

Discussion Papers

**A Primer on the Dynamic
Simulation of Income Model
(DYNASIM3)**

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Many individuals have contributed to the development of the *DYNASIM3* model over the years, too numerous to mention. However, the authors would especially like to thank Frank Sammartino (currently at the Joint Economic Committee of the U.S. Congress) for his contribution to this version of the model during his tenure at the Urban Institute. Eugene Steuerle and Sheila Zedlewski also provided critical leadership in the model's redevelopment. Nonetheless, responsibility for any errors in the model rests primarily with the authors.

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Contents

| | |
|-------------------------------------|----|
| The <i>DYNASIM3</i> Input File..... | 2 |
| General Model Structure..... | 3 |
| The Demographic Sector | 6 |
| The Economic Sector | 11 |
| The Taxes and Benefits Sector | 15 |
| Sample Projections..... | 17 |
| Summary | 20 |
| References..... | 21 |

A Primer on The Dynamic Simulation of Income Model (*DYNASIM3*)

DYNASIM3 is a dynamic microsimulation model designed to analyze the long-run distributional consequences of retirement and aging issues. Starting with a representative sample of individuals and families, the model “ages” the data year by year, simulating such demographic events as births, deaths, marriages and divorces, and such economic events as labor force participation, earnings, hours of work, disability onset, and retirement. The model simulates Social Security coverage and benefits, as well as pension coverage and participation, and benefit payments and pension assets. It also simulates home and financial assets, health status, living arrangements, and income from non-spouse family members (coresidents). In addition, it calculates SSI eligibility, participation, and benefits.¹

DYNASIM has a long history at the Urban Institute. It was originally developed here in the 1970s. A revised version of the model, *DYNASIM2*, was built in the early 1980s specifically to analyze retirement income issues (for an overview of the model’s earlier development, see Zedlewski 1990). *DYNASIM3* represents a major update of the model. It includes a more recent starting sample and recent information on demographics and family economics. *DYNASIM3* also includes new household saving and private pension coverage modules, and Social Security and Supplemental Security Income (SSI) calculators.²

The *DYNASIM3* model has been used recently to simulate how potential changes to Social Security will affect the future retirement benefits of at-risk populations, such as elderly widows and widowers, and certain divorcees and spouses (Favreault and Sammartino 2002; Favreault, Sammartino, and Steuerle 2002). The Institute has also used it to explore annuitization effects under a Social Security system with personal accounts (Uccello et al. 2003), potential retirement consequences of rapid work effort growth among low-wage, single mothers in the late 1990s (Johnson, Favreault, and Goldwyn 2003), and the implications of recent earnings inequality patterns for future retirement income (Smith 2003). Ongoing work examines personal account proposals and how they would intersect with current patterns of wealth accumulation and retirement preparedness (Butrica and Uccello forthcoming).

The remainder of this paper briefly summarizes the input data and key characteristics of the *DYNASIM3* model to give an overall sense of the model’s content. We outline the data used in the various estimation procedures and generally describe the structure of each module. We also include some baseline projections produced by a recent version of the model to provide a fuller sense of the model’s capacity. More detailed documentation of *DYNASIM3* is available upon request from the authors, and in the recent application papers mentioned above, available on the Institute’s web site.

¹ This version of *DYNASIM* was developed through a grant from the Mellon Foundation and a generous Urban Institute investment.

² Many of these new modules were adapted from those designed by the Urban Institute for the Social Security Administration’s Model of Income in the Near Term (see Toder et al. 2002).

The *DYNASIM3* Input File

The *DYNASIM3* input file is based on the 1990 to 1993 Survey of Income and Program Participation (SIPP) panels, a self-weighting sample of over 100,000 people and 44,000 families. We limited the sample to individuals interviewed in the long asset/pension topical module wave.³ We then randomly output families based on the panel-adjusted average person weight. *DYNASIM3* focuses on nuclear families; subfamilies and unrelated individuals are treated separately (table 1).

Table 1
Unweighted Number of People and Families
and Average Family Size and Person Weight, by Data Source

| | SIPP panel | | | | <i>DYNASIM3</i> |
|-----------------------|------------|--------|--------|--------|-----------------|
| | 1990 | 1991 | 1992 | 1993 | |
| Number of people | 55,707 | 34,952 | 49,300 | 47,321 | 102,877 |
| Number of families | 23,517 | 14,740 | 20,942 | 19,982 | 44,339 |
| Average family size | 2.37 | 2.37 | 2.35 | 2.37 | 2.32 |
| Average person weight | 4,469 | 7,352 | 5,212 | 5,539 | 2,498 |

The final *DYNASIM3* input file is treated as though all interviews were conducted in December 1992. We adjusted all year-specific variables to correspond to this date. For example, year of birth is calculated based on 1992 minus age. We divided all income variables (earnings, Social Security benefit, pension income, wealth) by the year-specific economywide average earnings.

Earnings Histories. To calculate Social Security benefits for individuals, lifetime Social Security-covered earnings are needed. For confidentiality reasons, the Social Security Administration (SSA) cannot allow users outside the agency to access the SIPP data matched with the SSA Summary Earnings Records (SER). Consequently, we created synthetic earnings histories for individuals in the SIPP input data by statistically matching SIPP records with earning histories constructed from the Panel Study of Income Dynamics (PSID) from 1968 to 1993. We also statistically matched earnings from 1951 through 1968 using an exact match of the 1972 Current Population Survey (CPS) and the SER.⁴

The first statistical match (SIPP to PSID) minimized a distance function for men and women separately within a three-year cohort bracket. For example, we matched 30-year-old men on the SIPP to 29-to-31-year-old men on the PSID. The distance function included annual

³ The long asset module is asked in wave 4 for the 1990 and 1992 panels and wave 7 for the 1991 and 1997 panels.

⁴ The 1972 exact match file served as the *DYNASIM* model's original input file. The conversion to the 1993 SIPP provides a huge advantage by supplying a more recent representation of the population and providing an excellent representation of individual and family housing and financial wealth. Note that synthetic earnings are used only in calculating Social Security benefits for years of work prior to 1992.

earnings observed on the SIPP, but also Social Security benefits, pension income, wealth, race, education, Hispanicity, cohort, and family size. Each factor's influence on the distance function varies over different age ranges. For example, wealth has a higher weight in the distance function for older individuals, and earnings has a higher weight in the distance function for younger individuals. Wealth tells more about historical earnings for 80-year-olds than their current earnings, but the opposite is true for 30-year-olds.

For earnings prior to 1968 we statistically matched the SIPP to the CPS/SER file using a minimum distance function for men and women separately within a single-year cohort based on observed 1968 to 1972 earnings (both year-specific values and the five-year average), race, and education. Again, each factor's influence varies over different age ranges.

The synthetic earnings histories have been validated extensively. Imputed earnings compare very closely with actual earnings histories by gender, race, education, and marital status (Smith, Scheuren, and Berk 2001).

Covered Earnings. The *DYNASIM3* model also needs to know which historic earnings years were subject to Social Security tax and relevant for computing benefits. We assigned Social Security coverage based on employment class observed on the SIPP. For federal government employees hired before 1983 (based on the employment history topical module), we assigned all earnings to noncovered employment. For state and local government employees, we randomly assigned noncovered employment based on the historic, state-specific rate of noncoverage. For retired workers (with zero earnings in 1992) we randomly assigned individuals to noncovered employment based on year-specific, historic noncoverage rates.

General Model Structure

The *DYNASIM3* model includes three sectors: demographics, economics, and the taxes and benefits. Table 2 lists the characteristics simulated within each sector. The computer implementation of *DYNASIM3* follows the structure of its predecessor and includes two separate microsimulation models, the Family and Earnings History (FEH) model and the Jobs and Benefits (JBH) model. The FEH model processes the full sample once for each year of simulation, simulating demographic and annual labor force behavior for each individual in the input file. The output from the FEH model is a set of longitudinal demographic and labor force histories that is the input for the JBH model. The JBH model processes each sample member through the entire simulation period, simulating an entire lifetime history of job tenure, industry of employment, private pension coverage, retirement, Social Security benefits, and private pension benefits.⁵

⁵ This structure has obvious limitations. Job tenure and industry do not affect lifetime earnings. Also, changes in Social Security benefits or pension provisions do not affect previously simulated demographic or economic outcomes.

Table 2
Simulated Events in *DYNASIM3*

| Demographic sector | Economic sector | Taxes and benefits sector |
|-----------------------------|-----------------------------------|---------------------------|
| Population growth | Earnings | Benefits |
| Birth | Labor force participation | Pension benefits |
| Death | Hours of work | OASI |
| | | DI |
| Immigration | Wages | SSI |
| | OASI take-up | Personal saving accounts |
| Family formation | Jobs and employee benefits | Taxes |
| Marriage | Job change | Payroll taxes |
| Mate matching | Pension coverage | |
| Divorce | | |
| Leaving home | | |
| Education and health | Asset accumulation | |
| Education | Saving/consumption | |
| Disability status | Housing savings | |
| DI take-up | | |
| Institutionalization | | |

Each demographic and economic characteristic modeled in *DYNASIM3* uses the latest appropriate data available and a functional form designed to simulate behavior over a long horizon. Table 3 highlights the data and processes used to estimate the key characteristics. *DYNASIM3* also includes Social Security, SSI, and payroll benefit and tax calculators. The discussion below provides a general sense of how the modules work.

Table 3
Core Demographic and Economic Processes

| Process | Data | Form and predictors |
|---------------------------|--------------------------------|--|
| Demographic sector | | |
| Birth | NLSY (1979–94), VS, OACT | Seven-equation parity progression model; varies based on marital status; predictors include age, marriage duration, time since last birth; uses vital rates after age 39; sex of newborn assigned by race; probability of multiple birth assigned by age and race. |
| Death | NLMS (1979–81), VS, OACT | Three equations; time trend from Vital Statistics 1982–97; includes socioeconomic differentials; separate process for the disabled based on age, sex, and disability duration derived from Zayatz (1999). |
| Immigration | Vital Statistics | Simple reweighting procedures. |
| First marriage | NLSY (1979–93), NCHS | Eight discrete-time logistic hazard models for persons age 15 to 34; depends on age, education, race, earnings, presence of children (for females); uses Vital Statistics rates at ages outside this range. |
| Remarriage | NCHS | Table lookups; separate by sex for widowed and divorced. |
| Mate matching | NA | Closed marriage market (spouse must be selected from among unmarried, opposite-sex persons in the population); match likelihood depends on age, race, education. |
| Divorce | PSID (1985–93) | Couple-level outcome; discrete-time logistic hazard model depends on marriage duration, age and presence of children, earnings of both spouses. (Also includes a separate model to predict separation.) |
| Leaving home | NLSY (1979–94) | Three equations; family size, parental resources, and school and work status are important predictors. |
| Living arrangements | SIPP (1990–93) | Projected at age 62 and older; predictors include number of children ever born, income sources, demographic characteristics. |
| Education | NLSY (1979–94), CPS (1995–98) | Ten cross-tabulations based on age, race, sex, and parents' education. |
| Disability | SIPP (1990–93) | Discrete-time logistic hazard model incorporates various socioeconomic differences (age, education, lifetime earnings, race/ethnicity, marital status and nativity). |
| Economic sector | | |
| Labor supply and earnings | PSID (1980–93), NLSY (1979–89) | Separate participation, hours decisions, wage rates for 16 age-race-sex groups; all equations have permanent and transitory error components; key predictors include marital status, education level, age splines, region of residence, disability status, whether currently in school, birth cohort, job tenure, and education level interacted with age splines; also number and ages of children. Model forms vary by outcomes. |
| Job change | SIPP, PENSIM | Assigned from PENSIM to DYNASIM population to age 50 through a statistical match (based on age, gender, education, industry, tenure, pension coverage and type of plan). |

Table 3 (Continued)
Core Demographic and Economic Processes

| Process | Data | Form and predictors |
|------------------------|--|--|
| Pension coverage | SIPP, PIMS | Accumulation of defined contribution plans based on self-reports; assignment of replacement rates for defined benefit plans with reductions in replacement rates based on number of job changes. |
| Saving/ Consumption | SIPP, PSID (1984–94), HRS, SIPP 1990–93 matched with SSA administrative data (1951–99) | Separate models estimated for housing and nonhousing wealth based on income and demographic characteristics using random effects and annual hazard models; each model includes an individual-specific error term. |
| Benefits sector | | |
| OASI | SIPP (1990–93) matched to SSA administrative data (1951–99) | Benefit claiming simulated beginning at age 62; model uses discrete-time hazard models to determine age at take-up based on age, benefit amount, spousal characteristics, and Social Security policy parameters. |
| DI | SIPP (1990–93) matched to SSA administrative data (1951–99) | Benefit claiming predicted through discrete-time hazard model including age, education, lifetime earnings, race, ethnicity, marital status, nativity, and disability status in $t - 1$. |
| SSI | SIPP (1990–93) | Uses program rules (income and asset tests) to determine eligibility and a participation function based on potential benefit and demographic and economic characteristics including age, education, race, family structure, home ownership, and sources of income. |

CPS = Current Population Survey; HRS = Health and Retirement Survey; NA = Not Applicable; NCHS = National Center for Health Statistics; NLMS = National Longitudinal Mortality Study; NLSY = National Longitudinal Survey of Youth; OASI = Old-Age and Survivors Insurance (Social Security); DI = Disability Insurance (Social Security); OACT = Intermediate assumptions of the OASDI Trustees; PENSIM = Pension Simulation Model; PIMS = Pension Insurance Modeling System from the Pension Benefit Guaranty Corporation; PSID = Panel Study of Income Dynamics; SIPP = Survey of Income and Program Participation; VS = Vital Statistics.

The Demographic Sector

The demographic sector simulates all the processes required to project the population, its education attainment, and its family structure. *DYNASIM3* also includes control totals or targets for each major process. These controls are used to allow a user to track long-term projections from another source (such as the SSA or the Census Bureau). They can also be used to understand the sensitivity of the model’s results to assumptions about long-term trends in any of the included modules. For example, *DYNASIM3* typically uses SSA’s intermediate assumptions

about future mortality rates. The model can also simulate more optimistic assumptions that assume people will live longer and trace the effects on Social Security benefits. While these assumptions are a critical part of the model, they are not detailed in this brief document.

Birth. *DYNASIM3*'s fertility module is designed to produce the age-race-sex population distribution in any future year so that the number of people at risk of paying Old-Age, Survivors, and Disability Insurance (OASDI) taxes and/or collecting OASI and DI benefits is correct. It also is designed to produce the proper distribution of birth timing and sequencing to use as an input for generating career trajectories, especially for women. The model uses the maximum amount of information possible on the nature of the current relationship between women's characteristics (e.g., age, race, marital status, education, work history) and their childbearing to model births both historically (1993 to 2003) and in the future (from 2004 onward).

As indicated in table 3, we use regression models to predict the conditional probability of giving birth in a particular year, with all choices conditional on whether a woman is married and has had a prior birth (and, if so, how many: one, two, or more). We use separate equations for different population subgroups to allow full sets of interaction terms between each group's defining variables (marital status and parity) and the independent variables in the equations.⁶ Dividing women's lifetimes along these two dimensions (marital status and parity) yields seven separate equations to drive the process of childbearing. These include equations for the following groups: Unmarried teens at risk of first births; All other unmarried women at risk of first births; Unmarried women at risk of second births; Unmarried women at risk of third or higher births; Married women at risk of first births; Married women at risk of second births; and 7) Married women at risk of third or higher births. As the data source chosen does not permit us to estimate birth probabilities for women age 40 and above, we use data derived from Vital Statistics to assign age-race-parity-specific probabilities of having a child to these women. We use standard Monte Carlo techniques to realize probabilities of having a birth.

Once *DYNASIM3* simulates a birth, it determines the characteristics of the birth, including whether it is a multiple birth and the sex of the child or children. The estimates for these functions take into account the increasing likelihood of having twins and triplets today compared with twenty years ago. As a final step, we calibrate the model predictions to meet external targets.

DYNASIM3 includes five alignment groups to calibrate the model's predictions to the intermediate assumptions of the OASDI Trustees. As the SSA does not produce separate birth projections for different racial or ethnic groups and as Morgan et al. (1999) report important biases in Vital Registration data, we only align births by age of the mother, not by age and race. The age groups used are 14 to 19, 20 to 29, 30 to 34, 35 to 39, and 40 and higher. We use a straightforward linear (multiplicative) adjustment approach, which preserves the principle of

⁶ Marriage/cohabitation distinctions are potentially important in this section of the model. We have not taken them into account here, but could add them if nonmarital cohabitation were a state that *DYNASIM* generated.

monotonicity in probabilities.⁷ In our preliminary analyses, we have found that adjustment factors are very small (close to one) at higher age ranges (over 30), and more significant at younger ages (especially teens).

Death. Mortality information is particularly important when calculating lifetime information about OASDI (e.g., internal rates of return, lifetime transfers, replacement rates) and when estimating the long-term financial balance of the system. The *DYNASIM3* model predicts deaths in every year based on individuals' characteristics (age, race, marital status, education, work history) and their likelihood of death.

DYNASIM3 predicts death using a four-stage process that relies on both micro-level and aggregate data. This approach allows us to draw on the respective strengths of each data source: while only micro-level data can characterize within-cohort sex group differentials, aggregate data can capture age-race-sex-specific trends and levels more reliably. In the first stage, we estimate an individual's death probability as a function of his or her fixed characteristics and varying socioeconomic attributes using data from the National Longitudinal Mortality Study (NLMS) from 1980 to 1982. We estimate three separate regression equations based on age and sex. In the second stage, we use data from Vital Statistics over the 1982–97 period to calibrate the age-race parameters in the NLMS models and incorporate a time trend. For those receiving Disability Insurance (DI), the third stage of the model assigns probabilities based on the estimates from aggregate data that Zayatz (1999) derives.

In the final stage, the expected probability of death is calibrated in broad age-sex groups to targets produced by Social Security Actuaries for the 2002 Trustees' Report. *DYNASIM3* includes 12 separate groups (6 age groups by 2 sexes) for alignment of the micro-level probabilities generated by the NLMS equations. The age ranges include infants (age 0 to 1), ages 1 to 54, 55 to 64, 65 to 74, 75 to 84, and 85 and higher. In aligning, we use linear adjustment procedures analogous to those employed in the fertility module. We take target data from unpublished SSA sources.⁸

Immigration. The current model includes a simple assumption about immigration. The population weight grows over time to reflect net immigration. (This area of the model is under further development.)

Marriage and Remarriage. Accurately projecting marriage is integral to other demographic and economic processes. The distribution of the population by marital status and the characteristics within couples directly affect probabilities in the fertility module, labor force participation probabilities, and Social Security benefit calculations.

⁷ This means that we sum up all the probabilities for the group and then divide by the number of cases to get the average probability. We then scale all the probabilities by the ratio of the target to this average probability. This factor should lead us to hit the target for the group if the procedure does not create any probabilities greater than one.

⁸ Felicitie Bell's projections using 2002 Trustees' data, personal correspondence, 2002.

DYNASIM3's marriage module assigns a probability of marriage to unmarried persons above age 15 and then, based on these probabilities, enters these persons into a marriage market that matches couples and forms new families. Along with other demographic processes, such as mortality and divorce, the marriage module attempts to project a population in which historical patterns of marital status distributions by age, sex, and race are maintained into the future.

The probability of marriage for persons age 15 to 34 is based on estimates from discrete time logistic hazard models. We used the longitudinal nature of the National Longitudinal Study of Youth (NLSY) to capture relationships between covariates and marriage probabilities over several cohorts over several years. Those outside the age range of 15 to 34 are assigned marriage probabilities based on age, sex, and previous marital status using data obtained from the National Center on Health Statistics.

After probabilities are assigned to each individual, *DYNASIM3* applies two adjustments to the estimates to closely approximate annual targets by sex, age, and previous marital status. The adjustment applies to first marriages between the ages of 15 and 34 and consists of annual alignment factors applied to the probability estimates in a lagged fashion (because alignment requires an annual calculation). (It is unnecessary to align marriage probabilities for first marriages outside this age range and for remarriages since the probabilities are directly assigned based on the target data.) There are 10 alignment categories—for age groups 15–17, 18–19, 20–24, 25–29, and 30–34, with separate categories for men and women.

The second adjustment is required to align the marriage market. Not every person who is sent to the marriage market leaves with a new spouse, because there can be a surplus of one sex or the other after the marriage market is finished processing all the potential matches. This can lead to a slight discrepancy between the estimated marriage rates going into the marriage market and the actual marriage rates after *DYNASIM3* processes the marriage market. The average discrepancy between the rates going into the market and the rates coming out of the market was estimated in a trial simulation as 5 percent over the 1993–2003 period. *DYNASIM3* applies this factor to each marriage probability to align marriage rates to the targets.

Mate Matching. The mate-matching module pairs males and females who have been selected to marry in the marriage module. The input information is a list of males and females to be married. The mate-matching module produces a set of new household records, which contain information on the newlywed family units. Individuals not matched are returned to the single population. The lists of males and females are ordered randomly except that they are segregated by race, age, and education; matches only occur within these categories.

Divorce. Divorce directly influences future remarriage rates and is essential to determining survivors' and spousal Social Security benefits. Current Social Security regulations require that a couple stay married for at least 10 years before either spouse is eligible for survivors' or spousal benefits. Thus, accurately estimating marriage duration is pertinent to producing future Social Security benefits. The divorce module assigns a probability that an intact marriage will end in divorce in a given year. Probabilities are assigned based on a regression of characteristics ranging from duration of marriage and age at marriage to family composition and

earnings of each spouse on actual divorces. Couples are then stochastically selected to be divorced based on their probabilities.

DYNASIM3's divorce probabilities are based on a discrete-time logistic hazard model for couples at risk of divorce. It applies these coefficients to produce annual probabilities of divorce for each couple. This process allows us to use longitudinal data with time-varying covariates and couple-level characteristics in the regression model. The level of analysis is couple-years. Each observation represents a year in which the couple is still married until divorce or widowhood. Couples that divorce are recorded as an event in the dependent variable, while a couple in which one of the members dies simply ceases to be included in the analysis.

Separation. Because there is such a strong difference in separation rates by race, and because couples that separate may be disproportionately underrepresented by the time they formalize their divorces due to attrition, we include separation as a variable in the model. We estimated a simple model of separation and evaluated the coefficients to produce a probability of separation as an independent variable in the divorce model. We estimate a discrete-time logistic hazard model of separation controlling for age (one linear term for age under 30 and another for age 30 and over) and race. The coefficients from this model are then evaluated for each individual each year and included in the divorce model.

Leaving Home. *DYNASIM3* simulates *families* rather than *households*. Unrelated adults are included as multiple one-person families. As part of its family change process, *DYNASIM3* requires home-leaving algorithms to create new, one-person families. Further, whether a person lives at home with a parent or parents might be an important predictor of his or her behavior in other areas (for example, likelihood of having a baby, continuing in school, marrying, or working).

The home-leaving module combines deterministic and stochastic processes. Leaving home is mandatory for persons marrying at time t and for mothers who are unwed at the time of a child's birth. For the stochastic portion of the model, *DYNASIM3* assigns each person a probability of leaving home using one of three separate regression equations—one for persons age 14 to 17 and separate equations for men and women age 18 and over. Key determinants in these equations include family size, parental resources, and school and work status.

Education. Education is an important determinant of wage rates and trajectories. Further, both completed education and schooling status are important predictors in other economic and demographic processes, such as fertility, education, marriage, and divorce. As shown in table 3, *DYNASIM3* uses 10 separate cross-tabulations to predict a young person's progression through educational institutions. The key parameters in these cross-tabulations include race, sex, parental education, and the amount of time that the person has spent in school to date. This structure is consistent with sociological literature on status attainment, which has consistently found that parents' status is one of the strongest predictors of a child's success in school.

Disability Status (Work Limitations). *DYNASIM3* includes a discrete-time hazard model for this binary dependent variable. We model the *conditional* probability of entering, exiting, or remaining in a state at time t , employing characteristics at $t - 1$ as predictors. In the

case of work limitations, we model both entries (reporting a work limitation at time t given that one did not have a work limitation at $t - 1$) and exits (reporting no work limitation at time t given that one did have a work limitation at $t - 1$).

We use many of the same explanatory variables that previous authors have used in modeling work limitations, including standard demographic and economic variables (age, education, lifetime earnings, race/ethnicity) (for details, see Favreault 2002). Additionally, we incorporate indicators for marital status and nativity, which prior work has found are important correlates of disability and mortality experience.

Living Arrangements. *DYNASIM3* includes projections of living arrangements (either independent, or shared with an adult family member other than a spouse) at age 62 and above. A discrete-time event history model, estimated using SIPP data, projects whether one coresides based on economic and demographic characteristics (including the number of children one has had). For those projected to coreside, summary characteristics of the persons with whom one resides are imputed using a statistical match to SIPP data on current coresiders.

The Economic Sector

DYNASIM3's economic sector simulates information essential to creating labor force histories for each person in the sample and each year of the projection. As noted earlier, this sector includes separate models for labor force participation, hours of work, and earnings. The economic sector also simulates information essential to calculating retirement incomes. It simulates job histories, including private pension coverage on those jobs, individual savings and consumption, and individual decisions to claim Social Security and Supplemental Security (SSI) benefits. Final assignment of values of these benefits occurs in the third sector of the model, described in the next section. Note that this sector of the *DYNASIM3* model also includes targets that allow it to track external projections of labor force participation and real wage growth.

Labor Force Participation, Hours, and Wages. The labor force module predicts labor force participation, hourly wages, and annual hours worked for individuals age 16–80 in the *DYNASIM* sample. Coefficients are estimated by race, sex, and age group using individuals from the PSID from 1980 to 1993 and the NLSY from 1979 to 1989. The NLSY is used for the youngest sample group, age 16–24. The PSID is used for all other age groups—25–54, 55–64, and 65–80. Race is categorized as black and nonblack.

The simulation model first predicts whether an individual will participate in the labor market for the given year. For those individuals simulated to work, the model predicts hourly wage and annual hours worked and uses these values to calculate annual earnings. All three equations assume an error term with permanent and transitory components. The permanent component is an individual-specific error calculated from the PSID historic earnings donor record. This component ensures consistency between the imputed historic earnings and the individual-specific errors. *DYNASIM* imputes individual-specific errors for children at age 16 based on the distribution of individual-specific errors estimated on the PSID. The transitory component is drawn each year and is assumed to follow an AR1 process. The parameters for the

error term, the lag parameter, and the distributions of the permanent and transitory errors are estimated using the variance-covariance matrices from the race-, age-, and sex-specific equations for hours, wages, and participation.

The coefficients in the simulation model are estimated in four steps. First, hourly wages are estimated using a random-effect model of the logarithm of hourly wages for individuals with positive income for the year. Next, the coefficients from the wage equations are used to calculate a predicted wage for all individuals in the PSID. Then, annual hours are estimated using a tobit model that includes predicted wage as a regressor. Finally, labor force participation is estimated using a random-effect probit model. *DYNASIM3* predicts a latent wage and hours worked for all individuals age 16 to 85, but only simulated participants are assigned earnings.

Employment rate results are aligned to targets from the OASDI Trustees' Report, disaggregated by age (with 8 groupings, including 16–19, 20–24, 25–49, 50–54, 55–59, 60–64, 65–69, and 70 and older) and sex. We use the Trustees' wage growth assumptions for future periods.

Job History. Job change is important for accurately estimating pension benefits, especially from defined benefit (DB) plans. Self-reported information on the SIPP provides all the job-related information needed to project pension benefits from prior jobs. It also provides most of the information needed to project pension benefits from current jobs. What is not known, however, is when individuals will leave their current job. Also unknown are the timing and job characteristics (including pension coverage) of future jobs. To impute this information, *DYNASIM3* explicitly models job changes up to age 50. After age 50, the retirement module simulates retirement decisions.

For job changes prior to age 50, *DYNASIM3* incorporates data on synthetic work histories from the Policy Simulation Group's PENSIM model, developed for the Department of Labor's Pension and Welfare Benefits Administration. PENSIM simulates job histories using job tenure models estimated from the SIPP and applied to a synthetic dataset. PENSIM also simulates pension coverage using Form 5500 data augmented by CPS data for public-sector workers.⁹ For each worker in the PENSIM dataset, information is available on the start and stop age for each job, characteristics of each job (industry and firm size), and individual characteristics (gender and education). Pension coverage information is also available for each job. For each job, individuals have either no pension plan, DB coverage only, defined contribution (DC) coverage only, or both DB and DC coverage.

Job history information, including pension coverage and pension type, is assigned from PENSIM to the *DYNASIM3* population. These job histories cover the time from the SIPP interview to age 50. Job histories are assigned (with replacement) based on the following characteristics at the time of the SIPP interview: age, gender, education, industry, tenure, pension coverage, and pension type. Because job and pension histories are assigned to all workers,

⁹ See Holmer, Janney, and Cohen (2001) for more detail on the PENSIM model.

regardless of pension coverage status, future pension coverage of current nonparticipants is handled automatically.

Pension Coverage. The pension module estimates pension benefits and wealth from DB plans, DC plans, Keoghs, and IRAs for future retirees. Two sets of output are produced. The first provides pension wealth estimates under several retirement age scenarios. These estimates are then used in the module that determines each worker's retirement age. The second set provides estimates of annual DB pension benefits and DC account balances, given that retirement age.

Pension benefits are projected using several data sources. Initial pension coverage information is based on self-reports from the SIPP Retirement Expectations and Pension Plan Coverage topical module. This module includes information regarding the type of pension and years of pension plan participation to date, employee contributions toward pension plans, and 401(k) balances. In addition, the SIPP Annual Income and Retirement Accounts topical module provides information on annual contributions to 401(k), IRA, and Keogh accounts. The SIPP Assets and Liabilities topical module provides additional information about IRA and Keogh account balances.

Data from other sources supplement the SIPP data. As noted earlier, job changes and pension coverage on future jobs are simulated by linking data from the PENSIM model to the *DYNASIM3* population. Data from the Pension Benefit Guaranty Corporation's Pension Insurance Modeling System (PIMS) are used to determine DB benefits for DB participants. We also incorporate information from the EBRI/ICI database to develop assumptions regarding DC contribution and asset allocation behavior.

In summary, we obtain information regarding pension coverage on current and past jobs from the self-reported information on the SIPP. Next, we use data from the PENSIM model to impute future job changes and pension coverage on future jobs. We then project pension benefits from past, current, and future jobs. DB plan benefits are projected using PIMS DB plan formulas. DC account balances are projected using self-reported information on the SIPP regarding account balances and contribution rates, along with assumptions regarding asset allocations and future contribution rates.

Saving/Consumption. The *DYNASIM3* wealth module projects the value of home equity and financial assets. Individuals begin the simulation with values for home ownership, home equity, and financial assets reported on the SIPP wealth topical module.¹⁰ *DYNASIM3* projects these values forward year by year based on family characteristics including age, historic earnings, family type, demographic characteristics, pension characteristics, and disability status.

Homeownership, home equity, and net financial assets are projected separately for married couples and singles over three age ranges (25 to 50, 50 to retirement, and retirement to death). This yields 12 total projection equations. For homeowners, we project the value of the home using random-effects models. For all families, we project non-pension financial wealth

¹⁰ Families not included on the SIPP wealth topical module are excluded from the *DYNASIM* sample.

based on random-effects models.¹¹ The dependent variables are the logarithm of home equity and the logarithm of net financial assets. To estimate financial debt, we add an offset to financial assets before taking the logarithm. This offset is then subtracted from the predicted value. Comparisons of results with the Survey of Consumer Finances for the historic period show that the model provides a very good representation of the distribution of assets including debt.

For families that do not own a home, we project net home purchases (defined as purchases of a primary residence) based on an annual hazard model. Similarly, for all families that do own a home, we project net home sales (defined as the sale of the primary residence with no repurchase, or shift to rental status) based on an annual hazard model.

These models are based on several major data sets. Home equity and asset accumulation from the starting SIPP value to age 50 were estimated using data from the PSID. Home equity and asset accumulation from age 51 to retirement were estimated using the Health and Retirement Study. Asset spend-down equations were estimated using data from the 1983 and 1990–93 SIPP panels matched to SSA data on earnings, benefits, and mortality.

Each model includes an individual-specific error based on a statistical match between the SIPP and PSID for individuals under age 50 on the SIPP. This statistical match insures internal consistency between the imputed earnings history and the observed starting wealth. The individual-specific error captures the dramatic range in saving behavior among otherwise similar households and ensures that we capture the wide distribution in housing and financial assets. Wealth projections after age 50 are implemented at changes in wealth. The SIPP starting value captures the individual’s actual saving behavior including their individual-specific effect. For more information on saving/consumption, see Toder et al. (2002).

OASI Take-Up. *DYNASIM3* models Old-Age and Survivors’ Insurance (OASI) take-up (or benefit claims) beginning at age 62.¹² The model estimates benefit take-up using discrete-time hazard models that individuals face at each age from 62 until claiming their benefits, but everyone who is eligible takes up benefits by age 70. These equations are estimated on the 1990–93 SIPP panels matched to SSA administrative data on earnings and benefits from 1951 to 1999. The model specifications take program differences and incentives into account through separate equations based on Social Security eligibility status (for example as a spouse only or as a worker) and for groups with different ratios of recent earnings to the Social Security exempt amount. The OASI take-up model includes variables that describe spousal characteristics and Social Security policy parameters (e.g., dual entitlement), both of which are known to influence the timing of benefit take-up.

DI Take-Up. *DYNASIM3* includes a discrete-time hazard model to predict Disability Insurance benefit claims, or DI take-up. It only includes DI entries—exits for reasons other than death are too rare in the data to permit reliable estimation. *DYNASIM3* includes many of the same explanatory variables that previous authors have used in modeling DI receipt, including

¹¹ Equity in second homes is included in financial assets.

¹² Consistent with current law, widow(er)s can take up Social Security benefits at age 60 and 61 in the model.

standard demographic and economic variables (age, education, lifetime earnings, race/ethnicity) (for details, see Favreault 2002). Additionally, it includes indicators for marital status and nativity, previously established as important correlates of disability and mortality experience. These models were estimated using data from the 1990–93 SIPP panels matched to SSA earnings, benefit receipt, and mortality records.

SSI Take-Up. The *DYNASIM3* aged SSI take-up module first determines each individual’s SSI eligibility by applying the program’s rules (income and asset tests) to individuals age 62 and older on the basis of filing unit (individual versus couple), living arrangements, disability status (for those 62 to 64), and state of residence. Once the model has determined whether a unit is eligible for benefits, it forecasts benefit take-up (program participation). Previous research has consistently shown rates of SSI take-up among the elderly of between one-half and two-thirds of those who are eligible.¹³ We estimated participation functions from SIPP data from the early 1990s linked to administrative records. In predicting participation, it is important to use administrative records, given high levels of underreporting of SSI participation on household surveys (see, for example, Huynh, Rupp, and Sears 2002).

Consistent with prior literature, *DYNASIM3* ties SSI participation to need (i.e., those who are worse off economically are more likely to claim benefits than those who are better off) and to several other demographic and economic characteristics. Model parameters are calibrated so that the model’s predictions match historical participation patterns. Finally, the model uses an algorithmic approach to assign annual benefit levels given take-up.

DYNASIM3 also roughly models SSI for the younger population (age 25 to 61).¹⁴ It makes a few simplifying assumptions, including the following: (1) calibration of the disability indicator to DI beneficiary targets from administrative data approximates SSI’s disability screen, (2) sources of income that *DYNASIM3* does not project (such as Temporary Assistance for Needy Families) do not affect eligibility, and (3) benefit take-up among eligible persons can be predicted using expected benefits alone.

The Taxes and Benefits Sector

This sector of the *DYNASIM3* model currently includes calculators to estimate pension, OASDI, and SSI benefits from the demographic and economic projection data as well as historic, current, and projected program rules appropriate to the individual years of the simulation. It also includes mechanisms to calculate personal account balances, given assumptions about contributions to these accounts, and payroll taxes. Obviously, program rules may change over time, and the model cannot predict future benefit systems. But it can be used to assess the effects of alternative

¹³ Researchers from early studies that use self-reported measures of SSI participation (for example, McGarry 1996) typically find participation rates ranging between 50 and 60 percent of those eligible. More recent studies that rely on matched administrative records (for example, Davies et al. 2002) document somewhat higher participation rates of about 63 percent.

¹⁴ The model does not currently include SSI benefits for children.

benefit formulae in relation to current law. Indeed, this is the essential function of the model. Demographic and economic trend changes will have implications for current benefit systems. Given these demographic and economic forces, it is important to understand how programmatic changes will affect the income distribution and economic well-being of older Americans.

The description below generally explains the current-law calculators. *DYNASIM3* is parameterized so that current law can be modified for future simulation years. New benefit calculators could also be added so far as the basic model predicts the essential characteristics required to make those calculations.

Pension Benefits. *DYNASIM3*'s pension model first determines whether a benefit should be calculated. A benefit is calculated if a worker who is participating in a pension plan leaves his or her current job. The model first determines if the person is currently eligible for normal or early retirement benefits from the current pension plan. If the person is not immediately eligible for benefits, the model determines whether the person has a vested claim to a benefit that he or she will receive upon reaching the plan's normal retirement age.

If a worker is eligible for an employer benefit, either immediate or vested, the model assigns a pension plan formula, for example a percent of earnings times years of service. The model uses several types of formulae for defined benefit plans (based on the PIMS) and a single formula for defined contribution plans. Having assigned a benefit formula, the model then assigns values to the parameter of the formula, such as the percentage of earnings, and determines whether a worker is subject to a maximum-years-of-service limitation. The model next computes a benefit, applies an early retirement reduction and a minimum benefit amount where appropriate, and checks for benefit reductions for a survivor's benefit.

OASDI Benefits. The model calculates a history of benefits for each person in the population starting with the first simulation year (currently 1993) through the final simulation year or year of death. Benefits are calculated when an event triggers benefit entitlement, such as reaching retirement age, an incidence of disability, or the death of a spouse. The model calculates retirement, disability, spouse, and survivor benefits, applying statutory adjustment factors for retirement at ages other than the normal retirement age and the Retirement Earnings Test. *DYNASIM3*'s projected family and earnings histories provide information essential to these calculations. For example, divorced spouses are only eligible for benefits on their ex-spouse's benefit record if the marriage lasted at least 10 years.¹⁵

There are four major steps in calculating retirement benefits. First, the model checks insured status. Second, it calculates a primary insurance amount (PIA) for all persons with the required insured status. Third, it applies the appropriate adjustments to the PIA based on age. Finally, it checks current earnings to see whether a benefit is actually received. The benefit calculator includes all historic and projected Social Security program rules. It assumes that all workers begin to collect retirement benefits at the simulated take-up age (described above),

¹⁵ The model does not currently include OASDI children's benefits or the family maximum, though no limitations of the model would prevent such an extension.

unless they are simulated to have earnings that would reduce their annual benefit to less than one month's benefit.¹⁶

SSI Benefits. Forecasting SSI expenditures into the future requires making a number of assumptions about the likely future course of government actions.¹⁷ Where legislation mandates changes to the federal program (e.g., benefit levels increase with changes in the Consumer Price Index), we adjust values using assumptions from the OASDI Trustees' Report (Board of Trustees 2002). Where changes are not part of the law, but rather implemented on an ad hoc basis by Congress, we assume that the program's parameters grow at the same rates that they have since SSI's inception in 1974. For example, SSI asset test thresholds have grown at a lower rate than inflation. We carry this average annual rate of increase indefinitely into the future.¹⁸

Personal Saving Accounts. The model currently simulates a simple mandatory personal saving account. All workers contribute a fixed percentage of Social Security–covered earnings every year. Accounts earn interest at a single fixed rate. At retirement, workers receive an indexed annuity that includes a 50 percent survivor benefit.

Payroll Taxes. The model simulates OASDI and HI (medicare) taxes for all covered workers. The model keeps track of the separate employee and employer portion of each tax.

Sample Projections

The *DYNASIM3* model produces detailed projections of the entire population. Recent analyses have focused on projections of 2020 through 2040, the period during which the baby boomers will retire. The results obviously will reflect the underlying model characteristics and assumptions used to guide aggregate projections for population and economic growth and real interest rates.

Table 4 shows a sample of the model's output based on 2000 intermediate assumptions of the Board of Trustees of the OASDI Trust Fund. The table shows the demographic characteristics of individuals at or above the normal retirement age in 1992, 2020, and 2040. Note that the normal retirement age is increasing gradually from 65 in 1999 (and earlier) to 67 in 2022 (and later). Therefore, the table excludes younger individuals over time as the normal retirement age increases.

The projections show the expected, dramatic increase in the share of individuals age 85 and older. Sixteen percent of individuals in the retirement-age group fall in this age category in 2040 compared with 7 percent in 1992. The *DYNASIM3* projections also indicate that the share of older Americans who are female will decline somewhat over time as male mortality rates are expected to improve faster than those for females.

¹⁶ One option in the model disallows all benefits if the person has any earnings above the exempt amount.

¹⁷ In *DYNASIM*, virtually all these assumptions are parameterized so that users can change them fairly readily.

¹⁸ *DYNASIM3*'s SSI model includes an approximation of state supplements to SSI.

Table 4
***DYNASIM3* Projections of the Characteristics of the Retirement Age Population** ^{a,b}

| | Percent of population | | |
|----------------------------------|------------------------------|-------------|-------------|
| | 1992 | 2020 | 2040 |
| All | 100 | 100 | 100 |
| Age | | | |
| 65–69 | 33 | 28 | 16 |
| 70–74 | 27 | 30 | 26 |
| 75–79 | 20 | 20 | 23 |
| 80–84 | 13 | 12 | 19 |
| 85+ | 7 | 10 | 16 |
| Gender | | | |
| Male | 41 | 43 | 44 |
| Female | 59 | 57 | 56 |
| Marital status, by gender | | | |
| Male married | 31 | 28 | 25 |
| Male widowed | 5 | 6 | 8 |
| Male divorced | 3 | 5 | 5 |
| Male never-married | 2 | 3 | 6 |
| Female married | 25 | 23 | 20 |
| Female widowed | 25 | 21 | 21 |
| Female divorced | 4 | 10 | 10 |
| Female never-married | 4 | 3 | 6 |
| Education | | | |
| High school dropouts | 38 | 14 | 10 |
| High school graduates | 49 | 59 | 57 |
| College graduates | 13 | 27 | 33 |
| Race | | | |
| White non-Hispanic | 86 | 78 | 72 |
| Black non-Hispanic | 8 | 9 | 11 |
| Hispanic | 4 | 9 | 12 |

Source: Urban Institute tabulations of *DYNASIM 3*.

- a. As the normal retirement age increases over time, younger individuals are excluded from the table.
- b. Based on 2000 intermediate assumptions of the Board of Trustees of the AOSDI Trust Fund.

The projections also show changes in marital status over time, with greater shares of males and females entering into retirement either never married or divorced. Widows also are expected to make up a smaller share of the population in the future because of both the decline in marriage rates and the decreased mortality rates of males, including married males. The projections show a substantial increase in the share of older Americans with college degrees by 2040, reflecting recent increases in college enrollment among young people. Finally, the model predicts that an increasing share of the retirement-age population will be black or Hispanic,

reflecting higher fertility rates for those groups relative to whites and relative improvements in their mortality rates over time.

Figure 1 provides a baseline picture of the incomes of those at or above the normal retirement age from 1992 through 2040 (Smith 2003).¹⁹ The projections suggest that income from assets will represent a larger share of total income for future older Americans and the share from pensions will decline somewhat as more Americans save for retirement in tax-deferred vehicles. Social Security benefits grow in real terms over time reflecting the wage-indexed, current-law benefit formula. The model also predicts a substantial increase in the share of income from current earnings, especially for the youngest cohort shown.

Figure 1
Average Real per Capita Total Income by Source, Age, and Year
All Individuals at or above the Normal Retirement Age: 1992 to 2040

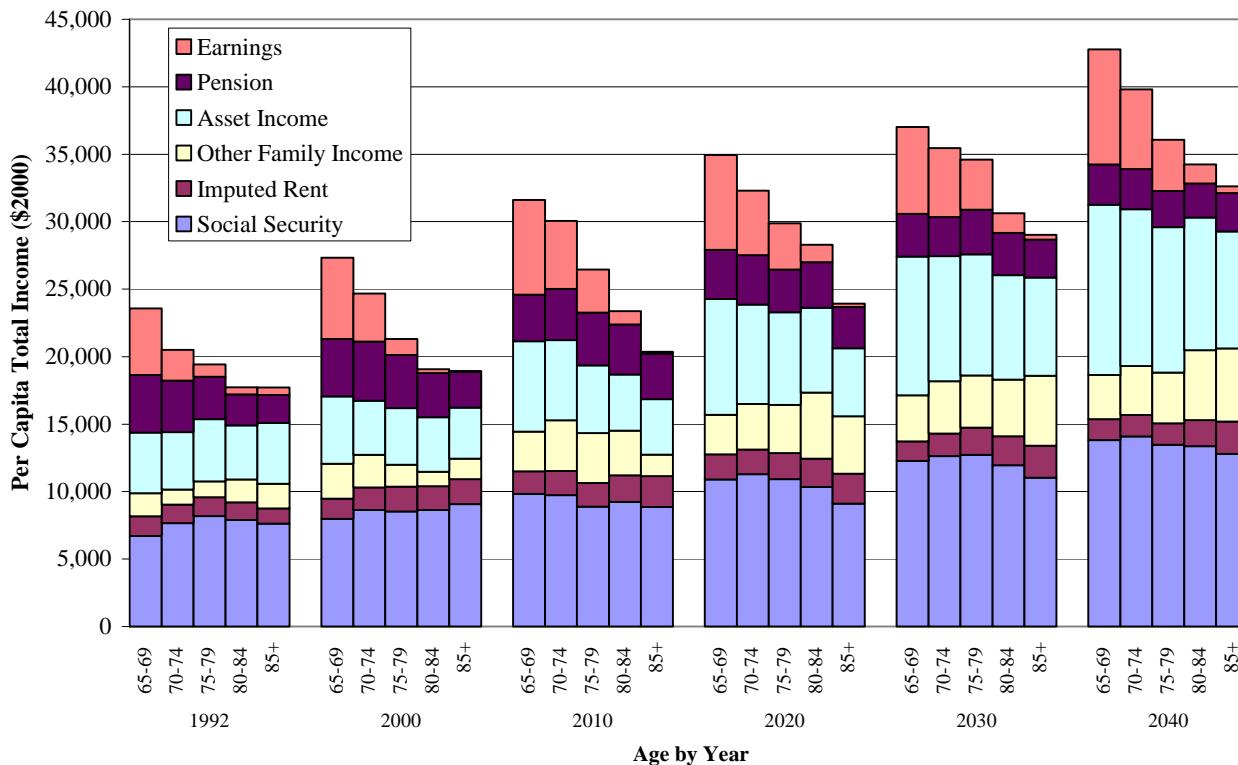


Table 4 and Figure 1 provide just two examples of the *DYNASIM3* model's output. Interested readers are referred to the papers discussed earlier to more fully explore the model's characteristics and projections.

¹⁹ Note that some characteristics of the model have been further developed or expanded since these projections and new model results may differ somewhat from these estimates.

Summary

The *DYNASIM3* model provides a powerful tool for analyzing demographic and economic change and its implications for future retirement incomes. The most recent model development includes substantial updates and upgrades over the earlier version. The input data represents a recent period and the SIPP provides a rich underlying data set to use as a projection starting point. Each module uses state-of-the-art estimation techniques and a wide variety of longitudinal data sets appropriate for each process. Developers have benefited from learning through developing the Social Security Administration's Model of Income in the Near Term, which also uses the SIPP for its starting population. They also have benefited from access to new data sources and the rapidly declining cost of computer resources.

While this version of *DYNASIM3* represents a major update, the model can always benefit from further development. New data that could be used to update or validate model output continually become available. New processes or models that simulate health benefits and personal income taxes would be desirable. Developers would also like to add links to accepted macroeconomic models to provide consistent forecasts of future economic growth. Nonetheless, given the data improvements and reduced costs of computing, it seems that the time has come for dynamic models that project the upcoming implications of current demographic and economic trends. While models like *DYNASIM3* cannot predict the future, they provide policymakers important guidance on what might happen with critical systems such as Social Security if the current law continues or alters.

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