYR-1}$  and  $pMCDW_{RES}^{TRYR+9} \times SRADJ^{MCDW}$ . After the 10<sup>th</sup> year of the projection period, we linearly grade the adjustment factors to one over the 10 years beyond the end of the short-range period, thus gradually eliminating the effect of the short-range adjustment factors, so that we ultimately return to the long-range projections.

### Equations 3.3.7-8 – Student Children of Retired and Deceased Workers (SCRWN and SCDWN)

#### Student Children of Retired Workers

Exposure: SSA population by age of the student (18-21) and sex of the account holder

- Linkages:
- $pSCRW_{DEA}$  = probability that at least one parent is retired
  - $pSCRW_{AGA}$  = probability that the primary account holder (PAH) is age 62 or older
  - $pSCRW_{FIA}$  = probability that the PAH is fully insured
  - $pSCRW_{CPA}$  = probability that the PAH is receiving benefits
  - $pSCRW_{SSB}$  = probability that the child is indeed attending school
  - $pSCRW_{RES}$  = probability that a child who is eligible to receive student-child benefits actually receives the benefits

#### Student Children of Deceased Workers

Exposure: SSA population by age of the student (18-21) and sex of the account holder

- Linkages:
- $pSCDW_{DEA}$  = probability that at least one parent is deceased
  - $pSCDW_{AGA}$  = probability that the PAH is age 62 or older (set to 1)
  - $pSCDW_{FIA}$  = probability that the PAH is fully insured
  - $pSCDW_{CPA}$  = probability that the PAH is receiving benefits (set to 1)
  - $pSCDW_{SSB}$  = probability that the child is indeed attending school
  - $pSCDW_{RES}$  = probability that a child who is eligible to receive student-child benefits actually receives the benefits

We project the number of student children of retired and deceased workers, along with all linkage factors, by age of the student ( $as = 18, 19$ ) and sex of the account holder ( $sa = 1$  for male,  $sa = 2$  for female). We calculate the projected number of student children of retired and deceased workers as follows:

$$SCRWN = SCRW_{POP} \times pSCRW_{DEA} \times pSCRW_{AGA} \times pSCRW_{FIA} \times pSCRW_{CPA} \times pSCRW_{SSB} \times pSCRW_{RES} \quad (3.3.7)$$

$$\begin{aligned}
SCDWN = & SCDW_{POP} \times pSCDW_{DEA} \times pSCDW_{AGA} \times pSCDW_{FIA} \\
& \times pSCDW_{CPA} \times pSCDW_{SSB} \times pSCDW_{RES}
\end{aligned} \tag{3.3.8}$$

$SCRW_{POP}$  and  $SCDW_{POP}$  represent the subset of the population from which these beneficiaries are drawn, and we set them equal to the Social Security area population ( $SSAPOP$ ).

$$SCRW_{POP} = SCDW_{POP} = SSAPOP$$

$pSCRW_{DEA}$  and  $pSCDW_{DEA}$  represent the status of the parent (PAH). For student children of retired workers, we set this equal to the proportion of the subset of the population where neither parents are deceased. For student children of deceased workers, we set this equal to the proportion of the subset of the population where at least one parent is deceased.  $CHI_{DEA}$  represents the number of student children having at least one deceased parent.

$$pSCRW_{DEA} = 1 - \frac{CHI_{DEA}}{SCRW_{POP}}$$

$$pSCDW_{DEA} = \frac{CHI_{DEA}}{SCDW_{POP}}$$

$pSCRW_{AGA}$  and  $pSCDW_{AGA}$  represent the probability that the PAH is age 62 or older. For student children of retired workers, we set this equal to the proportion of the student population that has one parent age 62 or older,  $CHI_{62+}$ . For student children of deceased workers, we set the factor equal to one.

$$pSCRW_{AGA} = \frac{CHI_{62+}}{SCRW_{POP}}$$

$$pSCDW_{AGA} = 1$$

$pSCRW_{FIA}$  and  $pSCDW_{FIA}$  represent the probability that the PAH is fully insured. For student children of retired workers, we set this equal to the portion of the population aged 62 to 64+ $as$  where the PAH is fully insured ( $FI_{PAH}$ ). For student children of deceased workers, we calculate the factor similarly with the population being aged 25+ $as$  to 35+ $as$ .

$$pSCRW_{FIA} = \frac{\sum_{62}^{64+as} [SSAPOP \times FI_{PAH}]}{\sum_{62}^{64+as} SSAPOP}$$

$$pSCDW_{FIA} = \frac{\sum_{25+as}^{35+as} [SSAPOP \times FI_{PAH}]}{\sum_{25+as}^{35+as} SSAPOP}$$

$pSCRW_{CPA}$  and  $pSCDW_{CPA}$  represent the probability that the PAH is receiving benefits. For student children of retired workers, we set this factor equal to the portion of the population aged 62 to 64+ $as$  where the PAH is receiving benefits ( $RETIRED$ ). For student children of deceased workers, we set this factor equal to one.

$$pSCRW_{CPA} = \frac{\sum_{62}^{64+as}[SSAPOP \times FI\_PAH \times RETIRED]}{\sum_{62}^{64+as}[SSAPOP \times FI\_PAH]}$$

$$pSCDW_{CPA} = 1$$

$pSCRW_{SSB}$  and  $pSCDW_{SSB}$  represent the probability that the child is indeed attending school (full-time elementary or secondary school). This factor is dependent upon the age of the child, and we calculate it as follows.

$$pSCRW_{SSB} = pSCDW_{SSB} = \begin{cases} \frac{1}{as - 16}, & year \leq 1981 \\ \frac{0.5}{as - 16}, & year > 1981 \end{cases}$$

$pSCRW_{RES}$  and  $pSCDW_{RES}$  represent the probability that a child who is eligible to receive student-child benefits actually receive the benefits. For all historical years, we calculate  $pSCRW_{RES}^{year}$  and  $pSCDW_{RES}^{year}$  as the ratio of  $SCRWN$  and  $SCDWN$ , the actual number of student children receiving benefits, to the number of persons meeting all previously mentioned requirements by age and sex of the parent.

$$pSCRW_{RES}^{year} = \frac{SCRWN}{SCRW_{POP} \times pSCRW_{DEA} \times pSCRW_{AGA} \times pSCRW_{FIA} \times pSCRW_{CPA} \times pSCRW_{SSB}}, \quad year < TRYR$$

$$pSCDW_{RES}^{year} = \frac{SCDWN}{SCDW_{POP} \times pSCDW_{DEA} \times pSCDW_{AGA} \times pSCDW_{FIA} \times pSCDW_{CPA} \times pSCDW_{SSB}}, \quad year < TRYR$$

For each age and sex of parent, we use a least squares regression over the last ten years of historical data to determine a starting value in TR-1 for  $pSCRW_{RES}^{year}$  from which we project future values. We apply an adjustment,  $SRADJ^{SCRW}$ , to the 10<sup>th</sup> year of the projection period in order to match the projections made by the Short-Range office. We linearly interpolate the values of  $pSCRW_{RES}^{year}$  for intermediate years between the regressed values for  $pSCRW_{RES}^{TRYR-1}$  and  $pSCRW_{RES}^{TRYR+9} \times SRADJ^{SCRW}$ . After the 10<sup>th</sup> year of the projection period, we linearly grade the adjustment factors to one over the 10 years beyond the end of the short-range period, thus gradually eliminating the effect of the short-range adjustment factors, so that we ultimately return to the long-range projections. We calculate the values of  $pSCDW_{RES}^{year}$  similarly.

*Equations 3.3.9-10 – Disabled Adult Children of Retired and Deceased Workers (DCRWN and DCDWN)*

Disabled Adult Children of Retired Workers

Exposure: SSA population by age of the adult child (18-95)

Linkages:  $pDCRW_{AGA}$  = probability that the primary account holder (PAH) is age 62 or older

$pDCRW_{DEA}$  = probability that the parent is retired

$pDCRW_{FIA}$  = probability that the PAH is fully insured

- $pDCRW_{CPA}$  = probability that the PAH is receiving benefits  
 $pDCRW_{SSB}$  = probability that the child is indeed disabled  
 $pDCRW_{RES}$  = probability that a child who is eligible to receive disabled-child benefits actually receive benefits

Disabled Adult Children of Deceased Workers

Exposure: SSA population by age of the adult child (18-95)

- Linkages:  $pDCDW_{AGA}$  = probability that the PAH is age 62 or older (set to 1)  
 $pDCDW_{DEA}$  = probability that the parent is deceased  
 $pDCDW_{FIA}$  = probability that the PAH is fully insured  
 $pDCDW_{CPA}$  = probability that the PAH is receiving benefits (set to 1)  
 $pDCDW_{SSB}$  = probability that the child is indeed disabled  
 $pDCDW_{RES}$  = probability that a child who is eligible to receive disabled-child benefits actually receive the benefits

We project the number of disabled adult children of retired and deceased workers, along with all linkage factors, by age group of the disabled adult child ( $ad = 1-10$ ) and sex of the account holder ( $sa = 1$  for male,  $sa = 2$  for female). The age groups are 18-19, 20-24, ..., 55-59, 60+. We calculate the projected number of disabled adult children of retired and deceased workers as follows:

$$DCRWN = DCRW_{POP} \times pDCRW_{AGA} \times pDCRW_{DEA} \times pDCRW_{FIA} \times pDCRW_{CPA} \times pDCRW_{SSB} \times pDCRW_{RES} \quad (3.3.9)$$

$$DCDWN = DCDW_{POP} \times pDCDW_{AGA} \times pDCDW_{DEA} \times pDCDW_{FIA} \times pDCDW_{CPA} \times pDCDW_{SSB} \times pDCDW_{RES} \quad (3.3.10)$$

We calculate all factors similarly to those for student children with the exception of the following.

$pDCRW_{DEA}$  is set equal to the proportion of the married and widowed population who are married (for ages of the parent that are reasonable based on the given age range of the disabled child). We calculate  $pDCDW_{DEA}$  similarly for disabled children of deceased workers.

$$pDCRW_{DEA} = \begin{cases} \frac{SSAPOP_{mar}}{SSAPOP_{mar} + SSAPOP_{wid}}, & ad = 1 - 9 \\ \frac{0.25 \times SSAPOP_{mar}}{SSAPOP_{mar} + SSAPOP_{wid}}, & ad = 10 \end{cases}$$



$$pDCDW_{DEA} = \begin{cases} \frac{SSAPOP_{wid}}{SSAPOP_{mar} + SSAPOP_{wid}}, & ad = 1 - 9 \\ \frac{0.25 \times SSAPOP_{wid}}{SSAPOP_{mar} + SSAPOP_{wid}} + 0.75, & ad = 10 \end{cases}$$

$pDCRW_{SSB}$  and  $pDCDW_{SSB}$  represent the probability that the adult child is indeed disabled. DCPREM is the preliminary calculation of this factor and we assume it to remain constant. For the projection period, for  $ad = 6-10$ , we set  $pDCRW_{SSB}$  and  $pDCDW_{SSB}$  equal to the preliminary factor, plus an adjustment which accounts for the year.

$$DCPREM = \begin{cases} 0.012, & ad = 1, 2 \\ 0.009, & ad = 3 \\ 0.007, & ad = 4 \\ 0.006, & ad = 5 \\ 0.005, & ad = 6 \\ 0.004, & ad = 7-10 \end{cases}$$

$$pDCRW_{SSB} = pDCDW_{SSB} = \begin{cases} \min[0.005, DCPREM + 0.0001 \times (year - TRYR)], & ad = 7 - 10 \text{ and} \\ & year > TRYR + 1 \\ DCPREM, & elsewhere \end{cases}$$

$pDCRW_{RES}$  and  $pDCDW_{RES}$  represent the probability that a child who is eligible to receive disabled-child benefits actually receive the benefits. For all historical years, we calculate  $pDCRW_{RES}^{year}$  and  $pDCDW_{RES}^{year}$  as the ratio of  $DCRWN$  and  $DCDWN$ , the actual number of disabled children receiving benefits, to the number of persons meeting all previously mentioned requirements by age and sex of the parent.

For  $year < TRYR$ :

$$pDCRW_{RES}^{year} = \frac{DCRWN}{DCRW_{POP} \times pDCRW_{DEA} \times pDCRW_{AGA} \times pDCRW_{FIA} \times pDCRW_{CPA} \times pDCRW_{SSB}}$$

$$pDCDW_{RES}^{year} = \frac{DCDWN}{DCDW_{POP} \times pDCDW_{DEA} \times pDCDW_{AGA} \times pDCDW_{FIA} \times pDCDW_{CPA} \times pDCDW_{SSB}}$$

We apply an adjustment,  $SRADJ^{DCRW}$ , to the 10<sup>th</sup> year of the projection period in order to match the projections made by the Short-Range office. We linearly interpolate the values of  $pDCRW_{RES}^{year}$  for intermediate years between  $pDCRW_{RES}^{TRYR-1}$  and  $pDCRW_{RES}^{TRYR+9} \times SRADJ^{DCRW}$ . After the 10<sup>th</sup> year of the projection period, we linearly grade the adjustment factors to one over the 10 years beyond the end of the short-range period, thus gradually eliminating the effect of the short-range adjustment factors, so that we ultimately return to the long-range projections. We calculate the values of  $pDCDW_{RES}^{year}$  similarly.

Equations 3.3.11-12 – Young Spouses of Retired and Deceased Workers (YSRW and YSDW)

Young Spouses of Retired Workers

Exposure: SSA population by age (15-69), sex of account holder, and marital status (married)

- Linkages:  $pYSRW_{AGA}$  = probability that the primary account holder (PAH) is of the required age.  
 $pYSRW_{ECB}$  = probability that the young spouse has an entitled child in their care  
 $pYSRW_{FSB}$  = probability that the young spouse is not already receiving benefits based on another child in their care  
 $pYSRW_{RES}$  = probability that a person who is eligible to receive young-spouse benefits actually receive the benefits

Young Spouses of Deceased Workers

Exposure: SSA population by age (15-69), sex of the account holder and marital status (widowed and divorced)

- Linkages:  $pYSDW_{DEA}$  = probability that the PAH is deceased  
 $pYSDW_{ECB}$  = probability that the young spouse has an entitled child in their care  
 $pYSDW_{FSB}$  = probability that the young spouse is not already receiving benefits based on another child in their care  
 $pYSDW_{RMB}$  = probability that the young spouse is not remarried  
 $pYSDW_{RES}$  = probability that a person who is eligible to receive young-spouse benefits actually receive the benefits

We project the number of young spouses of retired and deceased-workers, along with all linkage factors, by age group ( $ab = 1-10$ ) of the young spouse and sex of the account holder ( $sa = 1$  for male,  $sa = 2$  for female). We also project young spouses of deceased workers by marital status of the young spouse ( $mb = 1$  for widowed and  $mb = 2$  for divorced). The age groups are under 25, 25-29 ..., 65-69. We calculate the projected number of young spouses of retired and deceased-workers as follows:

$$YSRW_{POP} = YSRW_{POP} \times pYSRW_{AGA} \times pYSRW_{ECB} \times pYSRW_{FSB} \times pYSRW_{RES} \quad (3.3.11)$$

$$YSDW_{POP} = YSDW_{POP} \times pYSDW_{DEA} \times pYSDW_{ECB} \times pYSDW_{FSB} \times pYSDW_{RMB} \times pYSDW_{RES} \quad (3.3.12)$$

$YSRW_{POP}$  and  $YSDW_{POP}$  represent the subset of the population from which we draw these beneficiaries. We set  $YSRW_{POP}$  equal to the married Social Security area population ( $SSAPOP_{mar}$ ) and we set  $YSDW_{POP}$  equal to  $SSAPOP_{mb}$  for  $mb = 1, 2$ .

$$YSRW_{POP} = SSAPOP_{mar}$$

$$YSDW_{POP} = SSAPOP_{mb}$$

$pYSRW_{AGA}$  represents the probability that the PAH is of the required age. We set  $pYSRW_{AGA}$  equal to the portion of the married population who has an aged spouse (*AGSP*).

$$pYSRW_{AGA} = \frac{AGSP}{YSRW_{POP}}$$

$pYSDW_{DEA}$  represents the probability that the PAH is deceased. For  $mb = 1$ , we do not apply any factor. For  $mb = 2$ , we set this factor equal to the portion of young spouses that is widowed.

$$pYSDW_{DEA} = \begin{cases} 1, & mb = 1 \text{ (widowed)} \\ \frac{SSAPOP_{wid}}{SSAPOP_{wid} + SSAPOP_{mar}}, & mb = 2 \text{ (divorced)} \end{cases}$$

$pYSRW_{ECB}$  and  $pYSDW_{ECB}$  represent the probability that the young spouse has an entitled child in their care. We set  $YSRW_{ECB}$  equal to the portion of persons meeting the previously mentioned requirements who have a minor or disabled adult child in their care. We set  $YSDW_{ECB}$ , by marital status, equal to the portion of persons meeting the previously mentioned requirements who have a minor or disabled adult child in their care.  $MCRWN^{ab}$  and  $DCRWN^{ab}$  represent the total number of minor and disabled adult children of retired workers where the other parent (young spouse) is in the age bracket  $ab$ .

$$pYSRW_{ECB}^{ab} = \frac{MCRWN^{ab} + DCRWN^{ab}}{YSRW_{POT} \times pYSRW_{AGA}}$$

$$pYSDW_{ECB}^{mb} = \frac{(MCDWN^{ab} + DCDWN^{ab}) \times \left[ \frac{YSDW_{POP}^{mb} \times pYSDW_{DEA}^{mb} \times pYSDW_{AGA}^{mb}}{YSDW_{POP}^{total} \times pYSDW_{DEA}^{total} \times pYSDW_{AGA}^{total}} \right]}{YSDW_{POP} \times pYSDW_{DEA}}$$

$pYSRW_{FSB}$  and  $pYSDW_{FSB}$  represent the probability that the young spouse is not already receiving benefits based on another child in their care. We set this factor equal to one divided by the number of children in the average family ( $ASOF_{ab}$ ) for the given age bracket of the spouse. For young spouses of retired workers, we do not apply a factor for  $sa = 2$ .

$$pYSRW_{FSB} = \begin{cases} \frac{1}{ASOF_{ab}}, & sa = 1 \\ 1, & sa = 2 \end{cases}$$

$$pYSDW_{FSB} = \frac{1}{ASOF_{ab}}$$

$pYSDW_{RMB}$  represents the probability that the spouse is not remarried. We assume this factor remains constant at 0.600.

$$pYSDW_{RMB} = 0.600$$

$pYSRW_{RES}$  and  $pYSDW_{RES}$  represent the probability that a person who is eligible to receive young-spouse benefits actually receive the benefits. For all historical years, we calculate  $pYSRW_{RES}^{year}$  as the ratio of  $YSRW_{RES}$ , the actual number of young spouses of retired workers receiving benefits, to the number of persons meeting all previously mentioned requirements by age, sex, and marital status. We calculate  $pYSDW_{RES}^{year}$  similarly, using the number of young spouses of deceased workers.

$$pYSRW_{RES} = \frac{YSRW_{RES}}{YSRW_{POP} \times pYSRW_{AGA} \times pYSRW_{ECB} \times pYSRW_{FSB}}, \quad year < TRYR$$

$$pYSDW_{RES} = \frac{YSDW_{RES}}{YSDW_{POP} \times pYSDW_{DEA} \times pYSDW_{ECB} \times pYSDW_{FSB} \times pYSDW_{RMB}}, \quad year < TRYR$$

For each age, sex, and marital status, we use a least squares regression over the last ten years of historical data to determine a starting value in TR-1 for  $pYSRW_{RES}^{year}$ . In addition, for each sex and marital status we graduate the regressed values of  $pYSRW_{RES}^{TRYR-1}$  over age using a weighted minimized third-difference formula to compute  $ESTRES^{YSRW}$ .  $ESTRES^{YSRW}$  are the preliminary estimates of  $pYSRW_{RES}^{TRYR+9}$ , the values in the 10<sup>th</sup> year of the projection period. For female young spouses, we apply an adjustment,  $SRADJ^{YSRW}$ , to the 10<sup>th</sup> year of the projection period in order to match the projections made by the Short-Range office. We exponentially interpolate the values of  $pYSRW_{RES}^{year}$  for intermediate years between  $pYSRW_{RES}^{TRYR-1}$  and  $pYSRW_{RES}^{TRYR+9}$ , (equal to  $ESTRES^{YSRW} \times SRADJ^{YSRW}$ ). After the 10<sup>th</sup> year of the projection period, we linearly grade the adjustment factors to one over the 10 years beyond the end of the short-range period, thus gradually eliminating the effect of the short-range adjustment factors, so that we ultimately return to the long-range projections. We calculate the values of  $pYSDW_{RES}^{year}$  similarly.

*Equation 3.3.13 – Number of Deaths of Insured Workers ( $LUMSUM_{ab}$ )*

We project the number of deaths of insured workers by sex and 5-year age group ( $ab = 1-14$ ). Age groups include 20-24, 25-29, ..., 80-84, 85+. We calculate  $EXPOSURE_{ab}$ , the estimated number of lump-sum payments paid during the year for age group  $ab$ , as the number of total deaths during the year times the probability that the deceased was fully insured and has a surviving spouse or child. We calculate  $BASE$  as the ratio of the actual total amount of lump-sum death payments paid in TRYR-1 to the estimated total amount of lump-sum payments paid in TRYR-1. We then calculate  $LUMSUM_{ab}$  for each year in the projection period.

$$LUMSUM_{ab} = EXPOSURE_{ab} \times BASE \tag{3.3.13}$$

**Appendix 3.3-1: Glossary**

**AB:** age group of the beneficiary

**AD:** age of the disabled child

**AGSP:** married population where at least one spouse is age 62 or older

**AM:** age of the minor child

**ARFGT3:** actuarial reduction factor for ages more than 3 years below normal retirement age

**ARFLE3:** actuarial reduction factor for ages less than 3 years below normal retirement age

**AS:** age of the student child

**ASDW:** aged spouse of deceased worker by linkage factor, age (60-95+), sex of the account holder, marital status (widowed, divorced) and insured status (insured, uninsured). Linkage factors are:

$ASDW_{POP}$	population of potential aged spouse of retired workers
$pASDW_{DEA}$	probability that the primary account holder (PAH) is deceased
$pASDW_{FIA}$	probability that the PAH was fully insured at death
$pASDW_{MBB}$	probability that the widow(er) is not receiving a young-spouse benefit for the care of a child
$pASDW_{FIB}$	probability that the aged widow(er) is fully insured
$pASDW_{GPB}$	probability that the aged-widow(er)'s benefits are not withheld or offset totally because of receipt of a significant government pension based on earnings in non-covered employment
$pASDW_{RES}$	probability that a widow(er) eligible to receive his/her own retired-worker benefits would instead apply for and receive widow(er) benefits

**ASDWN:** final number of aged spouse of deceased workers (product of all linkage factors)

**ASOF:** average number of children in a family, by age group (under 25, 25-29 ..., 60-64)

**ASRW:** aged spouse of retired worker by linkage factor, age (62-95+), sex of the account holder, and marital status of the beneficiary (married, divorced). Linkage factors are:

$ASRW_{POP}$	population of potential aged spouse of retired worker beneficiaries
$pASRW_{DEA}$	probability that the primary account holder (PAH) is not deceased
$pASRW_{AGA}$	probability that the PAH is of the required age
$pASRW_{FIA}$	probability that the PAH is fully insured
$pASRW_{CPA}$	probability that the PAH is receiving benefits
$pASRW_{MBB}$	probability that the beneficiary is not receiving a young-spouse benefit
$pASRW_{FIB}$	probability that the aged spouse is not fully insured
$pASRW_{GPB}$	probability that the aged-spouse's benefits are not withheld because of receipt of a significant government pension based on earnings in non-covered employment
$pASRW_{FS1}$	probability that a couple will engage in a filing strategy in which the PAH files for and suspends their benefit and an uninsured spouse receives an aged spouse benefit
$pASRW_{FS2}$	probability that a couple will engage in a filing strategy in which the PAH files for and may or may not suspend their benefit and the fully insured for their aged spouse benefit.
$pASRW_{RES}$	probability that a person who is eligible to receive aged-spouse benefits actually receive the benefits

**ASRWN:** final number of aged spouse of retired workers (product of all linkage factors)

**AH:** age of husband

**AW:** age of wife

**BASE:** ratio of actual to estimated total amount of lump-sum death payments paid in TRYR-1

**BBA:** Bipartisan Budget Act of 2015. A provision of this act closes unintended loopholes by eliminating (1) the ability to receive only a retired-worker benefit or an aged-spouse benefit when eligible for both, for those attaining age 62 in 2016 and later, and (2) the ability of a family member other than a divorced spouse to receive a benefit based on the earnings of a worker with a voluntarily suspended benefit, for voluntary suspensions requested after April 29, 2016.

**CHI\_62+:** number of children having at least one parent aged 62 or older

**CHI\_DEA:** number of children having at least one deceased parent

**CON:** number of persons converted from disabled-worker beneficiaries

**DCDW:** disabled child of deceased workers by linkage factor, age group of the child (18-19, 20-24, ..., 55-59, 60+) and sex of the account holder. Linkage factors are same as SCDW.

$DCDW_{POP}$ : population of potential disabled children

$pDCDW_{AGA}$ : probability that the PAH is age 62 or older

$pDCDW_{DEA}$ : probability that the parent is either retired or deceased

$pDCDW_{FIA}$ : probability that the PAH is fully insured

$pDCDW_{CPA}$ : probability that the PAH is receiving benefits

$pDCDW_{SSB}$ : probability that the child is indeed disabled

$pDCDW_{RES}$ : probability that a child who is eligible to receive disabled-child benefits actually receive the benefits

**DCDWN:** final number of disabled children of deceased workers (product of all linkage factors)

**DCPREM:** preliminary calculation of the probability that a child is disabled, by age

**DCRW:** disabled child of retired workers by linkage factor, age group of the child (18-19, 20-24, ..., 55-59, 60+) and sex of the account holder. Linkage factors are same as those for DCDW.

**DCRWN:** final number of disabled children of retired workers (product of all linkage factors)

**DIB:** number of disabled-worker beneficiaries

**DIFFADJ:** adjustment that accounts for the difference between the actual and estimated prevalence rate at each age in the most recent historical years

**DISPREV:** disability prevalence rate by age and sex

**DRC:** delayed retirement credit

**DSDW:** disabled spouse of deceased worker by linkage factor, age (50-69), sex of the account holder, and marital status (widowed, divorced). Linkage factors are:

$DSDW_{POP}$ : population of potential beneficiaries

$pDSDW_{DEA}$ : probability that the primary account holder (PAH) is deceased

$pDSDW_{FIA}$ : probability that the PAH was fully insured at death

$pDSDW_{SSB}$ : probability that the spouse is indeed disabled

$pDSDW_{DEB}$ : probability that the disabled spouse is not receiving another type of benefit

$pDSDW_{RES}$ : probability that a person who is eligible to receive disabled-spouse benefits actually receive the benefits

**DSDWN:** final number of disabled spouse of deceased workers (product of all linkage factors)

**ERROR:** actual prevalence rate minus the regressed prevalence rate in the most recent historical year

**ESTPR:** preliminary estimate of the prevalence rate for retired workers

**ESTRES:** preliminary estimate of the RES factor for the 10<sup>th</sup> year of the projection period

**EXPOSURE:** estimated number of lump-sum payments by age group (20-24, 25-29,...,80-84, 85+)

**FACTOR:** adjustment for calculation of MBB factor of aged spouse of deceased worker

**FINS:** portion of the SSA population that is fully insured

**FI\_PAH:** portion of married population where one spouse is fully insured

**FP:** status of the parent (retired, deceased)

**FILEG:** fraction of the LPR SSA population that is fully insured

**GPOAGE:** portion, by age, of the total beneficiaries expected to receive a significant government pension

**GPWHLD:** total number of beneficiaries (for all ages) expected to receive a significant government pension

**IN:** insured status of the beneficiary

**LFPR:** labor force participation rates for age 62, by sex

**LUMSUM:** number of deaths of insured workers by sex and age group (20-24,...,80-84,85+)

**MAR62PLUS:** number of couples where both husband and wife are age 62 and over

**MS:** marital status of the primary account holder

**MB:** marital status of the beneficiary

**MBAPIA:** ratio of the monthly benefit amount (MBA) to the primary insurance amount (PIA) by age (62-70) and sex

**MCDW:** minor children of deceased workers by linkage factor, age of the child (0-17) and sex of the account holder. Linkage factors are:

$MCDW_{POP}$  : population of potential minor children

$pMCDW_{DEA}$  : probability that the parent is either retired or deceased

$pMCDW_{FIA}$  : probability that the PAH is fully insured

$pMCDW_{RES}$  : probability that a child who is eligible to receive minor-child benefits actually receive the benefits

**MCDWN:** final number of minor children of deceased workers (product of all linkage factors)

**MCRW:** minor children of retired workers by linkage factor, age of the child (0-17) and sex of the account holder.

**MCRWN:** final number of minor children of retired workers (product of all linkage factors)

**NRA:** normal retirement age

**PAH:** primary account holder

**REGPR:** regressed prevalence rate for retired workers

**RETIRED:** number of retired workers receiving benefits

**RW:** retired workers by linkage factor, age (62-95+), sex, and marital status (single, married, widowed, divorced). Linkage factors are:

$RW_{POP}$  : population of potential retired-worker beneficiaries

$pRW_{FIA}$  : probability that the primary account holder (PAH) is insured

$pRW_{DBB}$  : probability that the PAH is not receiving a disabled-worker benefit

$pRW_{WBB}$  : probability that the PAH is not receiving a widow(er) benefit

$pRW_{RES}$  : retirement prevalence rate; probability that a fully insured worker (not receiving disability or widow(er)'s benefits) would receive a retired-worker benefit

**RWN:** final number of retired workers (product of all linkage factors)

**SA:** sex of the account holder

**SCDW:** student children of deceased workers by linkage factor, age of the student (18-21) and sex of the account holder. Linkage factors are:

$SCDW_{POP}$ : population of potential student children

$pSCDW_{DEA}$ : probability that the parent is either retired or deceased

$pSCDW_{AGA}$ : probability that the PAH is age 62 or older

$pSCDW_{FIA}$ : probability that the PAH is fully insured

$pSCDW_{CPA}$ : probability that the PAH is receiving benefits

$pSCDW_{SSB}$ : probability that the child is indeed attending school

$pSCDW_{RES}$ : probability that a child who is eligible to receive student-child benefits actually receive the benefits

**SCDWN:** final number of student children of deceased workers (product of all linkage factors)

**SCRW:** student children of retired workers by linkage factor, age of the student (18-21) and sex of the account holder. Linkage factors are same as SCDW.

**SCRWN:** final number of student children of retired workers (product of all linkage factors)

**SRADJ:** adjustment to match short-range projections in 10<sup>th</sup> year of projection period

**SSAPOP:** Social Security area population by age (0:100), sex, and marital status (single, married, widowed, divorced)

**SX:** sex of the beneficiary

**TRYR:** first year of the projection period

**WEIGHT:** estimated probability applied to each possible age of the spouse, given the age of the primary account holder

**YSDW:** young spouse of deceased worker by linkage factor, age group (under 25, 25-29, ..., 65-69), sex of the account holder and marital status (widowed, divorced). Linkage factors are:

$YSDW_{POP}$ : population of potential young spouse of deceased workers

$pYSDW_{DEA}$ : probability that the primary account holder (PAH) is of the required age

$pYSDW_{ECB}$ : probability that the young spouse has an entitled child in their care

$pYSDW_{FSB}$ : probability that the young spouse is not already receiving benefits based on another child in their care

$pYSDW_{RMB}$ : probability that the young spouse is not remarried

$pYSDW_{RES}$ : probability that a person who is eligible to receive young-spouse benefits actually receive the benefits

**YSDWN:** final number of young spouse of deceased workers (product of all linkage factors)

**YSRW:** young spouse of retired worker by linkage factor, age group (under 25, 25-29, ..., 65-69) and sex of the account holder. Linkage factors are:

$YSRW_{POP}$ : population of potential young spouse of retired workers

$pYSRW_{AGA}$ : probability that the primary account holder (PAH) is of the required age

$pYSRW_{ECB}$ : probability that the young spouse has an entitled child in their care

$pYSRW_{FSB}$ : probability that the young spouse is not already receiving benefits based on another child in their care



$pYSRW_{RES}$ : probability that a person who is eligible to receive young-spouse benefits actually receive the benefits

**YSRWN:** final number of young spouse of retired workers (product of all linkage factors)

**Process 4:**

**Trust Fund  
Operations &  
Actuarial Status**

#### ***4. Trust Fund Operations and Actuarial Status***

OCACT uses the Trust Fund Operations and Actuarial Status Process to project (1) the annual flow of income from payroll taxes, taxation of benefits, and interest on assets in the trust fund and (2) the annual flow of cost from benefit payments, administration of the program, and railroad interchange. The annual flows are projected for each year of the 75-year projection period. In addition, this subprocess produces annual and summarized values to help assess the financial status of the Social Security program.

The Trust Fund Operations and Actuarial Status Process is composed of three subprocesses: TAXATION OF BENEFITS, AWARDS, and COST. As a rough overview, TAXATION OF BENEFITS projects, for each year during the 75-year projection period, the amount of income from taxation of benefits as a percent of benefits paid. AWARDS projects information needed to determine the benefit levels of newly awarded retired workers and disabled workers by age and sex. COST uses information from the AWARDS and TAXATION OF BENEFITS subprocesses, as well as information from other processes, to project the annual flow of income and cost to the trust funds. In addition, COST produces annual and summarized measures of the financial status of the Social Security program.

## 4.1. TAXATION OF BENEFITS

### 4.1.a. Overview

The 1983 Social Security Act specifies including up to 50 percent of the Social Security benefits to tax return filer's adjusted gross income (AGI) for tax liability if a tax return filer's adjusted gross income plus half of his (or her) Social Security benefits is above the specified income threshold amount of \$25,000 as a single filer (or \$32,000 as a joint filer). Subsequently, the 1993 OBRA (Omnibus Budget Reconciliation Act) provided for taxation of up to 85 percent if a tax return filer's adjusted gross income plus half of his (or her) Social Security benefits is above the specified income threshold amount of \$34,000 as a single filer (or \$44,000 as a joint filer).

The proceeds from taxing up to 50 percent of the OASDI benefits, as a result of the 1983 Act, are credited to the OASI and DI Trust Funds, while additional taxes on the OASDI benefits, as a result of the 1993 Act, are credited to the HI Trust Fund.

Income to the Trust Funds from such taxation is estimated by using ratios of taxes on benefits to benefits for the OASI and DI programs separately. These ratios, called "RTBs", are applied to projected OASI and DI benefit amounts to estimate tax revenues to the OASI and DI Trust Funds.

Initially we rely on the OTA (Office of Tax Analysis)'s estimates of the percent of benefits taxable for OASI and DI benefits separately and the average marginal tax rates applicable to those taxable OASI and DI benefits. These estimates are based on IRS (Internal Revenue Service) tax returns data.

For the short range period (first 10 years of the projection), the Cost sub-process (4.3) uses OTA (Office of Tax Analysis)'s projected estimates for (1) the percent of benefits taxable and (2) the average marginal tax rates applicable to those taxable OASI and DI benefits. The multiplication of (1) and (2) produces projected RTBs under the 1983 Act (up to 50 percent of benefits taxable) and the 1993 OBRA (additional up to 35 percent of benefits taxable).

For the long range period (11<sup>th</sup> through 75<sup>th</sup> year of the projection period), we compute the RTB ratios for OASI benefits and those for DI benefits under the 1983 Act and the combined 1983 + 1993 Act with the following formula for each projection year.

$$\text{RTB}(\text{yr}) = \text{RTB}(\text{tryr}+9) * \{ \text{AWI}(\text{tryr}+9) / \text{AWI}(\text{yr}) \}^{\text{P}} + \text{RTB}(\text{ultimate}) * \{ 1 - \text{AWI}(\text{tryr}+9) / \text{AWI}(\text{yr}) \}^{\text{P}}, \quad (4.1.1)$$

where

tryr = first year of the projection period (year of the Trustees Report)

RTB(ultimate) = ratio of taxes on benefits to benefits assuming income

Threshold amounts equal zero.

AWI = SSA average wage index series

P = exponential parameter for a trend curve line.

After initial estimates of projected ratios of taxes on benefits to benefits by Trust Fund, based on the OTA's data, we include nonresident alien withholding tax revenue projections by our Short Range office since the OTA does not include nonresident withholding tax revenues. We add estimated nonresident tax revenues, as a ratio of taxes on benefits to benefits by Trust Fund, to the above projected ratios of taxes on benefits to benefits based on OTA data, to arrive at the final RTB ratios. Finally, the Cost sub-process (4.3) applies the projected RTB ratios to our own estimates of the projected OASI and DI benefit payments to produce taxation of benefit revenues to the OASI and DI Trust Funds.

#### **4.1.b. Input Data**

##### *OCACT Data*

###### Economics--process 2

- 1a. Projected SSA wage index series by year, updated yearly
- 1b. Projected COLAs and average wage index levels under the intermediate assumptions of the prior Trustees Report

###### Beneficiaries--process 3

- 2a. Projected OASI beneficiaries by age and sex under the intermediate assumptions of the prior Trustees Report
- 2b. Projected DI beneficiaries by age and sex under the intermediate assumptions of the prior Trustees Report

###### Trust Fund Operations--process 4

3. Aggregate OASI and DI benefit ratios (as a ratio of total OASDI benefits) under the intermediate assumptions of the prior Trustees Report

###### OCACT Short-Range Office Data

- 4a. Nonresident alien withholding taxes for the OASI and DI benefits for the short range period
- 4b. Total OASI and DI benefits respectively for the short range period

##### *Other input Data*

5. OTA's projected percent of benefits taxable and average marginal tax rates by type of benefit (OASI and DI) for the short range period (updated yearly).
6. OTA's ultimate ratios of taxes on benefits to benefits (i.e., with income thresholds, assumed equal to 0). Such ultimate ratios are provided on a combined OASDI benefit basis, and are expected to be updated annually based on OTA's update.
7. Current Population Survey (CPS) data for year ni-3
8. Marginal income tax bracket amounts for tax years 2016 - 2018
9. Marginal income tax rates for tax years 2016 - 2018
10. General filing requirement amounts (standard deduction amounts) for personal income tax purposes for tax years 2016 -2018
11. Ratios of taxable income to adjusted gross income by income level (IRS data) for tax year ni-3
12. Treasury's aggregate taxable benefit amount (IRS data) for tax year ni-3
13. OTA's estimated taxes on benefits for the OASDI and HI Trust Funds for tax year ni-3
14. Aggregate OASDI benefit payment for calendar year ni-3

#### ***4.1.c. Development of Output***

For the short range period, the Cost sub-process (4.3) uses OTA's projected RTBs for OASI and DI benefits under the 1983 Act, to project taxation of benefit revenues to the OASI and DI Trust Funds.

For the long range period, formula 4.1.1 computes projected ratios of taxes on OASI benefits to OASI benefits and projected ratios of taxes on DI benefits to DI benefits under the 1983 Act (up to 50 percent of benefits taxable). This formula essentially provides more weight to the ultimate RTB ratios as time progresses, using the ratio of AWI (10<sup>th</sup> year) to AWI (projection year) as the "weight." Additionally, an exponential parameter P value to the AWI "weights" is set judgmentally such that the estimate continues the short range trend into the transitional 11<sup>th</sup> through 20<sup>th</sup> projection years before it approaches the ultimate RTB ratio. For the RTB ratios for up to 50 percent of benefits taxable, the P values were set at 0.99 and 0.99 to project smooth transitional RTB ratios for OASI and DI benefits, respectively.

The ultimate RTB ratios used in the projection are based on OTA's ultimate ratios, reduced by about 3.0 percent. This reduction reflects estimates of the effect of the higher proportion of "old elderly" beneficiaries in the 2095 OASDI beneficiary population distribution relative to the 2026 OASDI beneficiary population distribution, due to improved mortality.

For the 2018 Trustees Report, the ultimate RTB ratios for up to 50 percent of OASI and DI benefits taxable were set at 0.0615 and 0.0205, as compared to 0.0575 and 0.0205 for the 2017 TR ultimate ratios. Changes in the ultimate RTB ratios reflect OTA's updated zero threshold estimates.

Lastly, the Cost sub-process (4.3) applies these projected RTB ratios to projected OASI and DI benefit payments to develop estimated taxation of benefit revenues to the OASI and DI Trust Funds.

## 4.2. AWARDS

Each year over 2 million workers begin receiving either retired-worker or disabled-worker benefits. The monthly benefits for these new awards are based on their primary insurance amount (PIA). The PIA is computed using the average indexed monthly earnings (AIME) and the PIA benefit formula as specified in the 1977 amendments. The AIME depends on the worker's number of computation years,  $Y$ , and the earnings in each year. For retired-worker beneficiaries who have attained or will attain age 62 in 1991 or later,  $Y = 35$ .

The AWARDS subprocess (AWARDS) selects records from a 10 percent sample of newly entitled worker beneficiaries obtained from the Master Beneficiary Record (MBR).<sup>1</sup> The selected sample, referred to as "sample", contains 287,150 beneficiary records, and each record,  $r$ , includes a worker's history of taxable earnings under the OASDI program as well as additional information such as sex, birth date, month of initial entitlement, and type of benefit awarded. To estimate the benefit levels of future newly entitled worker beneficiaries, AWARDS modifies the earnings records in the sample to reflect the expected work histories and earnings levels of future beneficiaries (equation 4.2.1). After the modifications, AWARDS computes an AIME for each record in the future sample of beneficiaries (equation 4.2.2). AWARDS subdivides the AIME value of each record into *bend point subintervals*<sup>2</sup> (equation 4.2.3). As input to the Cost subprocess, the AIME values are used to calculate aggregate percentages of AIME in each *bend point subinterval* for each age at entitlement, sex and trust fund (equation 4.2.4). Equations 4.2.1 through 4.2.4 outline the overall structure and solution sequence. The subscript  $n$  refers to the *bend point subinterval* and  $r$  refers to the sample record.

$$\text{Projected Earnings} = \text{Projected Earnings}(\cdot) \quad (4.2.1)$$

$$\text{AIME}(r) = \frac{\sum \text{Highest } Y \text{ Indexed Earnings}(r)}{Y * 12} \quad (4.2.2)$$

$$\text{AIME}_n(r) = \text{AIME}_n(\cdot) \quad (4.2.3)$$

$$\text{PAP}_n = \frac{\sum_r \text{AIME}_n(r)}{\sum_r \text{bp}_n} \quad (4.2.4)$$

where  $\text{bp}_n$  is the length of the  $n$ th bend point subinterval,  
 $Y$  is the number of computation years, and  
 $\text{AIME}_n(r)$  is the AIME amount contained within the  $n$ th interval for record  $r$ .

<sup>1</sup> A record is selected if the year of initial entitlement equals 2015 as of the December 2017 MBR extract file date, and the beneficiary is not in death status as of the December 2015 MBR extract file date. Retired beneficiaries over age 70 and disability beneficiaries under age 20 are excluded.

<sup>2</sup> The current law PIA formula has two bend points. For the purposes of PAP, the Awards subprocess instead uses 30 subintervals.



#### **4.2.b. *Input Data***

##### ***Long-Range OCACT Projection Data***

###### Demography–

1. Total Social Security area population (as of July) by sex and age.
  - From 1941 to 2100 (1951 to 2095 used in SOSI)
  - Updated annually
2. Other-than-lawful permanent resident (“other-than-LPR”) population (as of July) by sex and age
  - From 1964 to 2100 (1964 to 2095 used in SOSI)
  - Updated annually
3. Deferred Action for Childhood Arrivals (DACA) population (as of July) by sex and age.
  - From 2012 to 2100 (2012 to 2095 used in SOSI)
  - Updated annually

###### Economics –

4. Covered workers by sex and age—with earnings posted to the Master Earnings File (MEF) only - used with CWHS data to project future earnings levels
  - From 1937 to 2095 (1951 to 2095 used in SOSI)
  - Updated annually
5. Covered workers not in the other-than-LPR population by sex and age—with earnings posted to the Master Earnings File (MEF) only
  - From 1937 to 2095 (1951 to 2095 used in SOSI)
  - Updated annually
6. Average Wage Index (AWI), projected values.
  - From 2017 to 2095
  - Updated annually
7. Total taxable earnings and number of workers with taxable earnings by age, sex, and year from the Continuous Work History Sample (CWHS).
  - From 1951 to 2015
  - Updated annually
8. Historical Average Taxable Earnings (ATE) —with earnings posted to the Master Earnings File (MEF) only – used with CWHS data to project future earnings levels
  - From 1937 to 2016 (only 2011-2015 data used in SOSI)
  - Updated annually
9. Projected Average Taxable Earnings (ATE) —with earnings posted to the Master Earnings File (MEF) only – used with CWHS data to project future earnings levels
  - From 2017 to 2095
  - Updated annually
10. Projected Covered Worker Rate based on total covered workers/total population (not used in SOSI)
  - From 2017 to 2095
  - Updated annually

- 11. COLA (Cost of Living Adjustment) – not used in SOSI
  - From 2017 to 2095
  - Updated annually
- 12. Projected Wage Base (current law)
  - From 2019 to 2095
  - Updated annually

Fully Insured –

- 13. Historical and projected fully insured rates by sex and single year of age 14-95
  - From 1969 to 2095
  - Updated annually

Beneficiaries –

- 14. Distribution of number of in-current-pay retired beneficiaries by age at retirement from age 62 to 70 by year, sex and age
  - From 2017 to 2095
  - Updated annually

***Other input data***

- 15. 10% Awards Sample from the MBR and Master Earnings File
  - Newly entitled OASI / DI beneficiaries, whose initial entitlement year was 2015 as of the December 2017 MBR extract file date, and the beneficiary is not in death status as of the December 2015 MBR extract file date.
    - SSN
    - Type of benefit
    - Type of claim (retirement or disability)
    - Sex
    - Date of birth
    - Date of initial entitlement
    - Date of disability onset
    - PIA amount
    - Type of dual entitlement
    - Dual entitlement status code
    - PIFC
    - LAF
    - Eligibility year
    - Trust fund
    - Earnings histories for each worker from 1951 to 2014
  - Generally updated annually, pending validation of the sample
- 16. AWI, Average Wage Index, historical values
  - From 1951 to 2016
  - Data obtained from OCACT internet site.
  - Updated annually
- 17. Wage base, historical values
  - From 1951 to 2018
  - Data obtained from OCACT internet site.
  - Updated annually
- 18. COLA, cost of living adjustment (historical values) – not used in SOSI

- From 1975 to 2016
  - Data obtained from OCACT internet site.
  - Updated annually
19. Amount of earnings needed to earn one quarter of coverage
- From 1951 to 2018
  - 1978-2018 data obtained from OCACT internet site. 1951-1977 values estimated by applying projection methodology backwards from 1978.
  - Updated annually
20. Windfall Elimination Provision (WEP) factors, the percent of sample cases affected by the WEP which will no longer be affected by the WEP, by sex and projection year
- From 2017 to 2095
  - Data obtained from OCACT internal calculations
  - Updated annually
21. PIA bend points – not used in SOSI (except for 1979 bend points)
- From 1979 to 2018
  - Data obtained from OCACT internet site.
  - Updated annually
22. Hypothetical Wage Base (to reflect relative changes in relative taxable maximum levels over time)
- From 1951 to 2018
  - Updated annually
  -
23. HI scaled factors, scaled factors computed using HI earnings instead of taxable earnings
- From age 16 to 100.
  - Data obtained from OCACT internal calculations.
  - Updated annually.
24. Bucket earnings file
- Detail earnings for years 1978 and later for each worker in Awards Sample with at least one year of earnings at the taxable maximum during those years.
    - SSN
    - Tax year
    - Total Compensation (W-2 box #1)
    - Social Security taxable wages and tips (W-2 boxes #3 and #7)
    - Medicare taxable wages and tips (W-2 box #5)
    - Social Security taxable self-employment income
    - Medicare taxable self-employment income
    - Deferred Compensation Distributions (W-2 box 11)
    - Deferred Compensation Contributions (W-2 box 12)
25. Taxable ratio goals for OASI and DI
- Data obtained from OCACT internal calculations
  - Updated annually.

#### **4.2.c. Development of Output**

All equations described below are projected separately for the OASI and DI program.

##### ***Equation 4.2.1 – Projected Earnings***

In order to estimate future benefit levels, the work histories and earnings levels in the current sample must be modified to represent those for a sample of worker beneficiaries who are newly entitled in future years. Three distinct modifications are made to the earnings records. For each future year, changes are made to the earnings records in order to reflect:

- *Changes in Wage Bases.*  
For some years, the projected wage base (contribution and benefit base), on an AWI discounted basis, is higher than the historical wage base. Therefore, the taxable earnings of future beneficiaries need to include covered earnings above the reported historical wage base. Thus, for each record with reported taxable earnings at the wage base in a given year, AWARDS obtains or imputes his/her covered earnings. See below section “Change in Wage Bases” and appendix 4.2-1 for more information.
- *Changes in Covered Worker Rates.*  
Adjustments are made to work histories to be consistent with the projected changes in the economy-wide covered worker rates. Economy-wide covered worker rates are defined as the ratio of “legal” covered workers (from Economics subprocess) to the Social Security area “legal” population (from Demography subprocess). See the below detailed section “Changes in Covered Worker Rates” for more information.
- *Earnings Experience in the CWHS<sup>3</sup>.*  
Earning levels are modified to capture the changes to date that are reflected in the average taxable earnings reported in the CWHS by age and sex and the changes expected in the future.

##### *Change in Wage Bases*

The earnings posted in the sample are limited by the historical wage base (contribution and benefit base). Prior to 1975, the maximum annual amount of earnings on which OASDI taxes were paid was determined by ad hoc legislation. After 1974, however, the annual maximum level was legislated to be determined automatically, based on the increase in the Social Security Average Wage Index (AWI). Prior to these automatic wage base increases, a relatively large portion of workers earned amounts above the base. Additional legislation raising the annual maximum taxable amount occurred in 1979, 1980, and 1981 to improve the financial future of the OASDI Trust Funds. In addition, the AWI used in the automatic

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<sup>3</sup> This file is a 1% sample of individuals who had covered earnings at some point in their work histories.

calculation of the annual taxable maximum was modified in the early 1990s to include deferred compensation amounts.

Therefore, for each record in the sample with earnings at the wage base, AWARDS uses an additional data source to obtain covered earnings for 1994 and later, and to impute as best as possible covered earnings for years before 1994. This is done in order to reflect higher maximum taxable amounts imposed on future newly entitled beneficiaries. Then, these projected covered earnings are capped at the wage base values that would be in effect for future samples of retired workers (using the “projected wage base” input file) to determine the taxable earnings to use in the benefit calculations. Please refer to appendix 4.2-1 for more details on this method.

### Change in Covered Worker Rates

The *sample covered worker rate* by age group and sex is defined as the ratio of (1) the number of those beneficiaries with covered earnings in the sample to (2) the total number of beneficiaries in the sample. For both males and females, the work histories are modified to reflect changes in the covered worker rates that would apply to a future sample of beneficiaries. These changes in the covered worker rates are based on changes in the *economy-wide covered worker rates*. The *economy-wide covered worker rate* is defined for an age-sex group in a particular period which represents a future sample cohort as the ratio of (1) the number of “legal” workers in the economy in this group that have some earnings in this period, to (2) the total midyear “legal” population in this group in this period.<sup>4</sup> *Economy-wide covered worker rates* are calculated separately for each age-sex group and each historical and projected calendar year based on input data from the Economics, Demography, and Fully Insured subprocesses.

In projecting *sample covered worker rates*, examination is done for the change in *adjusted economy-wide covered worker rates*, by age-sex group, between the “base period” (representing individuals retiring in the sample year) and the “projection period” (representing individuals retiring in a year later than the sample year). The adjusted economy-wide covered worker rates in the base year take into account 60% of the change in projected age-62 fully insured rates relative to the base year, based on analyses of historical data. That is, for each projection year, the method estimates what the base year economy wide covered worker rates would have been if 60% of the increase in the covered worker rates were attributable to those individuals becoming newly fully insured (or losing insured status if the change in covered worker rates is negative). Details of how this change is used to estimate the change in a covered worker rate for retired workers from a current period in the sample to a future period are given below. The method used is the same for males and females in projecting sample

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<sup>4</sup> For this purpose, we define the “legal” population as the total SSA area population *minus* the other-than-lawful permanent resident (“other-than-LPR”) population (those in the U.S. illegally and those in the U.S. on a temporary basis, e.g., individuals with specific non-immigrant worker or student visas) *plus* the DACA population (DACA individuals are included in the other-than-LPR data but had been effectively made legal, for Social Security purposes, by policy directive or executive action). However, for the 2018 Trustees Report, the 2014 executive action augmenting the DACA program was no longer assumed to apply, such that the DACA-designated population was zeroed out after 2019.

covered worker rates. For additional explanation of this calculation, refer to example 1.1 in appendix 4.2-2 of this subprocess.

Projected sample covered worker rate equals (for increasing economy-wide rates):

- The ratio of (1) the potential difference in the *economy-wide male (or female) covered worker rate* in the projection year to (2) the potential difference in the *adjusted economy-wide male (or female) covered worker rate in the sample year (i.e., 1 – adjusted economy-wide male (or female) covered worker rate)*, multiplied by
- The corresponding potential difference in the *sample's male (or female) covered worker rates (i.e., 1 – sample male (or female) covered worker rate)*.
- The above result is subtracted from 1 to get the projected sample covered worker rate.

This presentation above presumes that economy-wide covered rates increase over time, which is very common for females but not always true for males. The calculation of the change in covered worker rate differs if there is a reduction in relevant economy-wide covered worker rates. Example 1.2 shows the calculations done for males and females if economy-wide covered worker rates decline.

A similar procedure exists for projecting sample covered worker rates for disabled workers, except that the calculations are further broken down by entitlement age group. See Example 1.3 for an illustration.

Once the covered worker rates for the future sample of beneficiaries are determined, modifications to work histories of the sample to attain these rates are generally done by randomly removing or adding earnings.<sup>5</sup> For males, the procedure is to select records randomly with no other restrictions or criteria. However, for females, an additional selection criterion is included in order to achieve a specified distribution of the number of years of earnings for retired female beneficiaries. Female records with 10 or fewer years of earnings are not modified. A distribution limit is set for those female workers with 11 to 25 total years of career earnings within the projection year. This distributional limit changes each projected year. In the first year after the sample year, the distribution limit for females is equal to the male distribution plus 97% of the difference between the initial male and female distributions within the sample. In each subsequent year, the percentage decreases by three percent until it reaches 0%. Thus, the females' years of earnings distribution for those with 11 to 25 years of earnings is adjusted to approach that of the males.

If a record is selected for adding earnings in a particular year, the amount of earnings added is based on the career earnings pattern of the selected record. When earnings are added to a record, AWARDS calculates the ratio of (1) the record's Average Indexed Earnings,  $AIE(r)$ <sup>6</sup>, to (2) the AIE of a hypothetical worker,  $w$ , whose year of birth and sex are the same as the

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<sup>5</sup> Individuals in the sample affected by the Windfall Elimination Provision are less likely to have earnings removed or added by this process.

<sup>6</sup> AIE is the average indexed annual earnings, average over the highest  $Y$  years of earnings (similar to AIME, but an annual amount).

record and whose annual earnings are set equal to *average taxable earnings*. For this purpose, *average taxable earnings* are determined by averaging the earnings over all records in the sample with the same sex and year of birth. Then, the preliminary amount of earnings<sup>7</sup> in year  $t$  that is added to the record is

$$\text{Earnings}(r, t) = {}^s\text{ATE}(tf, \text{sex}, t, a) * \frac{\text{AIE}(r)}{\text{AIE}(w)},$$

where  ${}^s\text{ATE}(tf, \text{sex}, t, a)$  is the average taxable earnings in year  $t$ , for those in the sample with the same sex as that of the record for year of birth  $a$  by trust fund  $tf$ .

For additional explanation of this calculation, refer to example 2 in appendix 4.2-2 of this subprocess. Note that all earnings levels get further adjusted by earnings experience in the CWHS for recent workers, as discussed in the below section.

### Earnings Experience in the CWHS

For historical years beginning with 1951, AWARDS uses average taxable earnings by age and sex ( $\text{CWHSATE}_{\text{as}}$ ) and numbers of covered workers by age and sex ( $\text{CWHS}\text{CW}_{\text{as}}$ ) as tabulated from the most recent CWHS file<sup>8</sup>. To estimate ATE levels for the first projection year, the AWARDS uses the average values of normalized average taxable earnings calculated from the last five historical years of the most recent CWHS file. These computed normalized values take into account changes in aggregate ATEs from the Economics subprocess between each of the five historical years and the first projection year; this allows the comparison of corresponding values from different years in a way that reduces time series effects.

Projections are made for each year after the base year through the end of the 75-year projection period using projected economy-wide number of covered workers by age and sex and aggregate annual average taxable earnings (ATE) from the Economics process<sup>9</sup> attributable to ages 15-80. The first step is to determine preliminary  $\text{CWHSATE}'_{\text{as}}$  (preliminary average taxable earnings by age and sex) by using the annual growth rate in the total economy-wide ATE and projected number of covered workers from the Economics process. A further multiplicative adjustment is made to each  $\text{CWHSATE}'_{\text{as}}$  such that the resulting aggregate average taxable earnings, determined by combining the projected values of covered workers from the Economics process and  $\text{CWHSATE}_{\text{as}}$  for the year, produces the same aggregate ATE level for that year as projected by the Economics process. A small constant adjustment is also made, based on historical data, to reflect the difference between aggregate ATE levels for ages 15-80 (as used here) and aggregate ATE levels for all ages produced by the Economics subprocess.

<sup>7</sup> In this subprocess, earnings histories of projected beneficiaries are all reflected as wage-indexed earnings histories in the 2015 sample.

<sup>8</sup> These historical values are tabulated by the Economic subprocess.

<sup>9</sup> Aggregate ATE values for all ages are based on earnings posted to the Master Earnings File (MEF), excluding earnings posted to the suspense file. Historical experience from the CWHS sample is used to estimate the ATE for the large age 15-80 subgroup, and is used throughout this part of the model.

For additional explanation of this calculation, refer to example 3 in appendix 4.2-2 of this subprocess.

The historical and projected  $CWHSATE_{as}$  are then used to change the earnings histories of the sample of newly entitled beneficiaries so that the earnings better represent newly entitled beneficiaries in future years. For a given sex, year of birth, trust fund, and earnings year, the expected annual average taxable earnings of a future sample is denoted as  $ATE_f'$ .  $ATE_f'$  equals the sample's average taxable earnings for a specific earnings year, multiplied by the comparable changes in the  $CWHSATE_{as}$ , that is, the wage-indexed changes in the  $CWHSATE_{as}$  between the year of earnings in the sample of new beneficiaries and the year of earnings in the projected sample. Refer to example 3.1 in appendix 4.2-2 for additional explanation.

$ATE_f'$  is then compared to the average taxable earnings of the sample (after adjustments to the records' earnings levels for changes in wage bases and covered worker rates), denoted as  $ATE_f$  and computed by sex, trust fund, earnings year, and year of birth. The difference between these values is the amount by which the average annual earnings levels are adjusted. Let

$$\delta(t) = ATE_f' - ATE_f,$$

for a specific age (or year of birth in the sample) in the projection year  $t$ . Denote the total workers in the sample in year  $t$  as  $TotalWorkers(t)$ . Then,  $(\delta(t) * TotalWorkers(t))$  is the total amount of earnings which the model distributes for a given sex and single age in a way so that the average taxable earnings after distribution is  $ATE_f'$ .

For additional explanation of the calculation  $\delta(t)$ , refer to example 4 in the appendix 4.2-2.

When  $\delta(t)$  is negative, earnings for the year are decreased. To achieve  $ATE_f'$  for the given sex, age, trust fund and earnings year, AWARDS multiplies  $CoveredEarnings(r, t)$  by a ratio,

$$ratio(t) = 1 + \frac{\delta(t)}{ATE_f(t)} + \alpha.$$

The term,  $\alpha$ , is a necessary additional adjustment because covered earnings near or above the wage base, may have either a partial effect or no effect on modifying  $ATE_f$  to  $ATE_f'$ . These  $\alpha$  values vary by sex, trust fund, and whether earnings increase or decrease. For OASI, the adjustment,  $\alpha$ , is further broken down by year of birth to better match the targeted ATE levels. Otherwise, the determination process for OASI and DI is the same. These  $\alpha$  values are set to best target  $ATE_f'$  while making adjustments throughout as many of the sample records as possible.

As AWARDS applies a  $ratio(t)$  to  $CoveredEarnings(r, t)$  by each record, it makes sure that the total earnings adjustment in a given earnings year and single age does not exceed  $\delta(t) * TotalWorkers(t)$ . For additional explanation of this calculation, refer to example 5 in appendix 4.2-1 of this subprocess.

### *Shuttling Method*



The change in distribution of the retired worker beneficiaries in projection years, as compared to the sample year, is another element in projecting earnings. To account for the general shifting to retirement by workers at later ages than the initial entitlement sample that is projected to occur, the “forward shuttling” method facilitates the shift and estimates the additional earnings for the corresponding years before later retirement. Records are randomly chosen for additional earnings in the later retirement years. The amount of earnings for these shuttled records with delayed retirement are assumed to be the projected sample average taxable earnings. The number of shuttled records with additional earnings depends on the projected sample covered worker rates by sex and age. In the case of “backwards shuttling”, which is also possible in projected years, workers could retire at younger ages than in the Awards initial entitlement sample. When this happens, the worker will have fewer years of earnings. The earnings are removed in the appropriate age(s) for backwards shuttling. Since backwards shuttling rarely occurs, this condition does not have a major effect.

For each age in a given projection year, the result of the shuttling method (forward or backward) is a weighted average of the PAPs that correspond to retirement at that age. As mentioned in the preceding paragraph, when the sample retirement age is earlier than the age in question (that is, individuals who delay retirement in the projection year), this calculation includes potential additional earnings in the AIME calculation for the additional years before retirement. Refer to example 7 in appendix 4.2-3 for additional explanation and illustration.

***Equation 4.2.2 – Average Indexed Monthly Earnings (AIME)***

*Step 1: Index Earnings*

To compute an individual’s AIME, all taxable earnings after 1950 are considered. First, the earnings are indexed up to the index year, *i*, which is defined as the year of attaining age 60 for retired-worker beneficiaries (eligible for benefits at age 62). For disabled-worker beneficiaries, *i* is set to be 2 years before the sample year. Thus,

$$\text{IndexedEarnings}(r,t) = \begin{cases} \text{Earnings}(r,t) * \frac{\text{AverageWage}(i)}{\text{AverageWage}(t)}, & \text{if } t < i \\ \text{Earnings}(r,t), & \text{if } t \geq i \end{cases}$$

*Step 2: Determine Computation Years*

For each record, the number of computation years, *Y*, is determined. For a retired-worker beneficiary in the sample, *Y* is 35.

For a disabled-worker beneficiary, *Y* is calculated as follows:

- Determine the number of elapsed years, which is equal to the year of disability onset (not

later than the year the worker turned age 62) *minus* the greater of 1951 or the year the disabled worker turned age 22.

$$\text{Elapsed Years} = \min\{ \text{Year of disability onset, Year attained age 62} \} - \max\{1951, \text{Year attained age 22} \}$$

- Divide the elapsed years by five and truncate. Subtract this number (cannot exceed five) from the number of elapsed years.

$$Y = \text{Elapsed Years} - \min\left\{ \left\lfloor \frac{\text{Elapsed Years}}{5} \right\rfloor, 5 \right\}$$

- Y must be at least 2.

*Step 3: Determine AIME*

Finally, an individual's AIME is computed by summing the highest Y indexed earnings and dividing by the number of months in those years. Hence, for each record,

$$\text{AIME}(r) = \frac{\sum \text{Highest Y Indexed Earnings}(r)}{Y * 12}$$

**Equation 4.2.3 – AIME<sub>n</sub>(r)**

The *Possible* AIME value is divided into 30 intervals (*bend point subintervals*). The length of each interval in 1979 dollars is given below:

$$\text{bp}_n = \begin{cases} \$45, & \text{if } 0 < n \leq 13 \\ \$100, & \text{if } 14 \leq n \leq 18 \\ \$200, & \text{if } 19 \leq n \leq 28 \\ \$1000, & \text{if } 29 \leq n \leq 30 \end{cases}$$

Thus, the interval points of AIME division given below in 1979 dollars,  $y_k$ , are equal to

$$\sum_{n=1}^k \text{bp}_n \text{ and}$$

$$y_k = \begin{cases} \$180, & \text{if } k = 4 \\ \$1085, & \text{if } k = 18 \\ \$5085, & \text{if } k = 30. \end{cases}$$

For each record (r), the values for  $\text{bp}_n$  are indexed from 1977 to his/her indexing year  $i$  using the Social Security average wage index (AWI). So for  $n = 1$  to 30,

$$\text{bp}_n(r) = \text{bp}_n * \frac{\text{AWI}(i)}{\text{AWI}(1977)}$$

Next the record's AIME amount,  $AIME(r)$ , is compared to the indexed intervals. If

$$\sum_{n=1}^{k-1} bp_n(r) < AIME(r) \leq \sum_{n=1}^k bp_n(r),$$

then  $AIME(r)$  falls within the  $k$ th interval. And for  $n = 1$  to 30,

$$AIME_n(r) = \begin{cases} bp_n(r), & \text{if } n < k \\ AIME(r) - \sum_{n=1}^k bp_n(r), & \text{if } n = k \\ 0, & \text{if } n > k \end{cases}$$

***Equation 4.2.4 – Potential AIME Percentages (PAPS)***

Finally, for  $n = 1$  to 30, AWARDS sums the values of  $AIME_n$  and  $bp_n$  across all the records for all projection years by sex, age (20-65 for disabled workers, and 62-70 for retired workers), and trust fund. The ratio of these values gives the average potential AIME percentages (PAPS):

$$PAP_n = \frac{\sum_r AIME_n(r)}{\sum_r bp_n(r)}.$$

For an example of this calculation, refer to example 6 in appendix 4.2-2 of this subprocess.

## Appendix 4.2-1

This appendix provides additional details on how the AWARDS process imputes covered earnings above the historical wage base. The taxable earnings in the Awards sample are less than or equal to the historical wage base.

The Hospital Insurance (HI) wage base was phased out from 1991 to 1993 and eliminated in 1994. For years 1994 and later, HI earnings are a good proxy for Social Security covered earnings. For years 1991 to 1993, HI earnings are a good proxy for Social Security covered earnings if they are under the HI wage base. Otherwise they give a lower bound for Social Security covered earnings. Total compensation (TC) earnings, available starting in 1978, are earnings subject to federal income tax. TC can differ from Social Security covered earnings but, where other data is lacking, gives a reasonable estimate of Social Security covered earnings. The program uses Hospital Insurance (HI) covered earnings for years 1991 and later and Total Compensation (TC) earnings for years 1978 and later to estimate covered earnings for those years. For years in which no good HI or TC estimate is available, including all years before 1978, the program estimates covered earnings based on available data from later years or from the application of HI “scaled” earning factors by age. The program then adjusts covered earnings estimates for years 1993 and earlier in order to align taxable ratios to taxable ratio “targets” based on CWHS, Economics, and sample data.

To start with, the covered earnings methodology determines which workers in the Awards sample had taxable earnings at the wage base in years 1978 and later. For these individuals we obtained ORES “bucket” file records. The records contained individual HI earnings, total compensation (TC) earnings, and deferred compensation. The records are for 1978 and later. Program module HI\_EarningsMod.f90 in the AwardsPart1 program reads the bucket file and makes the earnings available to module CoveredEarningsMod.90.

The program estimates covered earnings in three phases. In phase one, the program makes a best estimate of covered earnings in each year, for each record. In phase two, taxable ratio “targets” (the ratio of taxable to covered earnings) are computed by trust fund, sex, and year. These targets, for years 1993 and earlier, are externally computed based on economics data, Continuous Work History Sample data, and sample covered earnings after 1993. Finally, for phase 3, in an iterative process, the program adjusts covered earnings for years 1993 and earlier until the computed taxable ratios match the taxable ratio targets.

More details of each phase follow.

### Phase 1

Phase 1 makes a best estimate of covered earnings in each year for each worker using sample taxable earnings, bucket earnings, and scaled factors based on HI earnings.<sup>10</sup> For years with

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<sup>10</sup> HI scaled factors are computed using the same methodology as regular scaled factors [see actuarial note 2018.3 at <http://www.ssa.gov/OACT/NOTES/ran3/an2018-3.pdf>] except that HI taxable earnings are used in the calculations instead of Social Security taxable earnings. We discovered that the method worked better when HI scaled factors for ages under 22 were set equal to the age 22 factor so the factors hold steady under age 22.

sample taxable earnings under the wage base, covered earnings are simply set equal to taxable earnings. If taxable earnings are equal to the wage base then the program estimates covered earnings using the following data sources, in order of perceived accuracy: 1) HI earnings over the wage base in the year, 2) TC over the wage base in the year, 3) HI or TC earnings over the wage base in a later year combined with adjustments for AWI and HI scaled factors, 4) estimated lower bounds for covered earnings in earlier years with adjustments for AWI and HI scaled factors. In some cases, the program will choose the results from data source 4) over other sources if that results in a higher covered earnings amount. Note that comparing TC to HI in years 1994 and later, we observed that HI tends to be slightly higher than TC. When using TC to estimate covered earnings prior to 1994, we apply an adjustment factor to the TC earnings to account for this. TC, as used in the program, includes deferred compensation contributions but not distributions.

The program computes two estimates of covered earnings for each applicable record in the sample and takes the one judged to be the best estimate. The two estimates are “Covered\_earnings\_1” and “Covered\_earnings\_2.”

Covered\_earnings\_1 is an estimate of covered earnings based on earnings in the current and later years. The program computes some intermediate values that will be used to estimate covered earnings.

For each worker *iii* in the sample and for each earnings year (*iyear*) from 1978 through SAMPLE\_YEAR-1

$$HIplusAdjEarnings(iyear,iii) = \begin{cases} HIearnings(iyear,iii), & \text{if } iyear \geq 1994 \\ \max(HIearnings(iyear,iii),TC(iyear,iii)), & \text{if } 1978 \leq iyear \leq 1993 \end{cases}$$

For each worker *iii* in the sample and for each earnings year (*iyear*) from SAMPLE\_YEAR-1 through 1951 (stepping backwards), a variable *ratioYearToUse* is created for each earnings year:

$$ratioYearToUse(iyear,iii) = \begin{cases} 0, & \text{if } earnings(iyear,iii) < wagebase(iyear) \\ iyear, & \text{if } HIplusadjearnings(iyear,iii) > wagebase(iyear) \\ iyear + 1, & \text{if } ratioYearToUse(iyear + 1) = iyear + 1 \\ \text{earliest } iyear \text{ for which } HIplusadjearnings(iyear,iii) > wagebase(iyear) \\ -1, & \text{if none of the above conditions are met} \end{cases}$$

This will yield a value other than “-1” if an individual has HI or TC earnings over the wage base in any year 1978 or later.

Then, for each worker *iii* in the sample with at least one year of earnings at the wage base, for each earnings year (*iyear*) 1951 to SAMPLE\_YEAR-1:

$$ratio(iyear, iii) = \begin{cases} 0, & \text{if } ratioYearToUse(iyear, iii) \leq iyear \\ \frac{HIplusAdjEarnings(ratioYearToUse(iyear, iii))}{averageWage(ratioYearToUse(iyear, iii)) * HIscaldFactor(iage)}, & \text{otherwise} \end{cases}$$

where  $iage = iyear - yearOfBirth(iii)$

If there is a year, 1978 or later, with HI or TC earnings over the wage base, then Covered\_Earnings\_1 in that year will be set to the *HIplusAdjEarnings* value computed above. Otherwise, if the ratio is above zero, Covered\_Earnings\_1 will be set to the product of the ratio times the *HIscaldFactor* times the *averageWage* for the year, or to the wage base + \$1 if higher. If neither of these methods applies, then the variable is set to the wage base + \$1 and may be overwritten by Covered\_Earnings\_2 below.

Covered\_Earnings\_2 is an estimate of covered earnings in the current year based on estimates for earlier years. To set values for covered\_earnings\_2(year,iii) the program starts by setting the 1951 estimate to the taxable earnings value and using AWI increases and changes to HI scaled factors to estimate covered earnings in following years. For each consecutive year, the estimate will be the higher of the HI scaled factor and cumulative AWI increase applied to the prior year Covered\_Earnings\_2, or the taxable earnings of the prior year.

The program then decides whether to use the value for Covered\_earnings\_1 or Covered\_Earnings\_2 for the phase 1 estimate of covered earnings. Generally, Covered\_Earnings\_2 will be used if higher than Covered\_Earnings\_1, and if the Covered\_Earnings\_1 estimate is based on earnings at least 2 years different than the earnings year in question. In general, Covered\_Earnings\_2 ends up being used less often overall.

## Phase 2

The program uses the covered earnings from Phase 1 to compute taxable ratios by trust fund, year, and sex. Taxable ratio targets are developed for OASI and DI outside of the Awards program. These target values are produced by age and sex for years 1953-1993 for OASI and years 1970-1993 for DI for those aged 20-64 in those years. The program also takes weighted averages of these single age targets to obtain annual goals in aggregate by sex and trust fund.

The program reads in the taxable ratio targets from input files. Below is a summary of the process used to generate these taxable ratio targets:

- 1) Obtain data from the CWHS for years 2004-2013 of taxable and covered earnings by age and sex for individuals fully insured as of the end of each year, and compute taxable ratios for each cell
- 2) In a side FORTRAN program, for each year 1954-1993, match to the aggregate taxable ratio from the Economics group, separately revising each of year 2004-2013 CWHS data for this purpose. From this exercise, the resulting output is 10 sets of individual taxable ratios modeled to fit the aggregate 1954-1993 taxable ratios. Average these 10 years' worth of data to establish individual age/sex taxable ratios for each year 1954-1993.
- 3) By age and sex for OASI, adjust the taxable ratios in step 2 by a) a constant factor to align from Economic group's taxable ratio for each year 2004-2013 to that of the data

- in step 1, and b) a second constant factor to align from the 2004-2013 CWHS data developed in step 1 to the taxable ratio for the 2015 initial entitlement sample for birth cohorts 1945-1953
- 4) By age and sex for DI, adjust DI taxable ratios from the levels in step 2 by the relative percentage closer to 1.000 of the taxable ratios between the CWHS data and that of the 2015 sample at that age/sex. This attempts to reflect the relative difference of taxable ratios for the smaller subset of DI cases (usually higher, that is, less earnings over the taxable maximum)
  - 5) Aggregate these taxable ratio targets by year, sex, and Trust Fund, using the number of individuals in the 2015 sample at the appropriate age as the weights to derive one taxable ratio by trust fund, year, and sex.

### Phase 3

For this final phase, the program starts an iterative process to match the overall targeted taxable ratio for that year, sex, and Trust Fund. If, for a given combination, the computed taxable ratio is within epsilon (.001 for OASI, .002 for DI) of the taxable ratio target then the covered earnings for that combination are accepted and taxable ratios by single age result from the analysis. If the computed taxable ratio is not within epsilon of the target, then all records with corresponding covered earnings over the wage base are either increased or decreased to move the computed taxable ratio closer to the taxable ratio target, and the two ratios are compared again. This is repeated until the computed taxable ratio is within epsilon of the taxable ratio target. If, in rare instances, all covered earnings are less than or equal to the wage base then no more iterations are done and those covered earnings are accepted.

## Appendix 4.2-2

This appendix provides examples to help understand the calculations described in the model documentation of the AWARDS subprocess. **These examples do not necessarily reflect values actually used in the projections.**

### Example 1.1: (OASI-Male with increasing economy-wide covered worker rates)—same method applies for females

**Task:** In projecting the 2015 sample of newly entitled male beneficiaries to represent newly entitled male beneficiaries in 2035, an adjustment to the earnings histories for those males age 30-34 is needed to reflect higher covered worker rates expected for males in this age group.

This example illustrates the calculation of the projected covered worker rate for males who are age 30-34 in the projection period. We will be comparing the group of males age 30-34 in the base period with its counterpart group of males age 30-34 in the projection period.

#### **Information given:**

- Newly entitled retired male beneficiaries represented in the 2015 sample are age 30-34 in the base period, 1975-1987, and the counterpart group of males retiring in 2035 is age 30-34 in the projection period, 1995-2007.
- Based on the 2015 sample, the covered worker rate for males age 30-34 in the base period = 84.07%.
- Fully insured rate for male age 62 in 2014 (SampleYear -1) = 95.07%
- Fully insured rate for male age 62 in 2035 = 95.38%
- Unadjusted economy-wide covered worker rate for males age 30-34 = 88.25% in the base period (2014).
- Economy-wide covered worker rate for males age 30-34 = 88.64% in the projection period (2034).

#### **Calculations:**

1. Adjusted economy wide covered worker rate in the base period =  
Unadjusted economy-wide covered worker rate in the base period \* (1 + (Fully insured rate 2035/Fully insured rate 2014 - 1) \* .6) = 88.42%
2. The potential difference in the economy-wide covered worker rate for males age 30-34 in the projection period is 100.0% - 88.64% or 11.36%.
3. The potential difference in the adjusted economy-wide covered worker rate for males age 30-34 in the base period is 100.0% - 88.42% or 11.58%.
4. The ratio from *steps 2 and 3* is 98.12%.
5. The potential difference in the sample covered worker rate for the males age 30-34 in the base period is 100.0% - 84.07% or 15.93%.



6. The ratio from *step 4* is multiplied by the potential difference in the sample's covered worker rate for males age 30-34 in the base period to yield 15.63% (98.12% \* 15.93%).
7. The amount in *step 6* (15.63%) would be subtracted from 1 to yield the sample's covered worker rate for males who are age 30-34 in the projection period (84.37%).

**Example 1.2: (OASI-Male with decreasing economy-wide covered worker rates)—same method applies for females**

**Task:** In projecting the 2015 sample of newly entitled male beneficiaries to represent newly entitled male beneficiaries in 2050, an adjustment to the earnings histories for those males age 40-44 is needed to reflect lower covered worker rates expected for males in this age group.

This example illustrates the calculation of the projected covered worker rate for males who are age 40-44 in the projection period. We will be comparing the group of males age 40-44 in the base period with its counterpart group of males age 40-44 in the projection period.

**Information given:**

- Newly entitled retired male beneficiaries represented in the 2015 sample are age 40-44 in the base period, 1985-1997, and the counterpart group of males retiring in 2050 is age 40-44 in the projection period, 2020-2032.
- Based on the 2015 sample, the covered worker rate for males age 40-44 in the base period = 86.37%.
- Fully insured rate for male age 62 in 2014 = 95.07%
- Fully insured rate for male age 62 in 2050 = 94.39%
- Unadjusted economy-wide covered worker rate for males age 40-44 = 86.15% in the base period (2014).
- Economy-wide covered worker rate for males age 40-44 = 82.83% in the projection period (2049).

**Calculations:**

1. Adjusted economy wide covered worker rate in the base period = Unadjusted economy-wide covered worker rate in the base period \* (1+ (Fully insured rate 2050/Fully insured rate 2014 - 1) \* .6 ) = 85.78%
2. The economy-wide covered worker rate for males age 40-44 in the projection period is 82.83%.
3. The ratio from *steps 2 and 1* is .8283/.8578 or 96.56 %.

4. The ratio from *step 3* is multiplied by the sample's covered worker rate for males age 40-44 in the base period to yield 83.40% ( $96.56\% * 86.37\% = 83.40\%$ ).

The amount in *step 4* (83.40%) would be the sample covered worker rate for males who are age 40-44 in the projection period.

### **Example 1.3: (DI-Male with decreasing economy-wide covered worker rates) – same method applies for females**

**Task:** In projecting the 2015 sample of newly entitled male DI beneficiaries age 60-64 to represent newly entitled male beneficiaries in 2050, an adjustment to the earnings histories for those males age 40-44 is needed to reflect lower covered worker rates expected for males in this age group.

This example illustrates the calculation of the projected covered worker rate for males who are newly entitled at age 60-64 in 2050 and are age 40-44 in the projection period. We will be comparing the group of males age 40-44 in the base period with its counterpart group of males age 40-44 in the projection period. The formulas are similar to Example 1.2 in relating the age-group of earnings to a specific entitlement age-group, but with no fully insured adjustment to economy-wide covered worker rates in the base year.

#### ***Information given:***

- Newly entitled male DI beneficiaries who are age 60-64 represented in the 2015 sample are age 40-44 in the base period, 1991-1999, and the counterpart group of males DI beneficiaries who are age 60-64 in 2050 is age 40-44 in the projection period, 2026-2034.
- Based on the 2015 sample, the covered worker rate for males DI beneficiary age 40-44 in the base period = 91.28%.
- The economy-wide covered worker rate for males age 40-44 in the base period (2014) is 86.66%.
- The economy-wide covered worker rate for males age 40-44 in the projection period (2049) is 83.11%.

#### ***Calculations:***

1. The economy wide covered worker rate for male age 40-44 in the base period is 86.66%
2. The economy wide covered worker rate for male age 40-44 in the projection period is 83.11%.
3. The sample covered worker rate for males DI beneficiary age 40-44 is 91.28%.
4. The ratio from *steps 2 and 1* is 95.90 %.

5. The ratio from *step 4* is multiplied by the sample's covered worker rate for males age 40-44 in the base period to yield 87.54% (95.90 % \* 91.28%).

### **Example 2:**

**Task:** In projecting the 2015 sample of newly entitled male OASI beneficiaries to represent newly entitled male OASI beneficiaries in 2050, an adjustment to the earnings histories for those males age 30 is needed to reflect higher covered worker rates expected for males in this age group. To achieve this target, the desired numbers of records with zero reported earnings in this age group are randomly selected and assigned earnings.

This example illustrates the calculation of earnings to be assigned to a randomly chosen newly entitled retired male record with zero taxable earnings in the base year.

#### ***Information given:***

- Newly entitled retired male beneficiaries age 65 represented in the 2015 sample are age 30 in the base period 1980.
- Based on the 2015 sample, a male record,  $r = 44815$ , has been randomly selected to replace his zero taxable earnings reported in the base year 1980 at age 30 with an amount based on his career earnings pattern. His year of birth is 1950.
- The Average Indexed Earnings for this record, AIE (44815), is computed to be \$48,653. Note: This value is calculated by (1) using the record's annual taxable earnings reported each year through 2014, (2) converting them to 2014 year dollars, and then (3) summing the highest 35 years of earnings and dividing by 35.
- The Average Indexed Earnings for a hypothetical worker,  $AIE(w)$  whose year of birth is 1950 is \$57,280. This value is calculated as above given the hypothetical worker earned the *average taxable earnings* in each of the base years for males retiring at age 65 in the 2015 sample.
- The sample Average Taxable Earnings of males at age 30 in 1980 is  ${}^S\text{ATE}(\text{OASI, male, 1980, 1950}) = \$14,703$ .

#### ***Calculations:***

1. The ratio of the Average Indexed Earnings for record number 44815,  $AIE(44815)$  to the Average Indexed Earnings of a hypothetical male worker born in 1950 and retiring at age 65,  $AIE(w)$  is  $\$48,653/\$57,280$  or 0.8494.
2. The amount in *step 1* (0.8494) would be multiplied by  ${}^S\text{ATE}(\text{OASI, male, 1980, 1950})$ , which is given as \$12,488. This yields the amount of earnings assigned to record number 44815. Thus,  $\text{Earnings}(44815, 1980) = .8494 * \$14,703$  which equals \$12,488.

Note that, at this stage of the process, the average taxable earnings have been computed using projected earnings adjusted for changes in the wage base. Adjustments to earnings for the earnings experience in the CWHS have not yet been applied. See the earlier section “Earnings Experience in the CWHS” and example 4 below for a description of this adjustment process.

### **Example 3:**

**Task:** The AWARDS subprocess estimates projected values of Average Taxable Earnings by age and sex using the values<sup>11</sup> in the 2015 CWHS file supplied by the Economic subprocess as the base year on which to build our projections.

This example illustrates the calculation of the projected Average Taxable Earnings of the CWHS in 2019 for 42 year old females,  $CWHSATE_{42,female}(2019)$ . We will be using the number of female covered workers age 42 and the total taxable earnings for females age 42 as given the in 2015 CWHS data.

**Information given:**

- The average taxable earnings calculated from last 5 historical years in the CWHS for females age 42 are:

$$\begin{aligned}ATE\_cwhs(2011) &= 35,861.28 \\ATE\_cwhs(2012) &= 37,305.32 \\ATE\_cwhs(2013) &= 37,942.75 \\ATE\_cwhs(2014) &= 38,671.52 \\ATE\_cwhs(2015) &= 40,703.14\end{aligned}$$

- The economy-wide average taxable earnings 2011-2019 for females age 42 are:

$$\begin{aligned}ATE\_econ(2011) &= 34,314.81 \\ATE\_econ(2012) &= 35,213.09 \\ATE\_econ(2013) &= 35,943.94 \\ATE\_econ(2014) &= 37,053.51 \\ATE\_econ(2015) &= 38,199.19 \\ATE\_econ(2016) &= 38,596.84 \\ATE\_econ(2017) &= 39,930.24 \\ATE\_econ(2018) &= 41,278.37 \\ATE\_econ(2019) &= 42,941.92\end{aligned}$$

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<sup>11</sup> Because not all earnings are posted for the most recent years for a given CWHS file, adjustment factors, based on historical trends, are applied by the Economic subprocess to complete these earnings. For the 2015 CWHS, adjustment factors were applied to data in years 2011 through 2015.

Note: The above ATE values reflect an adjustment from the aggregate values supplied by the Economics group for all ages, to make them consistent with the historical CWHS ATE values for ages 15-80.

***Calculations:***

1. The normalized ATE for females age 42 in 2019, using 2011-2015 CWHS data brought forward to 2019 ATE levels. The calculation is shown in 2 steps:

Step a

$$\text{ATE\_cwhs}(2011) * \text{ATE\_econ}(2019) / \text{ATE\_econ}(2011) + \text{ATE\_cwhs}(2012) * \text{ATE\_econ}(2019) / \text{ATE\_econ}(2012) + \dots + \text{ATE\_cwhs}(2015) * \text{ATE\_econ}(2019) / \text{ATE\_econ}(2015)$$

Step b

Sum of Step a (\$226,274.25), then take the average (\$224,251.60 / 5 = \$45,254.85)

2. Repeat the same steps in (1) to calculate the normalized ATE for each age (15 to 80). Multiply the normalized ATE by number of econ-wide covered workers by age and sex in year 2019. This gives us the taxable earnings. Sum up the taxable earnings for all ages and sex (both male and female). Then divide the total taxable earnings (age and sex combined) by total number of economy-wide covered workers in 2018 (age and sex combined). The resulting ATE for 2019 using economy-wide covered workers and 2011-2015 CWHS data brought forward to 2019 ATE levels is \$42,293.81.
3. The value from *step 1* (\$45,254.85) is multiplied by a final multiplicative adjustment factor to match the aggregate ATE level produced by the Economic subprocess. The adjustment is a ratio of economy-wide ATE to CWHS projected aggregate average taxable earnings (\$42,941.92 / \$42,293.81 from step 2 above) yielding for females age 42 in 2019 an ATE value of \$45,948.

**Example 3.1:**

This example illustrates the calculation of the projected Average Taxable Earnings in 2005 for 40-year old females who retire at age 65 in 2030. We will be using the historical and projected ATE and distribution of retired workers in the projection year to calculate the weighted CWHS ATE for that year.

***Information given:***

- The historical ATE from CWHS sample for females age 40 in 1990, who retire at age 65 in sample year 2015, is listed as follows:

$$\text{ATE}(\text{female},1990,40) = 17,326$$

- The projected ATE, using historical CWHS sample data as a guide and projected covered worker data from the Economics group for age 40 in 2005, who retire at age 65 in sample year 2030, is listed as follows:

$$\text{ATE}(\text{female},2005,40) = 29,831$$

- Average wage index in 1990 = \$21,027.98
- Average wage index in 2005 = \$36,952.94
- Sample average taxable earnings for age 40 in 1990 = \$17,441

***Calculations:***

1. The ratio of AWI (1990) to AWI (2005) = .5691 (\$21,027.98/\$36,953)
2. Calculate the projected ATE (CWHS sample) for females age 40 in 2005 (in 1990 dollars). Multiply the projected ATE by the ratio in step (1) = \$16,976 (\$29,831\*.5691)
3. The adjusted sample ATE in 2005 (in 1990 dollar) = sample ATE in 1990 \* projected ATE (CWHS sample) in 2005 from step (2) / historical ATE (CWHS sample) in 1990 = \$17,089 (17,441 \* 16,976 / 17,326)

**Example 4:**

**Task:** In projecting the 2015 sample of newly entitled female beneficiaries to represent newly entitled female beneficiaries in 2030, the projected Average Taxable Earnings of females age 40 (year of birth 1950) in the sample ( $\text{ATE}_t$ )<sup>12</sup> for year  $t = 2005$  must be adjusted by an amount,  $\delta(2005)$ , to meet a targeted Average Taxable Earnings( $\text{ATE}_t'$ ) for 2005.

This example illustrates the calculation of  $\delta(2005)$  for the female cohort retiring at age 65 in the projection year 2030. The value  $\delta(2005)$  is the dollar amount in which the average annual earnings levels are adjusted for females age 40 in the year 2005 and retiring in 2030. We will be comparing this group of females age 40 in the projection 2005 year with its counterpart of females age 40 in the base year 1990.

***Information given:***

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<sup>12</sup> The average taxable earnings have been computed using projected earnings adjusted for changes in the wage base and for changes in covered worker rates.

- A cohort of newly entitled retired female beneficiaries retiring at ages 65 represented in the 2015 sample is age 40 in the base year, 1990, and the counterpart group of females retiring in 2030 is age 40 in the year 2005.
- Based on the 2015 sample, the average taxable earnings for females age 40 in the base year 1990 is \$17,441.
- For a sample projected to be retiring in 2030, the average taxable earnings ( $ATE_f$ ) for females age 40 in the year 2005 is \$17,337<sup>13</sup>, after applying adjustments to the records' earning levels for changes in the wage base and in covered worker rates.
- The average taxable earnings ( $ATE_f'$ ) of future sample (2030) for females age 40 in 2005 as shown in Example 3.1 is \$17,089.

***Calculations:***

- The difference in  $ATE_f'$  (\$17,089) and  $ATE_f$  (\$17,337) yields the  $\delta(2005)$  value  $-\$248$  ( $\$17,089 - \$17,337 = -\$248$ ).

**Example 5:**

***Task:*** In projecting the 2015 sample of newly entitled female OAB beneficiaries to represent newly entitled female OAB beneficiaries in 2030, for year  $t = 2005$ ,  $\delta(2005)$  is negative indicating an adjustment to earnings histories is needed to reflect lower average taxable earnings for females age 40 for the year 2005.

This example illustrates the calculation of the ratio (2005) in projection year 2005 for the females retiring at ages 65 in the projection year 2030. The value, ratio (2005), is the adjustment ratio that will be applied to females age 40 projected covered earnings in 2005 in order to achieve the targeted Average Taxable Earnings of this cohort for 2005.

***Information given:***

- Earnings in the year 2005 for the newly entitled female beneficiaries retiring at age 65 in 2030 is the counterpart corresponding to earnings in the base year 1990 for the newly entitled female beneficiaries retiring at age 65 in the 2015 sample.
- The targeted average taxable earnings  $ATE_{2005}'$  for the year 2005 is \$17,089 (shown in Example 4).
- For newly entitled females retiring at age 65 in 2030, the average taxable earnings ( $ATE_{2005}$ ) for the year 2005 is \$17,337<sup>14</sup> (shown in Example 4).
- $\delta(2005)$ , the difference in the targeted average taxable earnings  $ATE_{2005}'$  and  $ATE_{2005}$ , is calculated to be  $-\$248$  ( $\$17,089 - \$17,337$ ).

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<sup>13</sup> Amount is in 1990 dollars, 'sample year dollars'.

<sup>14</sup> Amount is in 1990 dollars, 'sample year dollars'.

- $\alpha$  is an subtractive constant to the ratio(2005). For females age 40 (1950 birth cohort in the 2015 sample) OABs the constant  $\alpha$  when  $\delta(t)$  is negative is .02.

**Calculations:**

- The ratio(2005) multiplied to the covered earnings in 2005 for females age 40 retiring in 2030 is  $1 + \delta(2005) / ATE_{2005} + \alpha = (1 + (-\$248/\$17,337) - 0.02)$ , or .9657.

**Example 6:**

**Task:** The AWARDS subprocess calculates the Average Indexed Monthly Earnings (AIME) of each beneficiary in the sample. The AIME values are then divided into 30 intervals.

This example illustrates the division of a possible AIME value into intervals.

**Information given:**

- An OAB beneficiary retired at age 64 in 2015
- This OAB beneficiary is record #150000 in the sample ( $r = 150000$ )
- The AIME for this individual is \$3,000
- The initial eligibility year is 2013, the year the individual turned age 62.
- The length of each interval ( $bp_n$ ) in 1979 dollars is given in Equation 4.2.3. The length of each interval in 2013 dollars is given by the equation

$$bp_n(r) = bp_n * AWI(2011) / AWI(1977)$$

where  $bp_n$  is the length of interval n in 1979 dollars

- The average wage index (AWI) for year 2011 is \$42,979.61
- The AWI for year 1977 is \$9,779.44
- When converting the intervals from 1979 dollars to 2013 dollars, there is a 2-year lag in AWI values.
- $AIME_n(150000)$  is the AIME value in interval n for Record #150000

**Calculations:**

- The AIME for this individual (\$3,000) is compared to the indexed intervals. It falls within the 14<sup>th</sup> interval.



- The AIME<sub>15</sub> is the residual of \$3,000 subtracting the cumulative indexed bend points up to 13<sup>th</sup> interval (\$2,571.01). The AIME for this individual in 14<sup>th</sup> interval is \$428.99
- AIME<sub>n</sub> (150000) for interval 1 through 13 equals bp<sub>n</sub> (150000) for the corresponding intervals, such that PAP<sub>n</sub> = AIME<sub>n</sub> / bp<sub>n</sub> = 1 for these intervals
- AIME<sub>15</sub>(150000) = \$428.99, such that PAP<sub>14</sub> = \$428.99 / \$439.49 = 0.9761
- AIME<sub>n</sub> (150000) for interval 15 through 30 equals 0, such that PAP<sub>n</sub> = 0 for these intervals.
- The following table details these results.

n	bp <sub>n</sub> in 1979 dollars	bp <sub>n</sub> (r) in 2013 dollars	$\sum_{k=1}^n$ bp <sub>n</sub> (r) in 2013 dollars	AIME <sub>n</sub> (r) in 2013 dollars	PAP <sub>n</sub> in 2013 dollars
1	\$45	\$197.77	\$197.77	\$197.77	1
2	45	197.77	395.54	197.77	1
3	45	197.77	593.31	197.77	1
4	45	197.77	791.08	197.77	1
5	45	197.77	988.85	197.77	1
6	45	197.77	1,186.62	197.77	1
7	45	197.77	1,384.39	197.77	1
8	45	197.77	1,582.16	197.77	1
9	45	197.77	1,779.93	197.77	1
10	45	197.77	1,977.70	197.77	1
11	45	197.77	2,175.47	197.77	1
12	45	197.77	2,373.24	197.77	1
13	45	197.77	2,571.01	197.77	1
14	100	439.49	3,010.50	428.99	0.9761
15	100	439.49	3,449.99	0	0
16	100	439.49	3,889.48	0	0
17	100	439.49	4,328.97	0	0
18	100	439.49	4,768.46	0	0
19	200	878.98	5,647.44	0	0
20	200	878.98	6,526.42	0	0
21	200	878.98	7,405.40	0	0
22	200	878.98	8,284.38	0	0
23	200	878.98	9,163.36	0	0

24	200	878.98	10,042.33	0	0
25	200	878.98	10,921.31	0	0
26	200	878.98	11,800.29	0	0
27	200	878.98	12,679.27	0	0
28	200	878.98	13,558.25	0	0
29	1000	4,394.89	17,953.15	0	0
30	1000	4,394.89	22,348.04	0	0

### **Appendix 4.2-3 Shuttling Method**

The Awards program works with a sample of workers newly entitled in the sample year of 2015. The sample contains the age-sex distribution of newly entitled worker beneficiaries in the sample year. The beneficiaries area (subprocess 3.3) projects that the age-sex distribution of newly entitled worker beneficiaries will vary throughout the long-range period. In past years, the “Cost” area (subprocess 4.3) adjusted the Awards output to align it with the age-sex distribution from subprocess 3.3. For this and future Trustees Reports, the alignment adjustment occurs in the Awards program. This alignment adjustment is referred to as the “shuttling method” as it “shuttles” some workers retiring at one age in the sample to different ages in the projection years.

The shuttling method consists of determining an array for each projection year, which determines what proportion of retirees at each age will “shuttle” to retirement at older ages, or in some rare instances, to retirement at younger ages. For example, it allocates the proportion of sample year 2015 age 62 retirees into later retirement ages 63 through 70 in the projection year. The same process applies to allocate the proportion of age 63 retirees into revised retirement ages 62 through 70, and so on, through age 70. Shuttling backward to the earlier retirement age is rare but possible. For example, it allocates the proportion of sample year 2015 age 66 retirees into earlier retirement ages 62 through 65. For a specific age, then, the final PAPs equal a weighted average of these shuttled PAPs, with the PAPs for revised retirement ages potentially reflecting additional earnings when the revised retirement age is later.

The frequency of earnings in the additional years is set to match projected covered worker rates by age group/sex/projection year, using randomization to achieve this match. Earnings amounts are based on cohort average taxable earnings and the individual’s relative earnings level. PAPs values are computed for each shuttling year and averaged using similar weighting factors, as previously existed in the Cost program before the 2017 Trustees Report, to obtain shuttled PAPs values.

#### **Example 7:**

**Task:** The AWARDS subprocess illustrates the process in determining the matrix of shuttling at age 62 to 70 in the 2015 sample and how the matrix is used in providing adjusted PAPs values by single retirement age.

**Information given:**

Consider the following example. In this example, the projection year is 2025, and the sex is males.

The *oadsrs* vector (initial sex-age distribution in 2015 from sample) is as follows.

	62	63	64	65	66	67	68	69	70
Male	0.2980	0.1173	0.0638	0.0939	0.3125	0.0451	0.0251	0.0157	0.0286

The unaligned age-sex distribution for projection year 2025 (from subprocess 3.3), that is the *oadscp* vector, is as follows.

	62	63	64	65	66	67	68	69	70
Male	0.2330	0.1112	0.0454	0.1053	0.1380	0.1951	0.0548	0.0400	0.0772

The matrix *oads*, computed in this subprocess (4.2) is as follows. An explanation of how this matrix is generated appears below.

<i>ageentRSB</i> \ <i>ageentAWD</i>	62	63	64	65	66	67	68	69	70	Total
62	0.2330	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2330
63	0.0650	0.0462	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1112
64	0.0000	0.0454	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0454
65	0.0000	0.0257	0.0638	0.0158	0.0000	0.0000	0.0000	0.0000	0.0000	0.1053
66	0.0000	0.0000	0.0000	0.0781	0.0599	0.0000	0.0000	0.0000	0.0000	0.1380
67	0.0000	0.0000	0.0000	0.0000	0.1951	0.0000	0.0000	0.0000	0.0000	0.1951
68	0.0000	0.0000	0.0000	0.0000	0.0548	0.0000	0.0000	0.0000	0.0000	0.0548
69	0.0000	0.0000	0.0000	0.0000	0.0027	0.0373	0.0000	0.0000	0.0000	0.0400
70	0.0000	0.0000	0.0000	0.0000	0.0000	0.0078	0.0251	0.0157	0.0286	0.0772
Total	0.2980	0.1173	0.0638	0.0939	0.3125	0.0451	0.0251	0.0157	0.0286	1.0000

Note that the column total is *oadsrs* and the row total is *oadscp*. The *oads* matrix is determined using these row and column sum constraints. The nonzero entries of the *oads* matrix zigzag down and to the right. Starting at the upper left hand corner, the lesser of *oadsrs* and *oadscp* is put there. So  $oads(62,62) = 0.2330$ .

In this case (as is usually the case), *oadscp* is less. This means that the  $oads(62,62)$  value meets the age 62 row constraint but not the age 62 column constraint. Since, the difference  $oadsrs(62) - oadscp(62) = 0.2980 - 0.2330 = 0.0650 < 0.1112 = oadscp(63)$ , by the column sum constraint we are forced to have  $oads(63,62) = 0.0650$  to meet the age 62 column constraint.

Next, for age 63, we want the column sum to equal  $oadsrs(63)$  (.1173) and the row sum to equal  $oadscp(63)$  (.1112). Continuing from  $oads(63,62)$  we move one spot to the right to  $oads(63,63)$ . Since  $oadscp(63) - oads(63,62) = 0.1112 - 0.065 = 0.0462 < 0.1173 = oadsrs(63)$ , the entry  $oads(63,63) = 0.0462$ .

With the row sum constraints for age 63 met, we move one spot down. Since  $oadscp(64) = 0.0454 < 0.1173 - 0.0462 = 0.0711$ , the entry  $oads(64,63) = 0.0454$ .

The row sum constraint for age 64 is now met since the row sum equals  $oadscp(64)$ , and we move one spot down. Since  $0.1173 - 0.0454 - 0.0462 = 0.0257 < oadscp(65) = 0.1053$ , the entry  $oads(65,63) = 0.0257$ .

Now the column sum constraint for age 63 is met, so we move one column to the right. Since  $oadscp(65) - oads(65,63) = 0.1053 - 0.0257 = 0.0796 > 0.0638 = oadsrs(64)$ , by the column sum constraint we are forced to have  $oads(65,64) = 0.0638$ .

The column constraint for age 64 is now met, but not the row constraint for age 65, so we move right one spot to  $oads(65,65)$ . For the row sum to be  $oadscp(65)$  we have  $oads(65,65) = 0.1053 - 0.0257 - 0.0638 = 0.0158$ .

Since the age 65 row constraint is now met, we move down to  $oads(66,65)$ .  $oadsrs(65) - oads(65,65) = 0.0939 - 0.0158 = 0.0781 < oadscp(66) = .138$ , so by the age 66 column constraint  $oads(66,65) = 0.0781$ .

Now we can get the age 66 row total to match  $oadscp(66)$  by setting  $oads(66,66) = 0.138 - 0.0781 = 0.0599$ .

Now that the age 66 row constraint is met, we move one row down to  $oads(67,66)$ . Since  $oadsrs(66) - oads(66,66) = 0.3125 - 0.0599 = 0.2526 > 0.1951 = oadscp(67)$ , by the age 67 row sum constraint we are forced to have  $oads(67,66) = 0.1951$ .

Now the age 67 row constraint is met but we are still trying to meet the age 66 column constraint. We move one row down to  $oads(68,66)$ . Since  $oadsrs(66) - oads(67,66) - oads(66,66) = 0.3125 - 0.1951 - 0.0599 = 0.0575 > 0.0548 = oadscp(68)$ , by the age 68 row sum constraint we are forced to have  $oads(68,66) = 0.0548$ . This meets the age 68 row constraint but still not the age 66 column constraint.

So we move another row down and set  $oads(69,66) = 0.0575 - 0.0548 = 0.0027$ , meeting the age 66 column constraint. Then we move right one spot to  $oads(69,67)$ . Now we can get the age 69 row total to match  $oadscp(69)$  by setting  $oads(69,67) = oadscp(69) - oads(69,66) = 0.04 - 0.0027 = 0.0373$ . Now this row constraint is

met, we move one row down to  $oads(70,67)$ .

$$oads(70,67) = oadsrs(67) - oads(69,67) = 0.0451 - 0.0373 = 0.0078.$$

Now the age 67 column constraint is satisfied and we move right to  $oads(70,68)$ . By the age 70 column constraint, this entry is forced to be  $oads(70,68) = 0.0251$ .

Moving to the right, by the age 69 column constraint, the entry  $oads(70,69)$  is forced to be 0.0157.

Finally, by the age 70 row and column constraints, the last entry,  $oads(70,70)$ , is 0.0286.

To obtain the  $w$  matrix, normalize the rows by dividing by the row sum.

<i>ageentRSB \ ageentAWD</i>	62	63	64	65	66	67	68	69	70
62	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
63	0.5845	0.4155	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
64	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
65	0.0000	0.2441	0.6059	0.1500	0.0000	0.0000	0.0000	0.0000	0.0000
66	0.0000	0.0000	0.0000	0.5659	0.4341	0.0000	0.0000	0.0000	0.0000
67	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
68	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
69	0.0000	0.0000	0.0000	0.0000	0.0675	0.9325	0.0000	0.0000	0.0000
70	0.0000	0.0000	0.0000	0.0000	0.0000	0.1010	0.3251	0.2034	0.3705

With these normalized weights, final PAPs are computed for each age (row) as a weighted average of the PAPs, shuttled and non-shuttled, for the applicable individual ages with non-zero values in each row. Going down the row of the above matrix, then:

- Age 62 final PAPs = age 62 original (unshuttled) PAP
- Age 63 final PAPs = .5845 \* age 62 PAPs shuttled to age 63 + .4155\*age 63 original PAP
- Age 64 final PAPs = Age 63 PAPs shuttled to age 64
- Age 65 final PAPs = .2441 \* age 63 PAPs shuttled to age 65 + .6059\*age 64 PAPs shuttled to age 65 + .1500\*age 65 original PAP
- Age 66 final PAPs = .5659 \* age 65 PAPs shuttled to age 66 + .4341\*age 66 original PAP
- Age 67 final PAPs = age 66 PAPs shuttled to age 67
- Age 68 final PAPs = age 66 PAPs shuttled to age 68
- Age 69 final PAPs = .0675 \* age 66 PAPs shuttled to age 69 + .9325\*age 67 PAPs shuttled to age 69
- Age 70 final PAPs = .1010 \* age 67 PAPs shuttled to age 70 + .3251 \* age 68 PAPs shuttled to age 70 + .2034 \*age 69 PAPs shuttled to age 70 + .3705 \* age 70 original PAP

When PAPs are shuttled from a given age to age + x, all sample cases at the given original age have their AIME recalculated for retirement at age + x, with potential x additional earnings years included.

### 4.3. Cost

#### 4.3.a. Overview

The COST subprocess projects the trust fund operations for each year of the long-range 75-year period. The COST subprocess projects the income and cost for each trust fund (OASI and DI). The two components of non-interest income are payroll tax contributions and taxation of benefits.<sup>1</sup> The other component of income is interest earned on the trust fund assets. The three components of cost are scheduled benefits, administrative expenses, and the railroad interchange. Each of these components is projected for each trust fund (OASI and DI). The end-of-year assets is computed by taking the beginning-of-year assets (*ASSETS*), adding payroll contributions (*CONTRIB*), taxation of benefits (*TAXBEN*), and interest income (*INT*), and subtracting scheduled benefits (*BEN*), administrative expenses (*ADM*), and the railroad interchange (*RR*).

Equations 4.3.1 through 4.3.6 outline this overall structure and sequence.

$$CONTRIB = CONTRIB(\cdot) \quad (4.3.1)$$

$$BEN = BEN(\cdot) \quad (4.3.2)$$

$$TAXBEN = TAXBEN(\cdot) \quad (4.3.3)$$

$$ADM = ADM(\cdot) \quad (4.3.4)$$

$$RR = RR(\cdot) \quad (4.3.5)$$

$$INT = INT(\cdot) \quad (4.3.6)$$

$$ASSETS_{EOY} = ASSETS_{BOY} + CONTRIB + TAXBEN + INT - BEN - ADM - RR$$

The COST subprocess produces annual values that help assess the financial status of the OASI, DI, and combined funds. These include the annual income rate (*ANN\_INC\_RT*), annual cost rate (*ANN\_COST\_RT*), and trust fund ratio (*TFR*) as outlined below.

$$ANN\_INC\_RT = ANN\_INC\_RT(\cdot) \quad (4.3.7)$$

$$ANN\_COST\_RT = ANN\_COST\_RT(\cdot) \quad (4.3.8)$$

$$TFR = TFR(\cdot) \quad (4.3.9)$$

The COST subprocess also produces summarized values. These values are computed for the entire 75-year projection periods, as well as 25- and 50-year periods. These include

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<sup>1</sup> As noted throughout the Trustees Report a third component of non-interest income is reimbursements from the General Fund of the Treasury. In the cost program such reimbursements are simply treated as payroll tax contributions.

the actuarial balance ( $ACT\_BAL$ ), unfunded obligation ( $UNF\_OBL$ ), summarized income rate ( $SUMM\_INC\_RT$ ), summarized cost rate ( $SUMM\_COST\_RT$ ), and closed group unfunded obligation ( $CLOSEDGRP\_UNFOBL$ ).

$$ACT\_BAL = ACT\_BAL(\cdot) \quad (4.3.10)$$

$$UNF\_OBL = UNF\_OBL(\cdot) \quad (4.3.11)$$

$$SUMM\_INC\_RT = SUMM\_INC\_RT(\cdot) \quad (4.3.12)$$

$$SUMM\_COST\_RT = SUMM\_COST\_RT(\cdot) \quad (4.3.13)$$

$$CLOSEDGRP\_UNFOBL = CLOSEDGRP\_UNFOBL(\cdot) \quad (4.3.14)$$

The following notation is used throughout this documentation:

- $ni$  represents the first year of the projection period-2018 for the 2018 TR
- $ni+74$  represents the final year of the projection period-2092 for the 2018 TR
- $nf$  represents the last year the cost program will project-2095 for the 2018 TR
- $nim1$  is equal to  $ni-1$
- $nim2$  is equal to  $ni-2$
- $ns$  is equal to  $ni+9$
- $nbase$ , the year of the sample, is equal to 2015

### 4.3.b. *Input Data*

Data received as input from the short-range office are presented first. Then data from long range and all other sources are identified separately for each equation.

#### *Short-range OCACT Data*

- 1) Estimates for the first ten years of the projection period for the first six equations mentioned above.
- 2) Assets at the beginning of year  $ni$ .

All of this information is updated annually.

#### *Long-range OCACT and other Data*

##### *i. Equation 4.3.1 – Tax Contributions (CONTRIB)*

###### Economics-Process 2

- 3) Projected effective taxable payroll for years  $nim1$  through  $nf$ , updated yearly

###### Other

- 4) Projected employee/employer payroll tax rate, by trust fund and year, for years 1981 through  $nf$ , updated as needed (e.g., as required due to legislative changes)

##### *ii. Equation 4.3.2 – Scheduled Benefits (BEN)*



### Demography-Process 1

- 5) Projected number of married and divorced people in the Social Security area population by age for end of years *nim1* through 2100, updated yearly

### Economics-Process 2

- 6) Historical COLA for year *nim2*, updated yearly
- 7) Historical CPI for years 1990 through *nim1*, updated yearly
- 8) Projected cost of living adjustment (COLA) for years *nim1* through *nf*, updated yearly
- 9) Historical SSA average wage index for year *nim2*, updated yearly
- 10) Projected percent increases in the average wage index for years *nim1* through *nf*, updated yearly

### Beneficiaries-Process 3

- 11) Projected number of disabled workers newly awarded by sex, attained age, and duration from entitlement (0 through 9 and 10+) for years *ni* through *nf*, updated yearly from subprocess 3.2
- 12) Projected number of disabled workers in current-pay status by sex, age in current-pay, and duration of disability (0 through 9 and 10+) for years *nim1* through *nf*, updated yearly from subprocess 3.2
- 13) Projected number of retired worker beneficiaries in current-pay status by sex, age in current-pay, and age at entitlement for years *nim1* through *nf*, updated yearly from subprocess 3.3
- 14) Projected number of auxiliary beneficiaries (by benefit category) of retired-worker, deceased-worker, and disabled-worker beneficiaries for years *nim1* through *nf*, updated yearly from subprocesses 3.2 and 3.3
- 15) Projected number of disability insurance beneficiaries who convert to retirement insurance status upon the attainment of normal retirement age by age in current pay, for years *nim1* through *nf*, updated yearly from subprocess 3.2 and 3.3
- 16) Retired Workers 65+ by sex, and marital status (single, married, widowed, and divorced) for years *nim1* through *nf*
- 17) Retired Workers 62+ by sex, and marital status (single, married, widowed, and divorced) for years *nim1* through *nf*
- 18) Male widowed retired workers by age band (62-64, 65-69, 70-74, 75-79, 80-84, 85-89, 90-95, 95+) for years *nim1* through *nf*
- 19) Female widowed retired workers by age band (62-64, 65-69, 70-74, 75-79, 80-84, 85-89, 90-95, 95+) for years *nim1* through *nf*

### Other

- 20) Adjustment factor, applied to DI worker retroactive benefit payments to align to historical data, updated yearly
- 21) Total (aggregate) PIA and MBA, not actuarially reduced, of DI male and female workers in current payment status, updated yearly from the Table 1-A Supplement

- 22) Total (aggregate) PIA and MBA, actuarially reduced, of DI male and female workers in current payment status, updated yearly from the Table 1-A Supplement
- 23) Total (aggregate) PIA and MBA, not actuarially reduced, of newly awarded DI male and female workers, updated yearly from the Table 1-A Supplement
- 24) Cumulative distribution of AIME dollars for newly entitled retired-worker beneficiaries by age (62 through 70) and sex, for years *nim1* through *nf*, updated yearly from subprocess 4.2
- 25) Cumulative distribution of AIME dollars for newly entitled disabled-worker beneficiaries by age (20 through 65) and sex, for years *nim1* through *nf*, updated yearly from subprocess 4.2. Ages 15 through 19 are assumed to have the same distribution of dollars as does age 20. Future age 66 disabled workers are assumed to have the same distribution of dollars as age 65 workers have
- 26) Starting average PIA matrix for retired-worker benefits for the year *nim1*, by age at entitlement, age in current-pay and sex, updated yearly
- 27) Starting average PIA matrix for disabled-worker benefits, for the year *nim1*, by age in current-pay, duration and sex, updated yearly
- 28) Starting average PIA matrix for beneficiaries who convert from disabled worker to retirement worker status for the year *nim1*, by age in current-pay and sex, updated yearly
- 29) Starting average MBA matrix for retired-worker benefits for the year *nim1*, by age at entitlement, age in current-pay and sex, updated yearly
- 30) Starting average MBA matrix for beneficiaries who convert from disabled worker to retirement worker status for the year *nim1*, by age in current-pay and sex, updated yearly
- 31) Benefit relationships between worker and auxiliary benefits (linkages) for the year *nim1*, for all benefit categories and worker account holders of both sexes, updated yearly from qlink18.xls
- 32) Benefit relationships between workers and aged spouses for years *nim1* through *nf* with the effect of the ‘Bipartisan Budget Act of 2015’ on “claiming strategies” taken into account
- 33) Retroactive payment loading factors for auxiliary beneficiary categories for all years, for each benefit category and both sexes, updated yearly
- 34) Initial and ultimate post entitlement factors for retired workers by sex and duration updated yearly. Factors are read in such that there is a twenty-year linear phase-in from initial factors to ultimate factors.
- 35) Initial and ultimate post entitlement factors for disabled workers by sex and duration updated yearly. Factors are read in such that there is a twenty-year linear phase-in from initial factors to ultimate factors.
- 36) Initial and ultimate post entitlement factors for DI conversion workers by sex and duration updated yearly. Factors are read in such that there is a twenty-year linear phase-in from initial factors to ultimate factors.
- 37) Initial Windfall Elimination Provision (WEP) factors by sex and age for attributed year, updated every 2 years
- 38) Ultimate WEP factors by sex read in as a percentage of the way from initial

- factors to one, updated every 2 years
- 39) Year in which ultimate WEP factor is reached by age at initial entitlement (62-70), updated every 2 years
  - 40) Trendline by which WEP factors are phased-in from initial value to ultimate value, updated every 2 years
  - 41) Workers' Compensation cumulative factors by duration that adjust benefits to account for decreasing offsets (i.e. – Workers Comp offsets decrease as duration increases), updated yearly
  - 42) Workers' Compensation reduction factors (used in retroactive category) to reflect offsets starting and stopping in the year of DI entitlement
  - 43) Workers' Compensation parameter to account for offsets that begin and end in the year of entitlement, updated yearly
  - 44) Dual entitlement regression coefficients for the 12 dual entitlement equations (3 each for number of widows, number of widowers and the average excess amount for widows, and, 1 each for number of wives, number of husbands and the average excess amount for wives), updated yearly
  - 45) Dual entitlement widower excess amount as a percent of widow excess amount, by age band and year, updated yearly
  - 46) Dual entitlement husband excess amount as a percent of wife excess amount, by year, updated yearly
  - 47) Dual entitlement average excess amounts and percentages of exposure population for December, year  $n_i-1$  for wives, husbands, widows, and widowers, updated yearly
  - 48) Average retired worker PIA in the last year of the projection period, by age band and sex, updated yearly
  - 49) Target values for ratios relating to the twelve dual entitlement categories, updated yearly
  - 50) Number of years in which the difference between the results from the regression coefficients and targeted values are phased in for the twelve dual entitlement categories, updated yearly
  - 51) Historical adjustment factor for each of the twelve dual-entitlement categories, updated yearly
  - 52) Adjustment factors for average retired and disabled worker benefit amounts (PIA and MBA) in current-pay at durations 0 and 1, by sex and age, updated yearly
  - 53) Number of months retroactive benefits are received by a worker who is paid retroactively in their year of entitlement, by trust fund
  - 54) Adjustment factors for average retired worker retroactive benefit amounts by sex, updated yearly
  - 55) Adjustment factors for disabled worker retroactive benefit amounts in current-pay at durations 0, 1 and 2+, by sex and age, updated yearly
  - 56) Retired worker actuarial reduction factors and delayed retirement credit levels based on year of birth, based on current law (generally not updated)

*iii. Equation 4.3.3 – Taxation of Benefits*

Trust Fund Operations and Actuarial Status

57) Taxation of benefits as a percentage of scheduled benefits by trust fund for years  $nim1$  through  $nf$ , updated yearly from subprocess #4.1

iv. *Equation 4.3.4 – Administrative Expenses*

Economics-Process 2

58) Average wage indexes for years  $nim1$  through  $nf$ , updated yearly

59) Ultimate value of productivity factor for the period  $ni$  through  $nf$  updated yearly

Beneficiaries-Process 3

60) Total number of beneficiaries in current-pay status by trust fund for years  $nim1$  through  $nf$ , updated yearly

v. *Equation 4.3.5 – Railroad Interchange*

Economics-Process 2

61) Increase in the average wage index for years  $nim1$  through  $nf$ , updated yearly

62) Ultimate value of productivity factor for the period  $ni$  through  $nf$  updated yearly

Trust Fund Operations and Actuarial Status

63) Taxation of benefits as a percent of the amount of benefits scheduled to be paid, by trust fund for years  $nim1$  through  $nf$ , updated yearly (use same factors as in equation 4.3.3)

Other input data

64) Nominal annual yield rate on the combined OASDI trust fund for year  $nim1$

65) Regression coefficients to project annual prescribed interest rates, related to railroad interchange, updated annually

66) Ratio of railroad retirement OASI and DI average benefits to overall OASI and DI average benefits, updated yearly

67) Number of railroad beneficiaries (retirement and disability) for December of year  $nim3$ , updated yearly

68) Average taxable earnings in railroad employment for year  $nim2$ , updated yearly

69) Expected railroad new awards as a percent of the average of historical employment data, updated yearly

70) Historical data on average railroad employment, 1960 through  $nim2$

71) Average worker benefit by sex and trust fund for December  $nim1$  and December  $nim2$ , updated yearly

72) Auxiliary loading factor by trust fund, updated yearly using 10 years of historical financial interchange benefit data

73) Railroad initial mortality rate by trust fund for year  $nim2$ , updated yearly using 10 years of historical financial interchange benefit data

- 74) Railroad mortality improvement rate by trust fund, updated yearly using 10 years of historical financial interchange benefit data
- 75) Fiscal Year Railroad transfer amount in millions of dollars for year  $ni$

vi. *Equation 4.3.6 – Interest Income*

Economics-Process 2

- 76) Annual increase in the CPI for years  $ni$  through  $nf$ , updated yearly

Trustees assumptions

- 77) Ultimate real interest rate, updated annually

Other input data

- 78) Factors for exposure to interest rate for benefits, payroll, and taxation of benefits, updated yearly
- 79) Factors for exposure to railroad interchange and administrative expenses, updated periodically

vii. *Equations 4.3.7 through 4.3.13 – Annual Values and Summarized Values*

All inputs for equations 4.3.7 through 4.3.13 are estimated internally in the Cost program.

viii. *Equation 4.3.14 – Closed Group Unfunded Obligation*

Demographics-Process 1

- 80) Single year population and mortality rate data for years 1941 through 2101, updated yearly

Economics-Process 2

- 81) Historical and projected single-year COLA data and average wage indexing series (AWI) data for years 1975 through 2095 (for COLA) and 1951 through 2095 (AWI), updated yearly as applicable
- 82) Historical and projected number of covered workers by single year of age 0-99 and 100+ from year  $ni-21$  through 2095, updated yearly
- 83) Ultimate assumed annual average wage increase,  $wg\_ult$ , updated yearly

Beneficiaries-Process 3

- 84) Total projected disabled workers by age for years  $ni$  to 2095, updated yearly
- 85) Total projected aged spouses, divorced aged spouses, surviving aged spouses and divorced surviving aged spouses by sex, single year of age (up to 95+) and for years  $ni$  to 2095.

Awards-Process 4

- 86) Projected number of workers and total taxable earnings by single year of age (15-80) and sex from  $ni$  to 2095, updated yearly

## Other

- 87) Total count of beneficiaries in 20 of the 28 beneficiary categories (excluding retired workers, disabled workers, aged spouses (married, divorced, and dually entitled excess), and aged widow(er)s (married, divorced, and dually entitled excess) from the December 2017 Master Beneficiary Record (MBR)<sup>2</sup>—updated yearly
- 88) Total benefits paid in 20 of the 28 beneficiary categories (excluding retired workers, disabled workers, aged spouses (married, divorced, and dually entitled excess), and aged widow(er)s (married, divorced, and dually entitled excess) from the December 2017 MBR—updated yearly
- 89) Consumer Price Index data from 1951-1974 from Bureau of Labor Statistics (not updated)
- 90) Number of covered workers and average taxable earnings by single year of age 1-14 for years 1995-2014 from 1 percent Continuous Work History Sample (CWHS), updated yearly to include year ni-4
- 91) Number of covered workers and average taxable earnings by single year of age 81-99 for years 1995-2014 from 1 percent CWHS, updated yearly to include year ni-4
- 92) Distribution of assumed age differentials between aged spouses and workers ranging from -12 years to 15 years seniority for the worker by sex of the beneficiary, age of the beneficiary 62-74, and marital status obtained from the December 2015 MBR—updated every 3 years
- 93) Distribution of assumed age differentials between widow(er)s and workers ranging from -6 years to 12 years seniority for the male (generally not updated)
- 94) Factors to apply to the 95+ “in current pay” counts of retired workers, aged spouses, surviving aged spouses, divorced spouses, and dually entitled spouses expanding the single age counts through 119, updated yearly

### **4.3.c. *Development of Output***

#### ***i. Equation 4.3.1 – Payroll Tax Contributions (CONTRIB)***

It would be natural to estimate the payroll tax contributions by trust fund by multiplying the applicable employer/employee tax rate by effective taxable payroll. However, tax contributions are reported on a cash basis. That is, tax contribution amounts are attributed to the year in which they are actually received by the trust funds, while taxable payroll is attributed to the year in which earnings are paid. In other words, the lag between the time the tax liability is incurred and when the taxes are actually collected must be reflected. If *lag* represents the proportion of incurred payroll taxes estimated to

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<sup>2</sup> For disabled adult children of deceased workers and lump-sum beneficiaries, data were extracted from a 1- percent sample of the December 2017 MBR, mainframe dataset ACT.TAPEL.CAN1217. For the other 18 auxiliary beneficiary categories, data was extracted from the 100 percent December 2017 MBR, mainframe dataset ACT.TAPEH.MBR100.D1712.CANSORT.

be received by the trust fund (*tf*) in year *yr*, then tax contributions (*CONTRIB*) are given by the formula

$$\begin{aligned} \text{CONTRIB}(tf, yr) = & \text{lag} \times \text{tax rate}(tf, yr) \times \text{payroll}(yr) \\ & + (1 - \text{lag}) \times \text{tax rate}(tf, yr - 1) \times \text{payroll}(yr - 1) \end{aligned}$$

for  $yr \geq ns$ .

The value of *lag* is estimated from the combined OASI and DI tax contributions estimated to be collected in the final year of the short-range period, *ns*, and is given by

$$\text{lag} = \frac{\sum_{tf=1}^2 \text{CONTRIB}(tf, ns) - \sum_{tf=1}^2 (\text{taxrate}(tf, ns - 1) \times \text{payroll}(ns - 1))}{\sum_{tf=1}^2 (\text{taxrate}(tf, ns) \times \text{payroll}(ns) - \text{taxrate}(tf, ns - 1) \times \text{payroll}(ns - 1))}.$$

For the first ten years of the long-range period, tax contributions are set equal to those provided by the short-range office. The same value of *lag* is used for all years, and both trust funds, thereafter.

**ii. Equation 4.3.2 – Scheduled Benefits (BEN)**

(1) Disabled-Worker Benefits

*Disabled Worker Beneficiary Matrix*

The number of disabled-worker beneficiaries for a given year and sex is provided from subprocess 3.2. For each projection year, two matrices are provided – one for males and one for females. The structure of each matrix is as follows:

- 11 columns. The columns are indexed by duration of disability (0-9 and 10+).
- 52 rows. These rows correspond to the age in current pay, ages 15 through 66.

The COST subprocess, however, only uses 10 durations (0-8 and 9+), and 47 ages (ages 20 through 66). This requires a manipulation of the matrix of DI beneficiaries in current-pay status from subprocess 3.2. For ages in current pay greater than or equal to 30, the duration 9 and 10+ columns of this matrix are added to give the total number of duration 9+ beneficiaries. For ages (*ag*) between 20 and 30 inclusive, the number of beneficiaries in current-pay aged *ag* and duration *ag-20* is the value provided by the DISABILITY subprocess added to the number of people in current pay aged *ag-j* and duration *ag-20* for  $j=1, \dots, 5$ . (For example, the number of people aged 20 of duration 0 is combined with the number of people aged 15, 16, 17, 18 and 19 of duration 0; the number of people aged 21 of duration 1 is combined with the number of beneficiaries in current-payment status aged 16, 17, 18, 19, and 20 of

duration 1, and so on. In other words, the five nonzero diagonals of the matrix provided by the DISABILITY subprocess are “combined with” the diagonal directly below it and then zeroed out.)

*Building the Average Benefit Matrix for Disabled Workers*

In each projection year, the COST subprocess produces an average benefit matrix for each sex. Each matrix is a 47 by 10 matrix whose entries are the average benefit amounts of disabled worker beneficiaries whose age in current pay is indexed by the rows (ages 20 through 66) and whose duration of disability is indexed by the columns (durations 0 through 8 and 9+).

The 100 percent Master Beneficiary Record (100% MBR) extract is processed by a side model. The final product of the side model is two matrices of average benefit levels, one for males and one for females, for December *nim1* (2017 for the 2018 TR).

For a given year of the projection period, a new average benefit matrix is obtained by moving the average benefit matrix from the previous year one year forward. The next few paragraphs describe this procedure.

In general, for each age in current-pay, the age and duration are incremented by 1 and the previous PIA amount is given a cost of living adjustment. In addition, the beneficiaries are given a workers’ compensation adjustment and a post-entitlement adjustment. For each duration  $j = 0, 1, \dots, 7$ , and 8+ and sex, let the workers’ compensation offset factor be denoted  $wkcomp(yr, sx, dur)$ . We have, for durations 0 through 8, that

$$avgmba(yr, sx, ag, dur) = avgmba(yr - 1, sx, ag - 1, dur - 1) \times (1 + COLA(yr)) \times (1 + wkcomp(yr, sx, dur)) \times PEadj(yr, sex, dur).$$

A more careful explanation of the factors,  $wkcomp(yr, sx, dur)$  and  $PEadj(yr, sex, dur)$ , is given later in this document. See the section titled *Average PIAs and MBAs for Disabled-Worker Beneficiaries*, below. To move duration 8 average benefits to duration 9+ average benefits, both average benefits are given a cost of living adjustment and a post-entitlement adjustment (see section “Post-Entitlement Adjustments”). The resulting duration 9+ average benefit is the weighted average of the adjusted prior year duration 8 and 9+ average benefits, weighted by the prior year’s numbers of beneficiaries in current-pay status for durations 8 and 9+ respectively.

The only column that does not follow this procedure is the duration 0 column. The duration 0 column corresponds to newly entitled disabled-worker beneficiaries. The following sections describe how average benefits are determined for this group of beneficiaries.



*Average Benefits for Newly Entitled Disabled-Worker Beneficiaries*

The potential AIME percentage values for newly entitled disabled-worker benefits (DPAPs) are obtained from the AWARDS subprocess. The two bendpoints of the PIA formula, BP1 and BP2, are indexed by the increase in the average wage index. In 1979 dollars, the values of BP1 and BP2 are \$180 and \$1,085 respectively. The AIME dollars between 0 and BP1 are divided into four intervals (each of length \$45 in 1979 dollars). The AIME dollars between BP1 and BP2 are divided into fourteen intervals (nine of length \$45 and five of length \$100, in 1979 dollars). Twelve additional intervals are added beyond BP2 (ten of length \$200 and two of length \$1,000, in 1979 dollars).

To determine the average PIA for newly entitled beneficiaries, the DPAP values for each of the thirty intervals of AIME dollars are multiplied by the dollar amounts attributable to each interval (the length of the interval) and by the associated PIA factors. The distribution of prior year disability onset and current year disability onset is taken into consideration. It is assumed that this distribution is 6 months for prior year disability onset and 6 months for current year disability onset. In the formulas below,  $j = 1$  signifies current year disability onset and  $j = 2$  signifies prior year disability onset.

Let:

- $Wage\_Idx_j (sx, ag, yr) = \frac{avgwg(yr - \max(ag - 60, 1 + j))}{avgwg(1977)}$  for  $j=1,2$ .
- $Cum\_COLA_1(ag, yr) = \begin{cases} (1 + COLA(yr - 1)) \times (1 + COLA(yr)) & ag < 64 \\ \prod_{k=62}^{ag} (1 + COLA(yr - (k - 62))) & 64 \leq ag \leq 66. \end{cases}$
- $Cum\_COLA_2(ag, yr) = \begin{cases} 1 + COLA(yr) & ag < 63 \\ \prod_{k=63}^{ag} (1 + COLA(yr - (k - 62))) & 63 \leq ag \leq 66. \end{cases}$
- $w_j = \frac{6}{12} = \frac{1}{2}, j=1,2$ .
- $PIA\_factor_i$  represent the PIA factor for interval  $i$  (equal to 0.90 for intervals  $i=1, \dots, 4$ , 0.32 for intervals  $i=5, \dots, 18$ , and 0.15 for intervals  $i=19, \dots, 30$ ).
- $AIME\_dollars_i$  represent the length of interval  $i$ , expressed in 1979 dollars.
- $dpap_i (yr, sx, ag)$  represent the DPAP value for newly entitled disabled workers in year  $yr$  whose sex is  $sx$  and age is  $ag$ .

To take into account the workers' compensation offset to disability benefits, administrative data is reviewed, from which a factor is developed and applied to the average award benefit. We now describe how this factor,  $facm2p(yr, sx)$  is computed. The table 1-A supplement, for each month in 2017, contains total award PIA and MBA data for disabled workers, by sex, for beneficiaries both non-

actuarially reduced and actuarially reduced. Let  $totmba\_DIB\_nar(yr, sx)$  and  $totpia\_DIB\_nar(yr, sx)$  be the total annual MBA and PIA respectively for DIBs that are not actuarially reduced as found in the table 1-A data. In the historical period 2000-*nim1* we define  $facm2p(yr, sx)$  to be the ratio of the total MBA to the total PIA for those not actuarially reduced. In other words,

$$facm2p(yr, sx) = \frac{totmba\_DIB\_nar(yr, sx)}{totpia\_DIB\_nar(yr, sx)}.$$

In the period  $ni$  through  $ns+9$ ,  $facm2p(yr, sx)$  is defined as follows. Let

$$y1 = facm2p(nim1, sex)$$

$$y2 = (1.0 - y1) / 3.0$$

$$facm2p(yr, sx) = \max(y1 - y2, \min(y1 + y2, facm2p(yr - 1, sx) \times \left( \frac{facm2p(yr - 1, sx)}{facm2p(yr - 11, sx)} \right)^{1/20})).$$

Projected values of  $facm2p$  are therefore held within a delta of  $y2$  from the last historical year of  $facm2p$ .

This value is further adjusted by the variable  $facm2p\_param$  to reflect the offset amounts that end within the first entitlement year. For the 2018 TR the data suggests this factor should be .37. As a result, for  $yr = ni, \dots, ns+9$ ,

$$\begin{aligned} facm2p(yr, sx) &= x + (1 - x) \times 0.37 \\ &= 0.37 + 0.63 \times x. \end{aligned}$$

The factor reaches its ultimate value in years  $ns+10$  and later.

The preliminary average PIA for newly entitled disabled worker beneficiaries may now be defined. It is equal to

$$\begin{aligned} LR\_awdpia(sx, ag, yr) &= \sum_{i=1}^{30} PIA\_factor_i \times AIME\_dollars_i \times dpap_i(yr, sx, ag) \\ &\quad \times \left( \sum_{j=1}^2 w_j \times Wage\_Idx_j(sx, ag, yr) \times Cum\_COLA_j(ag, yr) \right) \\ &\quad \times facm2p(yr, sx). \end{aligned}$$

Once these average PIAs of newly entitled disabled-worker beneficiaries are computed, their values are filled into the average PIA matrices for duration 0 for the appropriate entitlement age.

#### *Average PIAs and MBAs for Disabled-Worker Beneficiaries*

An overall average PIA of newly entitled disabled worker beneficiaries for each sex and projection year is computed by taking the weighted average of  $awdpia(sx, ag, yr)$ ,

the weights being the number of disabled workers in current payment status of duration zero. This value is denoted  $awdpia(sx, yr)$ .

In addition, an overall average PIA and MBA for all disabled worker beneficiaries in current-payment status is computed by finding the weighted average of the average PIAs for each age in current-pay and duration with the number of people in current pay for each of these ages and durations. The average PIAs were already reduced by a workers' compensation offset factor, as briefly described above; a more careful description is given in this section. To get the average MBAs, we apply a factor that reflects the differences in average MBAs and PIAs for disabled workers, isolating only the trend in cases with an actuarial reduction. We also provide a relatively small reduction to reflect offsets starting and stopping in the year of DI entitlement that are not captured by the current method. There is an additional adjustment to the weighted average disabled worker PIA and MBA amounts in current pay at durations 0 and 1 to account for benefit level differences that are phased out by duration 2.

*Workers' Compensation Offset Factors*

For each duration  $j = 1, \dots, 7$ , and 8+ and sex we define a workers' compensation factor. This factor is applied to the average worker PIA matrix as mentioned above. It is denoted  $wkcomp(yr, sx, dur)$ . Let  $facm2p\_pct(dur)$  be defined as in the following table.

Duration	Cumulative product above set at x% of way between original $facm2p$ and 1
1	0.507776
2	0.684683
3	0.764297
4	0.812826
5	0.850587
6	0.872200
7	0.888780
8+	0.904762

Then  $wkcomp(yr, sx, dur)$  is defined so that

$$facm2p\_pct(dur) = facm2p(yr - dur, sx) \times \prod_{j=1}^{dur} (1 + wkcomp(yr, sx, j)).$$

This is an iterative process that first computes  $wkcomp(yr, sx, 1)$  by solving the above equation with  $dur$  set equal to 1. The remaining factors for higher durations are then computed recursively using the above formula.

*Trend in Average MBA to Average PIA*

This trend is captured in a factor denoted  $Fam2p(yr, sx)$ . The table 1-A supplement as of the end of December 2017 contains total in-current pay PIA and MBA data for disabled workers, by sex, for beneficiaries both non-actuarially reduced and

actuarially reduced. Let  $totmba\_nar(yr, sx)$  and  $totpia\_nar(yr, sx)$  be the total MBA and PIA respectively for DIBs that are not actuarially reduced as found in the table 1-A data. Similarly, let  $totmba\_ar(yr, sx)$  and  $totpia\_ar(yr, sx)$  be the total MBA and PIA respectively for cases that are actuarially reduced. In the historical period 2000-*nim1* we define  $fam2p(yr, sx)$  to be the ratio of the total MBA to the total annual PIA for those not actuarially reduced. In other words,

$$Fam2p(yr, sx) = \frac{totmba\_ar(yr, sx) + totpia\_nar(yr, sx)}{totpia\_ar(yr, sx) + totpia\_nar(yr, sx)}.$$

In the period  $ni$  through  $ns+10$ ,  $fam2p(yr, sx)$  is defined as follows:

$$y1 = fam2p(nim1, sx)$$

$$y2 = (1.0 - y1) / 3.0$$

$$fam2p(yr, sx) = \max(y1 - y2, \min(y1 + y2, fam2p(yr - 1, sx) \times \left( \frac{fam2p(yr - 1, sx)}{fam2p(yr - 11, sx)} \right)^{1/20})).$$

The factor reaches its ultimate value in years  $ns+10$  and later.

#### *More Workers' Compensation Offsets*

As mentioned above, we also we provide a relatively small reduction to retroactive benefits to reflect offsets starting and stopping in the year of DI entitlement that are not captured by the current method. Based on historical administrative data, we set these factors by duration as follows:

Duration	Percentage Reduction
0	0.2450%
1	0.1625%
2	0.0483%
3	0.0413%
4	0.0138%
5+	0%

We define  $wkcomp\_red(dur)$  to be 1 minus these percentage reductions.

By law, disabled workers are no longer subject to the workers' compensation offset at the attainment of a defined age. For those born prior to 1951, the defined age is 65. For those born in 1951 and later, the defined age is the Normal Retirement Age (NRA).<sup>3</sup> Therefore, all DI worker benefit levels are adjusted at either age 65 (for those born prior to 1951) or at conversion to a retired worker benefit (for those born 1951 and later) to eliminate the effect of the offset.

#### *Adjustment to Average Benefit Levels at Durations 0 and 1*

Average disabled worker PIA and MBAs are adjusted further at durations 0 and 1 by

<sup>3</sup> The NRA was 65 for individuals born before 1938. It increased to 66 at the rate of 2 months per year for individuals born 1938-1943. Under current law, the NRA will increase to 67 for individuals born from 1955-1960, again at the rate of 2 months per year.

a factor,  $DI\_RI\_facs$ , designed to account for average benefit level changes that occur when beneficiaries come on the rolls retroactively. This is different than projected retroactive payments discussed elsewhere in the documentation. These adjustments are phased out by duration 2, when the vast majority of disabled workers have started receiving benefits.

#### *Computation of Average MBA for DI Workers*

The disabled worker PIA as presented in the average benefit matrix was already incremented by age and duration using a COLA and a workers' compensation adjustment. The average PIA by year, age and duration, is denoted  $avgpia(yr, ag, sx, dur)$ . The overall average MBA by year and sex is the weighted average of  $avgpia(yr, ag, sx, dur) \times Fam2p(yr, sx, dur)$ , the weights being the number of DI workers in current payment status by age, sex, and duration.

#### *Post-Entitlement Adjustments*

As cohorts of beneficiaries age, their average benefit level will likely change for reasons other than just the COLA increase. The two primary reasons for this are post-entitlement work, which could lead to a re-calculation of one's benefit, and a known correlation between greater lifetime earnings and lower mortality rates. The Cost process uses post-entitlement factors by sex and duration to account for the expected dynamic benefit levels. One percent December MBR data from the most recent 10 historical years are used to calculate post-entitlement factors.

For disabled workers we calculate separate factors for those in current pay (ICP) who are younger than 50 and those ICP who are age 50 or older. We use separate factors for each sex and each duration (0-9<sup>+</sup>). Initial and Ultimate factors are calculated before being read into the cost program with initial factors set to the most recent 3-year historical average and ultimate factors at the most recent 10-year average.

All initial factors are phased-in linearly to the ultimate factors over the first 20 years of the projection period (reaching the ultimate values in  $ni+19$ ).

#### (2) Retired-Worker Benefits

##### *Retired-Worker Beneficiary Matrix*

The number of retired-worker beneficiaries for a given year and sex is provided from subprocess 3.3. Two matrices are provided – one for males and one for females. The structure of each matrix is as follows:

- 10 columns. The first 9 columns are the age at entitlement, ages 62 through 70. The last column is the number of disabled workers who are

projected to convert to retired-worker beneficiary status (DI conversions) at normal retirement age.

- 34 rows. These rows correspond to the age in current pay, ages 62 through 94 and ages 95+.

Note that the entries on the diagonal at ages 62 through 70 (where age in current-pay equals age at entitlement) are the number of new entitlements projected for that year.

### *Building the Average Benefit Matrices for Retired Workers*

In each projection year, the COST subprocess produces four average benefit matrices. For each sex there are two matrices, an average monthly benefit amount (MBA) matrix and the average primary insurance amount (PIA) matrix. Each matrix has the same structure as the beneficiary matrices. In other words, each matrix is a 34 by 10 matrix whose entries are the average benefit amounts of retired worker beneficiaries whose age in current pay is indexed by the rows and whose age at initial entitlement is indexed by the columns. The final column simply gives the average benefits for DI conversions at the various ages in current pay.

The 100% MBR extract is processed by a side model. This side model computes a starting matrix for year  $ni-1$ . This starting matrix contains the four initial *benefit* matrices, constructed using the most recent data. For a given year of the projection period, the average benefit matrix is updated from its previous year's value incrementing each benefit amount (PIA or MBA) by one year of age and increasing it by a cost of living adjustment (COLA) and by the appropriate post entitlement factor (see section "Post-entitlement adjustments") for males and females. Adjusted age 94 benefits and age 95+ benefits are averaged, based on the respective number of beneficiaries in current pay in the prior year, to get the new average benefit for age 95+. DI conversion benefits are handled similarly, except the average conversion benefit for each age 65 through 66 is combined (as a weighted average) between the DI conversion average benefits computed in subprocess 3.2 and the DI conversions of the corresponding age already receiving benefits (provided by subprocess 3.3).

The entries along the diagonal, the average benefits of newly entitled beneficiaries by age, must still be computed. The remainder of this section will explain how these average benefits are computed. Once these are computed, all entries are computed and the average benefit matrix for the year is complete.

### *Average Benefits for Newly Entitled Retired Worker Beneficiaries*

The potential AIME percentage (OPAPs) values for newly entitled retired-worker benefits are obtained from subprocess 4.2<sup>4</sup>. Average benefits for newly entitled

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<sup>4</sup> Prior to the 2017TR, the raw OPAP values from subprocess 4.2 needed to be altered by the cost subprocess in order to account for projected changes from the static age distribution for newly entitled retired workers used by Awards subprocess 4.2. The method for doing this was referred to as the "Shuttling Method". As of the 2017 TR, the shuttling method has been moved to subprocess 4.2.

retired-worker beneficiaries are calculated by sex and single years of age 62 through 69, and ages 70+. The two bendpoints of the PIA formula, BP1 and BP2, are indexed by the increase in the average wage index. In 1979 dollars, the values of BP1 and BP2 are \$180 and \$1,085 respectively. The AIME dollars between 0 and BP1 are divided into four intervals (each of length \$45 in 1979 dollars). The AIME dollars between BP1 and BP2 are divided into eighteen intervals (thirteen of length \$45 and five of length \$100, in 1979 dollars). Twelve additional intervals are added beyond BP2 (ten of length \$200 and two of length \$1,000, in 1979 dollars).

To determine the average PIA for newly entitled beneficiaries, the OPAP values for each interval of AIME dollars are multiplied by the dollar amounts attributable to each interval (the length of the interval). More precisely, let

- $PIA\_factor_i$  be the PIA factor for subinterval  $i$  (equal to 0.90 for intervals  $i=1, \dots, 4$ , 0.32 for intervals  $i=5, \dots, 18$ , and 0.15 for intervals  $i=19, \dots, 30$ ),
- $AIME\_dollars_i$  be the length of subinterval  $i$ ,
- $opap_i(yr, sx, ag)$  be the OPAP value from subprocess 4.2 for retired workers newly entitled in year  $yr$  whose sex is  $sx$  and whose age is  $ag$ .
- $wff(yr, sx, age)$  be a reduction factor to account for the Windfall Elimination Provision.<sup>5</sup>
- $Wage\_Idx(ag, yr) = \frac{avgwg(yr - (ag - 62))}{avgwg(nbase - 2)}$
- $COLA\_Idx(ag, yr) = \prod_{k=62}^{ag} (1 \times COLA(yr - (k - 62)))$

Then the average PIA for these newly entitled retired worker beneficiaries is equal to

$$LR\_awdpia(sx, ag, yr) = Wage\_Idx(ag, yr) \times COLA\_IDX(ag, yr) \times wff(yr, sx, age) \\ \times \sum_{i=1}^{30} PIA\_factor_i \times AIME\_dollars_i \times opap_i(yr, sx, ag).$$

This formula incorporates the fact that the PAP values are the estimated cumulative distribution of AIME dollars. The average award MBA for a worker beneficiary is then the average newly entitled PIA multiplied by the appropriate actuarial reduction factors and delayed retirement credits,  $arfdrc(ag, yr)$ , based on age at initial entitlement.

Once these average benefits of newly entitled retired-worker beneficiaries are computed, their values are filled into the appropriate average benefit matrices.

For summary purposes, the COST subprocess computes an average PIA and MBA for

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<sup>5</sup> The Windfall Elimination Provision (WEP) reduces the first PIA formula factor from 90% to as low as 40% for individuals who receive a pension based on specified categories of non-covered employment, primarily non-covered state and local government employees and federal workers receiving a pension under the Civil Service Retirement System. The cost process uses initial factors by sex and age, ultimate factors, years in which ultimate factors are reached and phase-in trend lines to the ultimate factor, all supplied by a side model.

all male and female newly entitled retired-worker beneficiaries. These are just the respective weighted averages of the average PIAs and MBAs by age and sex, the weights being the number of newly entitled retired-worker beneficiaries. Similarly, average PIA and MBA for all retired worker beneficiaries in current pay are computed, by sex.

### *DI Conversions*

Disabled-worker beneficiaries convert to retired-worker beneficiary status (called DI conversions) at normal retirement age (NRA). The average new DI conversion benefit for a given sex at age NRA is the weighted average of the average DI worker benefits from the prior year for that sex and age NRA-1, weighted by the number of people in current pay in each duration and then increased by the current year COLA and adjusted by the appropriate Post-Entitlement factor. The average DI conversion benefit for a given sex and single age NRA+1 through 95+ is the average DI conversion benefit from the previous year for the same sex and age cohort increased by the current year COLA and adjusted by the appropriate Post-Entitlement factor. Both the average conversion benefit for each sex and single age NRA through 95+, and the number of people in current pay for these ages, are used in the computation of average retired worker benefits.

### *Post-Entitlement Adjustments*

As discussed in the previous section, the Cost process uses post-entitlement factors by sex and duration to account for changes in benefit levels aside from the cost-of-living adjustment. For retired workers we calculate separate factors for those ICP who converted from DI status and those ICP who came on the rolls as a retired worker. We use separate factors for each sex and each duration (0-12<sup>+</sup>). Initial and ultimate factors are calculated before being read into the cost program with initial factors set to the most recent 3-year historical average and ultimate factors at a 10-year average. For females the ultimate post-entitlement factors are adjusted further to reflect the trend that female retired workers are starting to have earnings and benefit levels more similar to men. Therefore, female ultimate post-entitlement factors are calculated in the program as 90% of the male 10-year average plus 10% of the female 10-year average.

All initial factors are phased-in linearly to the ultimate factors over the first 20 years of the projection period (reaching the ultimate values in ni+19).

### *Adjustment to Average Benefit Levels at Durations 0 and 1*

Average retired worker PIA and MBAs are adjusted at durations 0 and 1 by a factor, *OA\_RI\_fac*, designed to account for average benefit level changes that occur when beneficiaries come on the rolls retroactively. This is different than projected retroactive payments discussed elsewhere in the documentation. These adjustments



are phased out by duration 2, when the vast majority of retired workers have started receiving benefits.

### (3) Annualizing Benefits

Scheduled benefits are calculated by trust fund and projection year. For each year, scheduled benefits for each trust fund are found by adding up the appropriate benefit categories.

This section applies to all benefit amounts except the “dual entitlement excess amount.” If a retired worker beneficiary is also entitled to auxiliary spouse or widow(er) benefits and these auxiliary benefits are greater, then the amount by which the auxiliary benefit exceeds the worker’s MBA is the dual entitlement excess amount. The four categories of excess amounts (dually entitled wives, widows, husbands, and widowers) are projected separately. More information is found in subsection (4).

The first step is to determine average benefits by category. A list of the beneficiary categories follows. An odd category number refers to the male account holder, while an even category number refers to the female account holder. As an example, for category 4, the aged married spouse is the aged married husband of the retired female worker.

Category # (cat)	<u>Beneficiary Type</u>
	<u>Old-Age Insurance Beneficiaries</u>
1 & 2	Retired worker (includes DI conversions)
3 & 4	Aged married spouse
5 & 6	Aged divorced spouse
9 & 10	Young spouse with child
11 & 12	Child < 18
13 & 14	Student child
15 & 16	Disabled adult child
	<u>Disability Insurance Beneficiaries</u>
17 & 18	Disabled worker
19 & 20	Aged married spouse
21 & 22	Aged divorced spouse
25 & 26	Young spouse with child
27 & 28	Young child
29 & 30	Student child
31 & 32	Disabled adult child
	<u>Survivors Insurance Beneficiaries</u>
33 & 34	Aged married widow
35 & 36	Aged divorced widow
39 & 40	Young married disabled widow
41 & 42	Young divorced disabled widow
43 & 44	Aged parent
45 & 46	Young married widow with child

47 & 48	Young divorced widow with child
49 & 50	Young child
51 & 52	Student child
53 & 54	Disabled adult child
55 & 56	Lump sum death benefit (\$255)

For the worker categories, the prior sections describe the computation of average benefit levels at the end of each year. For a specific auxiliary beneficiary category, the average monthly benefit at the end of each year (*avgben*) is determined by multiplying:

- The linkage factor (the assumed relationship between an auxiliary beneficiary’s benefit level and the corresponding worker benefit level) by
- The relevant average PIA or the average monthly benefit of the primary account holder (the worker beneficiary account on which the auxiliary beneficiary is entitled to receive the benefit).

Starting with the 2016 Trustees Report, the linkage factor for aged spouse categories comes not from the qlink workbook, but from file ‘BASps’. This file is created by a side model with the purpose of accounting for the expected changes to average aged spouse benefit levels due to the Bipartisan Budget Act of 2015.

In order to annualize benefits for each beneficiary category, two values are used. The beginning-of-year average benefit equals the average monthly benefit in December of the prior year. The end-of-year benefit equals the monthly average benefit of the worker beneficiary for December of the current year without the cost of living adjustment (COLA). The average benefit by category for each month is found by taking a weighted average of the benefits at the beginning and end of the year, the weights being the fractions of the year the prior and current year’s beneficiaries have been exposed. If  $cp(cat, yr)$  is the number of beneficiaries in category *cat* for year *yr*, and  $avgben(cat, yr)$  is the average monthly benefit for category *cat* for year *yr*, then the amount of aggregate benefits paid in year *yr* is given by the formula:

$$\begin{aligned}
 & \text{AggBen}(yr, cat) \\
 &= \sum_{i=0}^{11} \left[ \frac{(12-i)}{12} \times cp(cat, yr-1) \times avgben(cat, yr-1) + \frac{i}{12} \times cp(cat, yr) \times avgben(cat, yr) \right].
 \end{aligned}$$

For all beneficiary categories except for the lump-sum benefit, the aggregate benefit amount is increased by the retroactive payments that were projected to be paid during the year. See section (5), below.

#### (4) Dually Entitled Beneficiaries and Benefits

##### *Number of Dually Entitled Beneficiaries*

There are four primary categories of dually entitled beneficiaries. They are the dually

entitled wives, widows, widowers, and husbands. To project the number of dually entitled beneficiaries for each category we combine a series of regression equations (1 each for wives and husbands and 3 each, by age bands, for widows and widowers) with two coefficients each, a slope of  $a_1^{(k)}$  and a y-intercept of  $b^{(k)}$ , with a third factor,  $c^{(k)}(yr)$  derived from a process we describe as “add factoring”, and a fourth factor,  $d^{(k)}(yr)$  derived from an adjustment to the most recent historical data point:

$$\text{PctExp}^{(k)}(yr) = a_1^{(k)} \frac{\text{PIA}(yr,M) - \text{PIA}(yr,F)}{\text{PIA}(yr,M)} + b^{(k)} + c^{(k)}(yr) + d^{(k)}(yr)$$

(k=1,2,3,4,5,6,7,8) project the percentage of the exposed population entitled to wife (1), widow aged 62-74 (2), widow aged 75-84 (3), widow aged 85+ (4), widower aged 62-74 (5), widower aged 75-84 (6), widower aged 85+ (7), and husband (8) benefits.

PIA(yr,sex) is the average PIA of all retired worker beneficiaries in current pay by sex, and PctExp(yr) is the percentage of the entitled population in the category that is dually entitled. We use the “add factoring” method with variable  $c^{(k)}(yr)$  to account for the expected future comparative work history changes that will affect dual entitlement populations.

To derive  $c^{(k)}(yr)$ , suppose that  $ult^{(k)}$  is the value obtained from the regression equation without add-factoring in the final year of the projection period. Therefore

$$ult^{(k)} = a_1^{(k)} \frac{\text{PIA}(ni + 74, M) - \text{PIA}(ni + 74, F)}{\text{PIA}(ni + 74, M)} + b^{(k)}.$$

Let  $targ^{(k)}$  be the target value we estimate for the final year of the projection period. Let  $phaseyrs$  be the number of years it takes to fully phase in the target value. Then we have

$$c^{(k)}(yr) = \min(yr - 2016, phaseyrs) \times \frac{targ^{(k)} - ult^{(k)}}{phaseyrs}.$$

To derive  $d^{(k)}(yr)$ , suppose that  $b1$  is the measured difference between the most recent historical dual-entitlement percentage and the corresponding post-add-factoring regression value. We phase out this adjustment linearly over 20 years, thus:

$$d^{(k)}(yr) = b1 \times (1.0 - \min(yr - 2017, 20.0) / 20.0).$$

The following table displays the coefficients, target values, and phase-in years for each type of beneficiary.

$k$	Type	$a_1^{(k)}$	$b^{(k)}$	Target Value	Add-factoring Phase-in Years
-----	------	-------------	-----------	--------------	------------------------------

				$targ^{(k)}$	$phaseyrs$
1	Wife	0.84724	0.0	0.205	34
2	Widow 62-74	0.51830	0.36907	0.520	24
3	Widow 75-84	0.80926	0.42059	0.595	26
4	Widow 85+	1.24303	0.30186	0.615	25
5	Widower 62-74	-0.28348	0.14693	0.10	75
6	Widower 75-84	-0.46710	0.23265	0.095	30
7	Widower 85+	-0.14378	0.10585	0.08	75
8	Husband	-0.04864	0.02211	0.0085	31

In the above equations, the average PIA of newly entitled retired worker beneficiaries by sex has already been computed (see subsection (2) above).

#### *Average Excess Amount for Dually Entitled Beneficiaries*

The projection of the average excess amounts for two categories of dually entitled beneficiaries (wives and widows) is similar to that of the number of dually entitled beneficiaries. The structure of the equations used to project these amounts is similar to the equations used to project the percentage exposures and, as is the case with the percentage exposures, we use 1 regression for wives and 3 for widows (1 for each of 3 age bands).

The equations used to project the average excess amount each have two terms and two adjustment factors, similar to the process for the number of dually entitled beneficiaries. Each equation  $k$  has two coefficients, a slope of  $a_1^{(k)}$  and a y-intercept of  $b^{(k)}$ , with a third factor,  $c^{(k)}(yr)$  derived from add factoring, and a fourth factor,  $d^{(k)}(yr)$  derived from an adjustment to the most recent historical data. A target value in the 75<sup>th</sup> year of the projection period is used in deriving the “add-factor” adjustment. The four equations

$$AvgExcPct^{(k)}(yr) = a_1^{(k)} \frac{PIA(yr,M) - PIA(yr,F)}{PIA(yr,M)} + b_1^{(k)} + c^{(k)}(yr) + d^{(k)}(yr)$$

( $k = 1, 4$ ) project the average excess benefit amounts of wives (1), widows aged 62-74 (2), widows aged 75-84 (3), and widows aged 85+ (4). The derivations of  $c^{(k)}(yr)$  and  $d^{(k)}(yr)$  are completed in the same manner as for the number of dually entitled beneficiaries above.

The table below shows the regression coefficients and other relevant adjustments in the 2018 Trustees Report.

$k$	Type	$a_1^{(k)}$	$b^{(k)}$	Target Value (2092) in Nominal Dollars $targ^{(k)}$	Add-factoring Phase-in Years $phaseyrs$
1	Wife	0.45062	0.0	3,969.42	24
2	Widow 62-74	-0.41375	0.56377	10,617.89	36
3	Widow 75-84	1.13921	0.03264	10,303.80	26
4	Widow 85+	0.79090	0.17858	10,444.49	36

The average excess amount of widowers and husbands is estimated to be a fixed percentage of the average excess amounts of widows and wives, respectively. The average excess amount of husband beneficiaries is measured to be 77.78% of wives in 2017 and is assumed to linearly phase to 80% in the 16<sup>th</sup> year of the projection period (2033 for 2018TR). Widowers are broken down into the three age bands, such that the average excess amount for widowers aged 62-74 is based on the average excess amount for widows aged 62-74, etc. Similar to husbands, the factor is linearly interpolated from the measured historical value in 2017 to an ultimate factor in 2033. Below are the initial and ultimate factors:

Type	Average Benefit Level Relative to Widow (2017)	Average Benefit Level Relative to Widow (2033)
Widowers 62-74	56.90%	59.0%
Widowers 75-84	50.69%	54.0%
Widowers 85+	43.10%	46.0%

#### *Annualizing Excess Amounts*

The process to annualize excess amounts is very similar to the process for annualizing auxiliary benefits.

For each dual entitlement category, the number of beneficiaries is simply  $cp(yr, cat) = PctExp^{(cat)}(yr) \times ExposedPop^{(cat)}(yr)$ . With this method, however, no linkage factor is used. Instead, the projected average excess amount, as explained above, is used. Therefore,

$$\begin{aligned}
 & AggExcess(yr, cat) \\
 &= \sum_{i=0}^{11} \left[ \frac{(12-i)}{12} \times cp(cat, yr-1) \times AvgExcAmt^{(cat)}(yr-1) + \frac{i}{12} \times cp(cat, yr) \times AvgExcAmt^{(cat)}(yr) \right].
 \end{aligned}$$

#### (5) Retroactive Payments

Frequently, beneficiaries start receiving payments later than their actual entitlement date,

such that they receive a “catch-up” lump-sum amount for the time delay, in addition to regular monthly benefits going forward. These lump-sum amounts, which we call retroactive payments, apply for all beneficiary categories (except for the one-time \$255 death benefit) but are more significant for disabled workers because of the frequent and sometimes lengthy time lag in getting an allowance on their application, as well as the 12 months of retroactivity allowed at the time of benefit filing. This section discusses how retroactive benefit payments are projected for all beneficiary categories.

### Disabled Workers

The number of disabled-worker newly awarded beneficiaries for a given year and sex is provided from subprocess 3.2. For each projection year, two matrices are provided – one for males and one for females. The structure of each matrix is as follows:

- 11 columns. The columns are indexed by duration of disability (0-9 and 10+).
- 52 rows. These rows correspond to the age in current pay, ages 15 through 67.

The COST subprocess, however, only uses 10 durations<sup>6</sup> (0 through 9), and 48 ages (ages 20 through 67). This requires a manipulation of the matrix of newly awarded DI beneficiaries from subprocess 3.2. For ages in current pay greater than or equal to 30, the duration 9 and 10+ columns of this matrix are added to give the total number of duration 9 beneficiaries. For ages (*ag*) between 20 and 30 inclusive, the number of newly awarded beneficiaries aged *ag* and duration *ag-20* is the value provided by the DISABILITY subprocess added to the number of new awards aged *ag-j* and duration *ag-20* for *j=1,...,5*. (For example, the number of people aged 20 of duration 0 is combined with the number of people aged 15, 16, 17, 18 and 19 of duration 0; the number of people aged 21 of duration 1 is combined with the number of newly awarded beneficiaries aged 16, 17, 18, 19, and 20 of duration 1, and so on. In other words, the five nonzero diagonals of the matrix provided by the DISABILITY subprocess are “combined with” the diagonal directly below it and then zeroed out.)

Newly awarded disabled worker beneficiaries are denoted by year, sex, age and duration as *dibaw(year,sex,age,dur)*.

Let *dur* be a duration, 0 through 9. Define

- $Cum\_COLA(dur) = \prod_{j=0}^{dur} (1 + COLA(yr - j)).$

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<sup>6</sup> While the DI Awards file from subprocess 3.2 displays durations 0 through 9 and 10+, as of the 2018TR, there are no new awards after duration 5. Therefore, durations 6+ show zeros for all ages and years.

$$\bullet \text{ For } i = 0, \dots, 10, \text{ Num\_Months}(i) = \begin{cases} 2 & dur = 0 \\ 5 & dur > 0 \text{ and } i = 0 \\ 12 & dur > 0 \text{ and } 0 < i < dur \\ 6 & dur > 0 \text{ and } i = dur \end{cases}$$

Then the aggregate retroactive payments for disabled workers, in millions, are defined to be

$Retro\_DIB(sex, yr)$

$$= \sum_{age=20}^{67} \sum_{dur=0}^9 \sum_{i=0}^{dur} dibpia(yr, sex, \min(age, 66), dur) \times wkcomp\_red(dur) \times \frac{dibwv(yr, sex, age, dur)}{10^6} \times \frac{Num\_Months(i)}{Cum\_COLA(dur)}.$$

$dibpia$  is further altered in this formula by the adjustment factors in array:

$DI\_RI\_facs(sex, age, dur, 2)$

These adjustments to  $dibpia$  are designed to account for the small differences between average benefit levels for all beneficiaries and levels for those receiving retroactive credit.

$Retro\_DIB(sex, yr)$  is then further adjusted to account for differences between projected retroactive benefits and observed retroactive benefits paid in the historical period. This adjustment, denoted  $ret\_hist$ , is calculated to be 0.8481 for the 2018TR. After this adjustment  $Retro\_DIB(sex, yr)$  is simply added to the disabled worker benefit category by year and sex.

### Retired Worker Beneficiaries

Retired worker beneficiaries are assumed to have, on average, 0.7 months of retroactive payments as determined annually by a side model. Hence

$$retro\_OAB(sex, yr) = \sum_{age=62}^{70} \frac{0.7 \times \frac{oabicmp(yr, sex, age, age)}{1000} \times oabmba(yr, sex, age, age)}{1 + COLA(yr)}.$$

In the above formula,  $oabicmp(yr, sex, age, age)$  is the number of newly entitled beneficiaries at age equal to  $age$  (age in current pay equals age at entitlement equals  $age$ ) and  $oabmba(yr, sex, age, age)$  is the corresponding average benefit.

$oabmba(year, sex, age, age)$  in the above formula is further altered by the adjustment factors:

$$retrom\_adj(sex) = \{0.9476, 1.0330\}$$

These adjustments to oabmba are designed to account for the small differences between average benefit levels for all beneficiaries and levels for those receiving retroactive credit.

The aggregate retroactive benefits for retired worker beneficiaries are simply added to the retired worker benefit category by and sex.

Auxiliary Beneficiary Categories

Retroactive payments for auxiliary beneficiaries (determined by a side model) are treated as a loading of the aggregate annual benefits by auxiliary category. That is, each auxiliary benefit category has a loading factor to represent retroactive payments on top of regular monthly benefits, and the aggregate annual benefits by category are increased by this loading factor.

(6) Aggregate Scheduled Benefits (*BEN*)

Aggregate benefits by trust fund,  $BEN(tf, yr)$ , are computed as follows. For each year of the 75-year long-range projection period, the aggregate benefits by category (including retroactive payments, as described above) are summed up to give total annual scheduled benefits by trust fund. In the short-range period, the long-range values are overridden by the values estimated by the short-range office. The difference between long-range scheduled benefits and short-range benefits in the 10<sup>th</sup> year of the short-range period is called the scheduled benefits adjustment. In the 10 years after the end of the short-range period, the long-range scheduled benefits are adjusted by linearly grading the scheduled benefits adjustment to zero. From the 20<sup>th</sup> year forward, the projection is the pure long-range value.

iii. **Equation 4.3.3 – Taxation of Benefits (*TAXBEN*)**

The short-range office provides taxation of benefits levels by trust fund in the short-range period. These implicitly give, for each year, an estimated taxation of benefits factor, by trust fund, equal to the estimated taxation of benefits as a percentage of benefits scheduled to be paid. The long-range office projects these factors independently for every year of the projection period, also by trust fund. (See subprocess 4.1.) The difference in the factors between the two offices at the end of the short-range period is phased out linearly over the next ten years. The long-range projection of taxation of benefits is estimated by multiplying the projected taxation of benefits factors by the benefits scheduled to be paid, by trust fund. If  $taxben\_factor(tf, yr)$  is the percentage of scheduled benefits for the year, by trust funds, estimated to be collected as taxation on benefits, then

$$TAXBEN(tf, yr) = taxben\_factor(tf, yr) \times BEN(tf, yr)$$

for  $yr \geq ns + 10$ .

iv. **Equation 4.3.4 – Administrative Expenses (*ADM*)**



Administrative expenses are estimated separately by trust fund. In the short-range period, the short-range office provides the estimates of administrative expenses by trust fund. Thereafter, administrative expenses are computed by multiplying the previous year's administrative expenses by three factors: annual changes in total beneficiaries, annual changes in AWI, and one minus annual productivity growth. As a formula, if  $ticp(tf, yr)$  is the total estimated number of beneficiaries in current-pay status by trust fund and year,  $AWI(yr)$  is the average wage index in year  $yr$ , and  $prod$  is the ultimate assumed annual growth in productivity, then

$$ADM(tf, yr) = ADM(tf, yr - 1) \times [ticp(tf, yr) / ticp(tf, yr - 1)] \times [AWI(yr) / AWI(yr - 1)] \times (1 - prod)$$

for  $yr > ns$ .

v. **Equation 4.3.5 – Railroad Interchange (RR)**

Railroad interchange is disaggregated by trust fund and projection year. The long-range office does a projection for each year in the 75-year period. In the short-range period (first 10 years of the 75-year projection period), the short-range office provides the estimates of railroad interchange by trust fund and the long-range projection is overridden in these years. Over the next five years of the projection period, the estimate of the railroad interchange is a linear interpolation between the short-range projection at the end of the short-range period and the long-range projection five years hence. During the final 60 years of the projection period, the projection is as estimated by the long-range office.

By trust fund, the total cashflow in year  $yr$ ,  $rr\_cashflow(tf, yr)$ , is broken down into two positive components; railroad benefits in year  $yr$  and railroad administrative expenses in year  $yr$ , and two negative components; railroad contributions in year  $yr$  and railroad taxation of benefits in year  $yr$ . A positive cashflow in this calculation represents a net cost to the trust fund. Cashflows are calculated on a fiscal year basis.

Projections of numbers of newly entitled retired workers are determined by analyzing the ratio of new entitlements to previous levels of railroad employment using 1998-2015 new entitlement data in the analysis. After initial entitlement, a mortality rate of 5.4% for 2016 is assumed based on analysis of recent Railroad Retirement Board financial interchange data, with mortality assumed to improve thereafter. For projections of newly entitled disabled workers a similar trend analysis based on prior employment is used. A “mortality” rate (deaths plus recoveries plus conversions to retired worker benefits) is determined using Railroad Retirement Board (RRB) data, with the rate assumed constant thereafter.

Assuming a 90/10 male/female split, the average benefit level for an OASI railroad worker is calculated as a ratio to the average OASI retired worker benefit. This ratio is constant throughout the projection period and is derived by comparing MBR and Railroad Board data. Additionally, a constant loading factor based on the same data is applied to aggregate worker benefits to determine the aggregate benefit amounts for

auxiliary OASI beneficiaries. This same approach is used to determine similar constants for DI railroad benefits. The aggregate disabled worker railroad benefits (and beneficiaries) are estimated in the same way.

It is assumed that the ratio of OASI taxation of benefits to OASI benefits and DI taxation of benefits to DI benefits are both the same for railroad taxation of benefits. The railroad taxation of benefits is estimated by multiplying the railroad benefits by these ratios.

Administrative expenses for railroad are computed separately by trust fund. They are set at levels determined by short range in the short-range period. For years  $ni+10$  to  $nf$ , they are computed similarly to OASDI administrative expenses. Administrative expenses in  $yr-1$  are multiplied by (a) the change in the total number of worker beneficiaries, (b) the annual change in average wage, and (c) one minus the ultimate productivity growth.

Railroad contributions are estimated, by trust fund, to be total railroad employment, multiplied by average railroad earnings, multiplied by the combined OASDI employer/employee tax rate. Railroad earnings are assumed to grow with the increase in the average wage index, and railroad employment is assumed to decrease over time, both of which are in line with the Railroad Retirement Board's own "most likely" projections.

The interchange amount is calculated both on a fiscal year basis and at the date of the actual transfer from SSA to the Railroad Retirement Board (usually in the first week of June in the following year). These interchange amounts can be represented by  $RR\_Transfer\_FY(tf, yr)$  and  $RR\_Transfer\_CY(tf, yr+1)$ .  $RR\_Transfer\_FY(tf, yr)$  is calculated by adding the cashflow amount to an interest amount,  $rr\_interest(tf, yr)$ , which includes interest accrued by the cashflow components along with a reconciliation of interest amounts from the previous fiscal year calculated transfer amount and the current year June interchange. If  $irate\_presc(tf, year)$  is the prescribed interest rate used by the Railroad Retirement Board the interchange amount in June is:

$$RR\_Transfer\_CY(tf, yr) = RR\_Transfer\_FY(tf, yr-1) \times (1.0 + (2.0/3.0) \times Irate\_Presc(yf, yr))$$

**vi. Equation 4.3.6 – Interest Income (INT)**

In the short-range period, the projection of interest income by trust fund is provided by the short-range office. In each year of the short-range period, the annual yield rate is defined as the ratio of interest earned by a fund to the average level of assets held by the fund during the year.

The ultimate annual yield rate on each trust fund is equal to the nominal yield, which is the real interest rate increased for inflation. As a formula,

$$ultimate\ yield\ rate = (1 + real\ interest\ rate) \times (1 + inflation\ rate) - 1.$$

To get the yield rate for each year between the end of the short-range period ( $ns$ ) and 5 years later,  $ns+5$ , when the ultimate yield rate is assumed to be reached, the program

linearly interpolates between the values for years  $ns$  and  $ns+5$ .

The projection of interest income in a given year is the yield rate for that year multiplied by the average level of assets. As a formula,

$$INT(tf, yr) = yield(tf, yr) \times avg\_assets(tf, yr).$$

The amount of assets in a trust fund at the end of a given year is estimated from the level of assets at the beginning of the year by:

- Increasing the level for the tax contributions and taxation of benefits income received during the year (each exposed to the point in the year in which they are estimated to be received, on average), and
- Decreasing the level for scheduled benefits, railroad interchange, and administrative expenses paid during the year (each exposed to the point in the year in which they are estimated to be disbursed, on average).

For all years of the projection period, tax contributions are given an exposure of 0.518, taxation of benefits are given an exposure of 0.625, railroad interchange is given an exposure of 0.583, and administrative expenses are given an exposure of 0.5. For scheduled benefits, separate OASI and DI exposures are determined through a side model. The exposure,  $ben\_exp(yr)$ , is larger than 0.5 in the early years of the projection period for both trust funds, whereas in later years OASI benefit exposures fall below 0.5 with DI remaining above 0.5. The reason is that in the past, benefits were always paid on the 3<sup>rd</sup> of each month. Now benefits are paid out throughout the month, based on the birth date of the beneficiary. The reason for the differences between trust funds is that benefits are paid on the third of the month (exempting check cycling<sup>7</sup>) for a higher proportion of DI beneficiaries due primarily to (1) concurrent receipt of SSI benefits, or (2) state payment of Medicare premiums. The average assets held by the trust funds for a given year is estimated by the formula

$$\begin{aligned} avg\_assets(tf, yr) = & ASSETS_{BOY}(tf, yr) + 0.518 \times CONTRB(tf, yr) \\ & + 0.625 \times TAXBEN(tf, yr) - ben\_exp(tf, yr) \times BEN(tf, yr) \\ & - 0.583 \times RR(tf, yr) - 0.5 \times ADM(tf, yr). \end{aligned}$$

### **vii. Equations 4.3.7, 4.3.8 and 4.3.9 – Annual Values**

The annual income rate for a trust fund is computed as the sum of payroll tax contributions plus taxation of benefits as a percentage of taxable payroll.

$$ANN\_INC\_RT(tf, yr) = \frac{CONTRB(tf, yr) + TAXBEN(tf, yr)}{payroll(yr)}.$$

<sup>7</sup> Under check cycling many Social Security beneficiaries filing for benefits after April 1997 are paid on either the 2<sup>nd</sup>, 3<sup>rd</sup>, or 4<sup>th</sup> Wednesday of each month. In the past, benefits were always paid on the 3<sup>rd</sup> day of each month.

The annual cost rate for a trust fund is computed as the total cost of providing scheduled benefits from that fund as a percentage of taxable payroll. If

$$COST(tf, yr) = BEN(tf, yr) + RR(tf, yr) + ADM(tf, yr),$$

then

$$ANN\_COST\_RT(tf, yr) = \frac{COST(tf, yr)}{payroll(yr)}.$$

The trust fund ratio measures the amount of beginning of year assets that can be used to pay total cost. It is expressed as a percentage:

$$TFR(tf, yr) = \frac{ASSETS_{BOY}(tf, yr)}{COST(tf, yr)}.$$

**viii. Equations 4.3.10, 4.3.11, 4.3.12, and 4.3.13 – Summarized Values**

Present values of cash flows during the year are computed using the yield rate on the combined OASDI trust fund for that year. Each component of trust fund operations is exposed, with interest, to the point in the year in which, on average, it is received or disbursed. These exposure levels,  $ben\_exp(tf, yr)$ , are the same as described above. These exposed levels are then discounted to January 1 of the year of the Trustees Report,  $ni$ . If  $yield(j)$  is the annual yield rate on the combined OASDI trust funds for year  $j$  and  $v(yr)$  is the discounting factor for the year, then

$$v(yr) = \prod_{j=ni}^{yr} \frac{1}{[1 + yield(j)]}.$$

For a given year, and trust fund,

$$PV\_TAX(tf, yr) = (1 + 0.518 \times yield(yr)) \times TAX(tf, yr) \times v(yr),$$

$$PV\_TAXBEN(tf, yr) = (1 + 0.625 \times yield(yr)) \times TAXBEN(tf, yr) \times v(yr),$$

$$PV\_BEN(tf, yr) = (1 + ben\_exp(tf, yr) \times yield(yr)) \times BEN(tf, yr) \times v(yr),$$

$$PV\_RR(tf, yr) = (1 + 0.583 \times yield(yr)) \times RR(tf, yr) \times v(yr),$$

and  $PV\_ADM(tf, yr) = (1 + 0.5 \times yield(yr)) \times ADM(tf, yr) \times v(yr).$

The target fund for a year is next year's cost. Its present value is computed as

$$PV\_TARG(tf, yr) = [BEN(tf, yr + 1) + RR(tf, yr + 1) + ADM(tf, yr + 1)] \times v(yr),$$

Taxable payroll is exposed to the middle of the year when computing present values:

$$PV\_PAYROLL(yr) = (1 + 0.5 \times yield(yr)) \times payroll(yr) \times v(yr).$$

We also define

$$PV\_INC(tf, yr) = PV\_TAX(tf, yr) + PV\_TAXBEN(tf, yr)$$

and

$$PV\_COST(tf, yr) = PV\_BEN(tf, yr) + PV\_RR(tf, yr) + PV\_ADM(tf, yr).$$

Summarized rates are calculated using beginning of period assets and a target fund. Let  $yr_1$  = the first year of the valuation period and  $yr_2$  = the ending year of the valuation. Then the summarized income rate is:

$$SUMM\_INC\_RT(tf, yr_1, yr_2) = \frac{ASSETS_{BOY}(tf, yr_1) + \left( \sum_{j=yr_1}^{yr_2} PV\_INC(tf, j) \right)}{\sum_{j=yr_1}^{yr_2} PV\_PAYROLL(j)}.$$

The summarized cost rate is similarly computed:

$$SUMM\_COST\_RT(tf, yr_1, yr_2) = \frac{\left( \sum_{j=yr_1}^{yr_2} PV\_COST(tf, j) \right) + PV\_TARG(tf, yr_2)}{\sum_{j=yr_1}^{yr_2} PV\_PAYROLL(j)}.$$

The 75-year actuarial balance is computed for a period beginning January 1 of the Trustees Report year,  $ni$ . It includes both beginning of period assets and a target fund. Therefore,

$$ACTBAL_{75, yr}(tf) = SUMM\_INC\_RT(tf, ni, ni + 74) - SUMM\_COST\_RT(tf, ni, ni + 74).$$

In general, an actuarial balance may be computed for any given subperiod of the projection period. In general, actuarial balances for a subperiod beginning on January 1 of year  $ni$  and continuing through the end of year  $yr$  are computed using

$$ACTBAL_{ni, yr}(tf) = SUMM\_INC\_RT(tf, ni, yr) - SUMM\_COST\_RT(tf, ni, yr).$$

The unfunded obligation of a trust fund for a given period is the excess of the present value of the net cash deficits for each year of that period over the trust fund balance at the beginning of the period. The unfunded obligation for the period beginning on January 1 of year  $ni$  and continuing through the end of year  $yr$  is computed using

$$UNF\_OBL(tf, yr) = \sum_{j=ni}^{yr} [PV\_COST(tf, j) - PV\_INC(tf, j)] - ASSETS_{BOY}(tf, ni).$$

Note that the unfunded obligation excludes the target fund.

***ix. Equation 4.3.14—Closed Group Unfunded Obligation***

The closed group is defined as individuals who attain specified ages in the first year of the projection period (*ni*). The Statement of Social Insurance displays unfunded obligations for closed groups (1) attaining 15 or later in 2018, (2) attaining 62 or older in 2018, and (3) attaining 15 to 61 in 2018. For each year of the projection period, closed group calculations attribute a portion of the items in equations 4.3.1 through 4.3.6 to individuals falling in the defined closed group. The calculation of the closed-group unfunded obligation, then, uses the equation above but only considering the present values of cost and income attributable to the closed group.

The following information, developed elsewhere in the “Cost” process, is used for developing closed group unfunded obligation amounts:

- Total number of workers and total taxable earnings by single year of age 0-119 and sex, years 1951 through *nf*, updated yearly
- Taxable payroll, years *ni* through *nf*, updated yearly
- Payroll tax income, years *ni* through *nf*, updated yearly
- Income from taxation of benefits, years *ni* through *nf*, updated yearly
- Scheduled benefits by beneficiary category, years *ni* through *nf*, updated yearly
- Railroad interchange, years *ni* through *nf*, updated yearly
- Administrative expenses, years *ni* through *nf*, updated yearly
- Yield rate on the combined OASDI trust funds, years *ni* through *nf*, updated yearly
- Population counts for all retired workers, spouses, divorced spouses, and widow(er)s by year, sex, and age 95-119 (read in as a percentage of 95+ counts)
- Distribution of assumed age differentials between aged spouses and workers ranging from -12 years to 15 years seniority for the worker by sex of the beneficiary, age of the beneficiary 62-74, and marital status
- Distribution of assumed age differentials between aged widow(er)s and deceased workers from -6 years to +12 years

It is important to note that, for dependent beneficiaries, the age of the worker, on whose account the benefits are based, determines whether that beneficiary would fall in the closed group. For instance, if the closed group were defined as individuals attaining age 15 or later in 2018, a 3-year-old minor child receiving benefits in 2018 on the account of a retired worker aged 63 would be considered part of this closed group because the account holder was at least age 15 in 2018. The following describes how the various components of income and cost are allocated to the defined closed group in question:

*Payroll Tax Contributions*

Closed group taxable payroll is defined as the percentage of OASDI taxable payroll attributable to the closed group in question. An input file of *closed group payroll factors*, containing these percentages by year from 2018 through 2117, is used by the cost program to compute payroll tax contributions attributable to the closed group. For each year, the *closed group payroll factors* are determined as follows:

- The number of projected workers by single year of age (ages 0-119) and sex are multiplied by the associated average earnings by age/sex.
- Then, the portion of total taxable earnings attributable to the closed group is calculated.

For each year of the projection period, the number of workers and average taxable earnings by single year of age and sex are determined as follows:

- For ages 0-99, the number of projected workers comes directly from Economics group projections.
- For ages 100-119, the total age 100+ amounts from Economics are distributed among ages 100 through 119 for each projection year using mortality rates derived by looking back 10 years and multiplying these populations by 10 years of mortality increases by sex.
- For ages 0-14, the average taxable earnings are obtained by analyzing historical 1995-2014 data of the average earnings at each age relative to age 15 average earnings, and judgmentally assigning a ratio (to age 15 average earnings) for each age.
- For ages 15-80, the average taxable earnings by age and sex come directly from the AWARDS subprocess.
- For ages 81-99, the average taxable earnings are calculated as a weighted average of the average earnings for ages 76-80, weighted by the ratios of earnings between these ages and each age 81 through 99 for earnings years 1995 through 2014. This is similar to the method to calculate average earnings for ages 0 through 14, though here we are using five anchor years instead of one. For ages 100-119, average taxable earnings are set equal to the average earnings calculated for age 99.

### *Benefits*

Methodologies for computing benefits attributable to the closed groups differ among benefit categories, as described below:

#### *Retired Workers*

For each age in current pay, the number of beneficiaries is multiplied by the corresponding average benefit amount across all ages of entitlement. The same applies for DI conversion cases. Retroactive benefits for the current year, by age, are then calculated. The closed-group factors for old-age benefits for each year are found by summing the benefit amounts attributable to the specified closed group, as a proportion of total retired worker benefits for all ages. This process is done

separately by sex.

### *Disabled Workers*

For each age from 20 to the year before normal retirement age, the program adds the products of the number of beneficiaries for each duration and the PIA for that duration. Retroactive benefits for the current year, by age, are then calculated. The closed-group factors for disability benefits are found by summing the total benefit amounts attributable to the closed group, as a proportion of total disabled worker benefits for all ages. This process is done separately by sex.

### *Aged Spouses and Divorced Aged Spouses*

Closed Group calculations are done separately (although in the same manner) for aged wives, aged divorced wives, aged husbands and aged divorced husbands (combined), dually entitled aged wives, and dually entitled aged husbands. The number of aged spouse beneficiaries in each beneficiary category in current pay status (no dual entitlement) is provided by single year of age (up through 119). Then, for each single year of age, the program allocates total numbers of workers by age, from 12 years younger to 15 years older than the aged spouse using an assumed category-specific distribution. Next, for each age of worker in current pay, the number of workers is multiplied by the weighted average retired worker benefit for that age; this is done for all ages. The closed group factors, then, are obtained by determining the proportion of total benefit amounts attributable to the given closed group (based on the worker's age).

### *Aged Widows and Divorced Aged Widows*

Closed Group calculations are done separately (although in the same manner) for aged widows, aged divorced widows, aged widowers, and aged divorced widowers. The number of aged widow(er) beneficiaries in current pay status (no dual entitlement) is provided by age from 60 to 119. For each single year of age, the program allocates total number of aged widows by age of the deceased husband (age the husband would have been if he had not died), from 6 years younger to 12 years older than the aged widow using an assumed distribution. The same distribution is used in reverse order for aged widowers leading to an age range of 12 years younger to 6 years older for the deceased wife. For each age of deceased spouses aged 119 or younger, a real wage growth factor is applied to reflect ultimate real wage growth taken to the power of the number of years younger than age 119.

$$Benefit_{adj} = (1 + wg_{ult} - 1.026)^{(119 - \text{deceased worker age})}$$

This exponent is intended to reflect differences in average levels of benefits, with younger deceased spouses having higher benefits based on real wage growth. The closed group factors, then, are obtained by determining the proportion of total benefit



amounts attributable to the closed group.

For aged widow(er)s in dual entitlement status (i.e. aged widow(er)s with a smaller worker benefit) we do similar calculations with the assumption that the age distributions are equal to the combined distribution of non-dually entitled aged widow(er)s and aged divorced widow(er)s.

#### *Other Beneficiary Categories*

For the 20 other dependent beneficiaries of retired workers, disabled workers, and deceased workers, an input file of closed group benefit factors is created, which represents the proportion of total (open-group) projected benefits in that category attributable to the given closed group age and year. This file is used by the cost program to compute amounts from each beneficiary category attributable to the closed group. The file, separately created for each closed group run, contains closed group benefit factors for ages 0 through 150 for each of the 20 beneficiary categories by sex of the account holder (worker). These input files are created by examining a recent sample of Master Beneficiary Record (MBR) data<sup>1</sup> for each of the beneficiary categories by age of the worker, and projecting future distributions by age of the worker based on population and, for survivor benefits, projected deaths by age. Then, adjustments are made for real wage growth to reflect different benefit levels by birth cohort.

#### *Taxation of Benefits*

Since taxation of benefits is related to benefits, the closed-group taxation of benefit amounts are computed by multiplying the total (open-group) taxation of benefit amounts by Trust Fund, by the corresponding total closed-group benefit factors by Trust Fund.

#### *Administrative Expenses*

Since administrative expenses are also assumed to be related to benefits, the closed-group administrative expense amounts are computed by multiplying the total (open-group) administrative expenses by Trust Fund, by the corresponding total closed-group benefit factors by Trust Fund.

#### *Railroad Interchange*

Since the railroad interchange has both a payroll tax and benefit component, each component is multiplied by its corresponding closed-group factor. That is, total payroll tax contributions arising from railroad interchange are multiplied by the closed group payroll factor discussed above in the “Tax on Contributions” section. Total railroad benefits, by Trust Fund, are multiplied by the aggregate closed-group benefit factors by Trust Fund. Closed-group railroad administrative expenses and closed-group railroad taxation of benefits are also estimated by applying aggregate closed group benefit factors by Trust Fund. The final amount is then the difference in the components (closed group

railroad income less closed group railroad cost).