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Labor Force Trends and Future Social Security Benefits

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Abstract

Trends in employment and earnings patterns in the population, particularly the increase in the number of two-earner couples, create a hurdle for the long-term modeling of Social Security, because benefits are intricately related to employment and earnings. The spouse and widow benefits of women who are eligible for their own retired worker benefits are particularly problematic because of the dual entitlement reduction under which a woman's spouse or widow benefit is reduced, dollar for dollar, by any increase in the woman's retired worker benefit. This paper examines a technique that allows long-term macromodeling of the economy to incorporate these intricate effects. The technique makes use of a microsimulation model of individual workers, with the microsimulation model specified in such a way that the earnings and employment of its individuals can be constrained to meet specified calendar-year projections for aggregate employment and earnings. The technique is used to carry out a 75-year analysis, examining the sensitivity of Social Security taxes and benefits to changes in women's employment and earnings under three scenarios: an increase in women's employment holding average earnings constant, an increase in women's earnings holding employment constant, and a simultaneous increase in both employment and average earnings. As expected, the dual entitlement reduction limits the increase in benefits for many of the women.

Over the 75-year period the increase in payroll taxes from women's higher earnings will more than offset the increase in benefits from their earnings. The simulations indicate, however, that there is an additional effect from higher women's earnings through the national average wage indexing series, which is used to set the overall level of benefits. By raising the national wage index, higher women's earnings can increase the overall level of benefits, thereby offsetting some or all of the increase in payroll taxes.

I. Introduction

Long-term aggregate modeling of Social Security must deal with the often intricate relationships between the earnings of a cohort of workers and the benefits that cohort will receive many years later. Even if the economic and demographic patterns in the population were stable in the long term — if, for example, there were no changes in marital patterns, in the proportion of two-earner couples, in the number of years women work, or in women's earnings while they work — the ability to model the changes in aggregate benefits over 75 years resulting from some standard variations in benefit provisions is a substantial challenge. When the patterns themselves are changing, the modeling challenge is compounded.

This paper deals with one approach to this challenge. The work described in the paper is part of the development by the Social Security Administration (SSA) of a long-term macroeconomic model that examines the effects of Social Security on the rest of the economy and the macroeconomic feedback effects on the Social Security Trust Funds. The macro model is intended to explore such questions as, "If the trust funds add to national saving, what are the feedback effects from this increased saving on incomes in the national economy and on the payroll taxes and interest income received by the trust funds? If part of trust fund revenues are redirected into individual accounts, or if new payroll taxes are directed into individual accounts, or if general revenues are directed into individual accounts, and these accounts increase national saving, what are the effects on future national income, including the effects on the trust funds from higher wages and lower interest rates? If the labor force can be induced to postpone retirement, on average, what are the resulting effects on national income and on the trust funds?"

For most of its applications, the macro model is formulated in terms of a baseline simulation, under current law, and one or more alternative simulations, under which some provisions of current law are changed or some assumptions about future economic growth are varied. The baseline simulation is calibrated to give results the same as or close to the intermediate projections developed by SSA's Office of the Chief Actuary (OCACT), projections like those used in the annual Trustees Reports for the Old-Age and Survivors Insurance (OASI) and Disability Insurance (DI) trust funds. (These funds together will be referred to as the OASDI trust funds.) The calibration sometimes takes the form of direct use of the detailed age by year (and sometimes age by sex by year) projections by OCACT; sometimes it means adjusting the macro model's detailed projections so that the aggregates each year add up to the aggregates projected by OCACT.

The modeling problem faced by the macro model is the consistent modeling of the alternatives to the baseline. Even those simple changes in provisions that are easy to input into the macro model, such as changes in payroll tax rates by year or diversion of a specified proportion to taxes into individual accounts each year, create macroeconomic feedback effects on benefits which are difficult to model.

One of these is the effect on average wages among employed workers, which determine a fundamental index in the Social Security benefit calculation, the national average wage (NAW) index. The level of old-age benefits is determined in part by the NAW in the year a retired worker beneficiary reached age 60. For older beneficiaries it is possible to model, with a little work, the effects of this wage indexing. For beneficiaries at age 80, for example, the level of benefits depends on the national average wage 20 years earlier, plus any consumer price index increases in the 18 years since the beneficiaries turned 62. For modeling macroeconomic feedback effects of proposals that change the average wages, the benefit levels in all age-year cells in the alternative simulations can be adjusted appropriately for changes in the wage index in the year each cohort of beneficiaries turned 60.

The modeling of these simple effects on DI beneficiaries and on younger survivor beneficiaries is more complicated, since the critical level for the national wage index is for them not the year they turned 60, but the year two years before the year they became eligible for benefits. For any given age cell in the macro model age-year matrix, the feedback effect of a change in national average wages depends on a distribution of years of eligibility.

For 50-year-old beneficiaries, for example, some were eligible two years earlier, at age 48, while some were eligible 20 years earlier, at age 30. Changes in the growth in average wages will therefore have a distribution of effects on DI beneficiaries at a given age. Furthermore, as the composition of the DI beneficiary population changes, the distribution of these wage indexing lags also changes.

For analyzing all but the simplest changes in the benefit provisions, the macro model faces still more difficulties.

A change in the spouse provisions, for example, will have proportionate effects on benefits by age that dwindle in the future as more women become eligible for retired worker benefits on their own and as their spouse benefits shrink accordingly. (Spouse benefits, as will be described later, are reduced under the dual entitlement reduction by the amount of any retired worker benefits.) Simulation of this alternative in the macro model would therefore require a preliminary simulation for each age in each year of the amount by which benefits are reduced under the provision.

Similar hurdles are faced for the simulation of alternative assumptions about future labor-force trends, such as the trends in women's employment and earnings that will be examined in this paper. If women's career earnings rise, their retired worker benefits also rise, but because of the dual entitlement reduction, some proportion of women will not see a rise in their total benefit. This proportion of women is declining because of past changes in women's employment and earnings, and will decline still further if women's employment and earnings continue to increase in the future.

Many of these hurdles could be overcome on a case-by-case basis, studying the aspects of each problem and working up estimates for each age cell over the projection period of the proportionate effects on benefits. For our macroeconomic modeling, however, we need something much quicker.

The solution explored here is a hybrid model in which a sample of individual worker earnings histories is adjusted to reflect projected changes in the labor force, and benefits are then calculated for each worker or couple in the sample under both the baseline and the alternative. The change in the aggregate benefits from the baseline to the alternative in the individual simulation is then brought up to the macro model simulation as an estimate of the appropriate change in the aggregate cell values. The baseline, in short, is provided by the macro model, calibrated to intermediate projections from OCACT. The proportionate change in benefits between baseline and alternative in each cell in the model is provided from the simulation of individual histories representing present and future cohorts of workers and beneficiaries. The final assembly, the multiplication of the baseline value in each cell by the proportionate change in each cell, then is done under the macro model cell framework.

The simulation sample of life histories of earnings for workers and their spouses will be referred to here as the "embedded microsimulation model", or the "micro model" for short. The trick in using such a sample is to develop techniques for altering the sample systematically to represent the changing experiences of future cohorts. The same sample is used over and over, but the women in the sample, for example, have fewer years of zero earnings when the sample represents a cohort born in 1960 than when it represents a cohort born in 1930.

The techniques have been developed to the point where the average earnings and employment of men and women in the sample can be constrained to meet changing projections for aggregate employment and earnings by calendar year and sex over the projection period. Similar techniques for altering the marital histories of the sample have not yet been implemented. The development of such a model is an open-ended process. Future work may focus not just on marital histories but also on a capability for simulating changing disability and mortality trends among pre-retirement workers.

Although microsimulation modeling is usually found in the context of distributional analysis, examining the effects of proposed policies on important components of the population, the most important attribute of microsimulation — the calculation of effects at the individual level using actual policy provisions — is equally useful in developing macro-level estimates.

This will not be the first aggregate-level model to use an embedded microsimulation model. The models used by the Office of the Chief Actuary (OCACT) at Social Security have long used a submodel of a sample of individual workers as an important part of their projection of worker benefits. The long-term model under development at the Congressional Budget Office (CBO) also uses an embedded micro model.

The effort here is similar to the original goal of Guy Orcutt and his associates in the development of the Dynasim model, the first large microsimulation model of the national economy [see Orcutt, et al., 1976]. Dynasim was supposed to include an ability to aggregate up to a macro model that would fill in some of the gaps in the microsimulation model. The model here works from the other end. It is a macro model, but alters its results using the effects of a micro model to fill in some of the estimates that the macro model can't calculate.

The embedded microsimulation model is used here to examine the sensitivity of aggregate Social Security benefit payments over a 75-year projection period to three test scenarios for variations from the baseline of women's employment and earnings.

In the first scenario, the employment-only scenario, women's employment rates are increased slightly from the baseline, but the average earnings among employed women is held constant. In the second, the earnings-only scenario, the average annual earnings among employed women increases, but not the proportion employed. In the third, the combination scenario—or the employment and earnings scenario—the first two increases in employment and earnings are implemented simultaneously.

These scenarios are not meant to be more accurate projections of the future than the baseline scenario, and they are not meant to be finely tuned estimates of the most likely variations. They are in the spirit of the sensitivity analyses in the annual Trustees report for the OASDI trust funds, indicating how much the 75-year projection might change if the intermediate projections were changed.

The most important aspect of the estimates from the alternative scenarios in this paper is that they are generated automatically for the macro model using the embedded micro model. They are probably sufficiently accurate for the purposes of the macro model, whose goal is the exploration of the effects of changing national wages and interest rates under reasonably accurate specifications of the workings of OASDI taxes and benefits.

The modeling described here is by no means finished. Although it is generating results, a number of sectors of the micro model are still incomplete, and the macro model itself is still evolving.

The next section gives a very brief description of the macro model. The third section gives a quick summary of the results from the first scenario (the employment-only scenario) to give an indication of the types of estimates being calculated and the roles of the macro and micro models in calculating them.

The fourth section describes recent trends in employment and earnings, the intermediate projections of employment that are used in the baseline, and the alternative projection scenarios that will be used here as variations from the baseline. This section also presents calculations of the likely effects on taxes and benefits under the scenarios. These expected effects are important for checking that the microsimulation model is doing what it is supposed to and might also be of use to anyone making rough estimates of the effects of changing labor-force trends.

The fifth section describes the microsimulation model itself, and the sixth describes the sensitivity estimates under the three scenarios. A final section describes future work.

II. The Macro Model

The long-term macro model of the U.S. population carries out its calculations on age by year (and sometimes age by sex by year) matrices of numbers of persons, workers, and beneficiaries, as well as aggregate income, earnings, taxes, and benefits for every year in the projection period.[1] The age-by-year and age-by-sex-by-year elements of these matrices are referred to as "cells." The baseline cell values for population and employment for the model are adapted from cell projections by the SSA's Office of the Chief Actuary (OCACT). The aggregate earnings, taxes, and benefits are adapted from OCACT projections as well, although many of these projections are not at the cell detail needed by the macro model and must be distributed into cell values from the still more-aggregated projections provided by OCACT.

[1]The simulation actually extends over a much longer period than the 75-simulation period and includes many matrices that are age-by-year-of-birth rather than age-by-year.

The long-term macro model is designed to study questions other than the sensitivity of projected benefits to assumptions about women's labor force trends. Its primary focus is the study of changes in national saving and income associated with changes in Social Security, including changes in federal taxes and surpluses other than the OASDI taxes and surpluses projected by OCACT. For many of these questions, women's labor-force trends are held constant, and the OCACT baseline projections for women's earnings can be used for the whole analysis. Some analyses, however, deal with changes in labor-force participation themselves (such as a move to later retirement), and for these purposes, the model needs to be able to deal with changes in labor force behavior from the baseline projection.

In all such questions, the ability to model the interaction between women's earnings and their later benefits accurately is important. There is a dual relationship between the study of the effects of changes in women's earnings holding the benefit formulas constant and the effects of changes in the benefit formulas while holding women's earnings constant. Most of the questions the model is intended to study will be in this latter form. But the model's ability to accurately study these effects can also be tested with questions of the other form.

When the Office of the Actuary is faced with analyzing the projected effects of a change in a spouse's benefits, it can, on a case-by-case basis, come up with careful estimates of the likely effects in each age-sex cell over the projection period. (Their methods typically use benefits disaggregated in even more detail than age and sex, including marital status and many different types of benefits.) For the questions likely to be examined with the long-term macro model, such a case-by-case approach cannot be taken. The microsimulation technique outlined here provides a more automatic approach.

III. A Preview of One Set of Results

The simulations in section VI compare the baseline projections of OASDI taxes and benefits with the taxes and benefits under the three different employment and earnings scenarios mentioned in the introduction. This section, using the results from the first of these scenarios, describes the way the macro and micro parts of the model combine to form the estimates. The scenario examined here is one in which women's employment rates increase over 25 years, closing the current gap between women's and men's employment by 25 percent. Unlike the other scenarios that are examined later, the average earnings of employed women does not change from the baseline.

Employment

The estimates for the increase in employment, the increase in taxable payroll, and the increase in payroll taxes come straight from the macro model. Employment in the macro model is specified from an age-by-sex-by-year table of numbers of persons multiplied by an age-by-sex-by-year table of employment rates. In the baseline simulation, both the population and the employment rate are calibrated to intermediate projections. Under the alternative simulation, the population does not change, but the employment rate table is changed exogenously.

The simulation indicates that the number of employed women in the labor force would rise by about 5.4 percent relative to the baseline after 25 years. The men's labor force, as specified, does not change. The total employed labor force increases by 2.4 percent.

The national average wage index

The national average wage (NAW) index is calculated by the Social Security Administration each year and is a key figure in benefit calculations, because the overall level of benefits is scaled to the national average wage index two years before a beneficiary's year of eligibility for benefits. For retired worker beneficiaries, the year of eligibility is the year they turn 62, so their benefits are originally scaled to the national average wage index in the year they turn 60. (This scaling of benefits to the national average wage index is a consequence of the procedure for indexing the average earnings and of the simultaneous indexing of the benefit formula provisions. Benefits after age 62 continue to increase according to the consumer price index, rather than the national average wage.).[2]

The alternative simulation specifies not only that more women will enter the labor force but also that the earnings of women entering the labor force will be the same as the earnings of women already in the labor force at the same age and year. With women's earnings lower than men's, on average, this causes the national average index to fall. The reduction in the national average wage index, through its effect on the level of all future benefits, somewhat offsets the increase in benefits from the increase in women's earnings. It is conceivable that future widows benefits, because they are based on the deceased husbands' benefits, could fall, even though the widows' lifetime earnings had increased.

In the current implementation, the national average wage is calculated by the macro model, using an age-by-sex-by-year table of average annual earnings

[2]A reduction in the national average wage would also reduce the maximum taxable earnings, reducing payroll taxes from workers with earnings above the taxable maximum. This effect is not yet modeled.

that has been calibrated to produce, in the baseline specification, the intermediate projection of the national average wage. The national average wage index in any simulation year is the sum—over all the age-by-sex cells in that year— of the number employed times the average earnings, divided by the sum of the number employed.

The national average wage index in the first scenario simulation eventually declined by 0.6 percent from the baseline value. Because this decline in the wage index—through its effects on benefits—makes the benefit results difficult to interpret, the simulations have been run twice, first with the wage index held at its baseline value for the Social Security benefits calculations in the microsimulation (the "fixed NAW" simulation), and second with the wage index allowed to change from its baseline value according to the change in women's employment and earnings.

In the other scenarios that are considered in this paper, in which the average earnings of women is specified as closing some of the gap with men's earnings, the effect on the national average wage will run the other way: an increase in women's average earnings, if women's employment and men's employment and earnings stay constant, will unambiguously increase the national average wage index, which in itself will increase all future benefits. The simulation in which both women's employment and their average earnings increase will have a net increase in the national wage index. (If this last scenario had specified a larger employment change and a smaller earnings change, the net effect could have gone the other way.)

One important effect of an increase in women's employment is not simulated in this paper. An increase in women's employment, at the same time that it increases national output (reflected in the increase in aggregate earnings) will also have the macroeconomic effect of reducing all average earnings somewhat, moderating the increase in aggregate earnings. This macroeconomic effect on earnings would also affect the national average wage index and future benefits. Although the investigation of these macroeconomic feedbacks is the primary goal of the macro model, the feedbacks have been held at zero in this paper to keep the analysis simple while assessing the accuracy of the pre-feedback estimates.

It also should be noted that although the estimate of the change in the national average wage in this paper comes from the macro model, it could have been calculated from the micro model. The macro model estimate assumes that the women who are not in the labor force in the baseline simulation, but are in the labor force in the alternative simulation, have the same distribution of earnings as the women who are in the labor force in both simulations.

The micro model simulation of individual women's earnings histories specifies that some of the women in earlier cohorts who have many zero years of earnings correspond to simulation individuals in later cohorts with fewer years of earnings, with the gradual reduction in the number of years of zero earnings constrained in such a way that the aggregate employment rates from the micro model correspond to the aggregate employment rates in the macro model. When zero earnings at a given age for an early cohort individual are replaced with nonzero earnings at the same age for a late cohort individual, the nonzero earnings are imputed to be consistent with earnings at other ages for that individual. The distribution of these newly-imputed earnings does not necessarily match the distribution of the already existent earnings, and thus does not necessarily match the assumption in the macro model that the average new earnings equals the average already-existent earnings. If that is the case, then an estimate of the change in the national average wage from the micro model would be different from the change in the national average wage from the macro model and would lead to slightly different results.

The micro model simulation of women's earnings would be the natural vehicle for exploration of more complicated specifications of the relationship between women's work experience and their earnings.

In the current model, in the alternative scenario simulations to be described later, the increase in women's earnings by age, sex, and year is specified exogenously along with the increase in women's employment rates. It would be possible to specify, in the micro model, that a woman's earnings are in part a function of her years of experience in the work force, so that an increase in women's employment rates would have an endogenous effect on the earnings of women in the simulation. Such explorations, however, are well beyond the current state of the individual worker modeling.

Taxable payroll and payroll taxes

The estimate for the increase in taxable payroll comes straight from the macro model. A percentage increase in women's employment causes the same percentage increase in women's taxable payroll at each age, sex, and year under the assumption that average earnings in each age, sex, and year cell do not change. The overall increase in taxable payroll in a year is the sum of the increases within the age and sex cells in that year.[3] The payroll tax, equal to taxable payroll at the combined employer-employee OASDI payroll tax rate, increases in the same proportion.

In the simulation of the employment-only scenario, taxable payroll and

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[3]The actual macro modeling is more complicated, distinguishing compensation before and after fringe benefits, covered from noncovered employment, wage employment from self-employment, and covered earnings from earnings under the taxable maximum. But none of these are modeled separately by sex. The modeling therefore will not capture such effects as the possibility that average coverage characteristics at a given age and year might differ in the alternative simulation from the baseline simulation.

the payroll tax eventually increased by 1.86 percent.

Average indexed monthly earnings (AIME)

A key step in the calculation of a worker's retired-worker benefit is the calculation of the "average indexed monthly earnings" (AIME). To calculate a worker's AIME, all of the pre-age-60 earnings are indexed to age 60 using the national average wage index. Earnings at age 40, for example, are divided by the index from the year the worker turned 40 and multiplied by the index from the year the worker turned 60. The top 35 years of indexed earnings (including any unindexed earnings after age 60) are then averaged together and divided by 12 to get the AIME, which is fed into the benefit formula.

In the simulation, the calculation of the AIMEs is done entirely at the micro level, with changes in the individual AIMEs occurring as some zero years in the earnings histories are replaced by non-zero years. The eventual increase in the aggregate AIME among women approached 3.5 percent over the baseline. The overall increase in aggregate AIME (men and women) approached 1.1 percent over the baseline. The estimates include the effect of the change on the national average wage, which will have slightly decreased the AIME for both men and women.[4]

Retired Worker Benefits

The increase in aggregate worker benefits for women eventually approaches 2.4 percent over the baseline. (The increase to aggregate worker benefits for men and women combined approaches 0.8 percent.) The percentage increase in benefits is smaller than the percentage increase in AIMEs because of the progressivity of the benefit formula, which pays benefits proportional to AIMEs only at extremely low AIMEs.

The estimate of the percent increase in worker benefits at each age in each year comes entirely from the micro model. The estimate of aggregate benefits in the macro model includes both worker benefits and the auxiliary spouse and widow benefits. Although the proportion worker benefits in total benefits by age and sex can be tabulated for current beneficiaries from administrative data, this proportion would not apply to future beneficiaries because of, among other things, the changing proportion of two earner families. Even if an accurate baseline could be established for the projected future ratio of worker to total benefits, this proportion would have to be changed for each change in assumptions about growth in women's employment and earnings.

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[4]The aggregate AIME figure here is simply the sum of the individual AIMEs over all workers born in the same year. For women who did not have insured status in the baseline simulation because of a lack of insufficient quarters of covered earnings, the AIME was set to zero, even though they had positive earnings. If a positive AIME had been calculated and aggregated for these women, as well, the baseline AIME would have been higher and the percentage increase in AIME would have been lower.

Total benefits

The increase in total benefits to women, equal to the sum of the worker benefits and the auxiliary spouse or widow benefits, approaches 1.3 percent over the baseline. This increase is smaller than the increase in women's worker benefits, in part because women's worker benefits are only one component of total women's benefits, but more importantly because the remaining components actually fall when the women's worker benefits rise because of the dual entitlement reduction to women's spouse or widow benefits when their worker benefits increase. (The increase in total benefits, men's and women's, approaches 0.8 percent of the baseline.)

The estimate of the effect on total benefits combines the micro and the macro models. The macro model provides an estimate of total benefits by age and sex calibrated to the intermediate projections of OASI and DI benefits. The micro model provides an estimate of the increase in total benefits for each OASI cell in the form of the percentage increase of the alternative benefit over the baseline benefit for each cell. The macro model then assembles the alternative simulation estimates by multiplying the baseline macro model estimate for each cell by the percentage increase for that cell from the micro model.

Summary of 75-year effects

Long-term changes in OASDI taxes or benefits are often expressed as a ratio of the present-value sum of 75 years of change in the taxes or benefits to the present value sum of 75 years of taxable payroll. For this paper, all such measures will expressed as a ratio to the present value of 75 years of baseline taxable payroll, making the changes in taxes easier to interpret. (Otherwise, with the payroll tax rate constant over the 75-year period, there would be no change in the ratio of the 75-year summarized tax to the 75-year summarized taxable payroll.)

The increase in the summarized 75-year payroll tax was 0.17 percent of the baseline summarized taxable payroll. This increase is slightly less than 10 percent of the current estimate of the summarized 75-year actuarial deficit of 1.86 percent.

Summarizing the 75-year changes as a percent of taxable payroll under the scenario in which only the women's employment rate is increased:

Changes in Income and Costs Over 75-Years Under the Employment-Only Scenario

	Fixed NAW	Changing NAW
Income increase	0.18 %	0.18 %
Cost increase	0.09 %	0.00 %
Net change in balance	+ 0.10 %	+ 0.18%

In this scenario, the national average wage decreases as more women enter the labor force and ameliorates the benefit increase. In the scenarios in which the earnings of employed women close some of the gap with men's earnings, the national average wage will increase rather than decrease, leading to a larger—rather than a smaller—benefit increase, and a smaller, even negative, net change in the balance.

Caveats

These estimates require several caveats.

First, the modeling of benefits is incomplete. In the current implementation of the micro model, the benefit modeling is limited to old-age benefits. The younger OASI beneficiaries and all the DI beneficiaries are currently handled entirely within the macro model, which makes a rough estimate of the effect of a changing NAW on benefits but does not estimate the effect of changing earnings and employment patterns themselves. If DI beneficiaries and young survivors had been included in the micro modeling, there would have been some benefit increases not indicated here.

Second, the modeling of divorced spouses and of "early" widows (those widows whose spouses died before both had become entitled to benefits) shows only the increases in their own worker benefits, because the current microsimulation sample does not include histories of their spouses' earnings. For many such beneficiaries there actually would be no increase because of a larger spouse or widow benefit, so that the benefit increases modeled here are overestimated.

Third, the modeling of the changes in labor-force participation and earnings under changes in projected aggregates is still somewhat simple.[5]

Fourth, as already noted, macroeconomic feedback effects are not modeled. Increased labor force participation by women, because it increases the size of the labor force, should have an economic effect of reducing everyone's wages slightly, reducing both tax revenues and, with a lag, benefits. (This is a different effect from the effect discussed above of changing national average wages on the benefit formula.) An additional side effect of the larger labor force would be a rise in rate of return, including the interest rates earned by the trust funds. Although the macro model can estimate these effects, that side of the model has been turned off for the modeling exercises described here, both because the macroeconomic feedback part of the macro model is still being tightened up and because such feedbacks are not a part of the traditional actuarial balance sensitivity analyses and introduce a new layer of complication in interpreting the changes.[6]

All the shortcomings described above can be reduced or eliminated with further work. The focus in this initial work has been on developing a macromodeling framework within which the microsimulation contribution can evolve to the desired degree of accuracy. For reasons that will be given, the use of microsimulation as a means of developing estimates of changes in aggregates for input into a macro model often can get by with much less simulation detail than is needed in the use of microsimulation for distributional estimates. Once the framework is in place, exercises of the sort shown here will give some guidance for where the microsimulation component is most in need of further work for improving the macro modeling estimates.

IV. Employment and Earnings Trends and their Expected Effects

This section briefly describes past and projected trends in employment and earnings, including the three alternative scenarios that will be simulated. Most of the section is devoted to making rough calculations of the likely effect on OASDI taxes and benefits under the three scenarios. These rough estimates are important in assessing whether the simulation is performing as it should.

The most striking change in the labor force over the last several decades has been the increased participation of women at all ages and the higher earnings of the women who do participate. It is impossible for these trends to continue forever, and there are signs that the rate of increase has ebbed at some ages. The exact future trends are impossible to predict with any certainty.

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[5]Although the microsimulation modeling described here resembles the cohorts modeling of the Historical Cohort Model (HCM), the labor-force participation imputations in this model are not as sophisticated as those used in the HCM.
[6]To mention just one complication, calculation of summarized actuarial balances requires discounting with an interest rate, but with macroeconomic feedback the interest rate itself changes.

One approach to dealing with the uncertainty in future trends would be to assign a probability distribution to the possible trends, run the models many times for samples from this distribution, and take the average. The approach taken here is much simpler, since what we are interested in is not an accurate prediction of the average effect but an indication of how important it is to model the exact trend. For a sensitivity test, all that is needed are two or more trends representing a judicious selection from the range of possible trends. If the projections using the two selected trends show that the trust fund values are sensitive to the trend, two conclusions can be drawn. First, more research is justified into projecting the trends accurately. Second, users of the current projections need to be made aware of this uncertainty in the projections.

One of the two trends used in each sensitivity test is the intermediate projection made for the Trustees Report.[7] After slight adjustments in the first few years of the projection period, the intermediate projections hold age-by-sex participation rates constant at a value close to their most recently observed values. (There is a slight downward drift at some of the older ages.) This is the projection that might be selected if it were assumed that the trend to increased women's employment and earnings has pretty much run its course, so that, although the future employment rates are uncertain, they are as likely to fall as to rise.

The alternative projection in the employment-only scenario will use the concept of closing the gap between the sexes. At the beginning of the projection period, there is a gap at each age between women's and men's employment rates. The alternative projection simply assumes that some portion of this gap at each age will be gradually reduced over some specified number of years.

For the simulations in this paper, the gaps in employment and earnings in the year 2000 are narrowed over a 25-year period. For the employment-rate scenario (the one summarized in the preceding section), 25 percent of the employment rate gap is closed over 25 years. For the earnings-only scenario, 10 percent of the gap in average earnings among those employed is closed over 25 years. For the combination employment and earnings scenario, the two other specifications are combined: 25 percent of the employment rate gap and 10 percent of the average earnings gap is closed over a period of 25 years. The two ultimate closures — 25 percent of the employment rate and 10 percent of the average earnings — were chosen to give approximately equal effects on total earnings.

These specifications are simple enough to be easily applicable and structured enough to ensure against giving nonsense results. If it should turn out that it is important to model the projections more accurately, the women's employment rate projections could be given more structure, taking into account

[7]The participation rate projections have not yet been updated to the 2001 report.

for each cohort such explanatory variables as years of experience, marital status, and number of young children. More elaborate structural modeling of participation and earnings also would be appropriate for distributional modeling of the effects of labor force trends on benefits for particular types of families. For the present exercise, however, the simple gap closure specification is adequate.

Figure 1 shows the historical and projected labor-force participation rates for men (black) and women (gray) at selected ages. For the projected period both the baseline projection (solid) and the alternative projection (dotted) are shown. Only four ages are shown; for the simulation, participation rates from age 16 through age 70 are used.[8]

The specification used here — an equal closure of the employment and/or earnings gap at all ages — is easy to apply, but it is not the most realistic specification of the most likely possible variants. More realistic, but more complicated, approaches would take into account the fact that the ultimate gap, whatever it is, is likely to be approached at early ages before it is approached at later ages, since employment at later ages is a function, in part, of the experience of employment at earlier ages. If employment and earnings for 30-year-olds were to reach their final values this year, the full effect on the employment and earnings of 60-year-olds might not be felt for another 30 years.

The increase in women's labor-force participation can be expected to have several effects. There is the immediate effect on payroll tax revenues, which should increase almost in proportion to the increase in women's earnings. There is an effect through the national average wage index, which determines the overall future level of benefits being paid and affects the benefits of all workers, male and female. There is the effect on the women's retired worker benefits themselves, which should increase as the women's average lifetime earnings increase, but not proportionately. Finally, for those women who will receive spouse or widow benefits, there is a masking effect that offsets the increase in their worker benefits.

Some ballpark figures for women's employment and earnings

In the rest of this section, estimates of the effects of the specified changes in women's employment and earnings are calculated. The approximations assume that, at the start, women are 45 percent of the employed labor force and that the employed women earn, on average, 66 percent of what the employed men earn.[9] If there are approximately equal numbers of men and women, a 25

[8]The rates shown in Figure 1 are the annual averages of the monthly participation rates. A more appropriate rate for simulations using annual earnings would be the annual employment rate: the percentage of persons who had any income during the year.
[9]The figures 45 percent and 66 percent were chosen *after* running the simulations reported below. They are designed to give changes in labor force and earnings that are approximately the same as those seen in the simulations. I haven't checked how accurate the 45 and 66 percent figures are

percent closure of the gap between women's employment rates and men's would bring the women-to-men ratio in the employed labor force from 45:55, the pre-closure ratio, to 47.25:55, the post-closure ratio. The increase in women's employment from 45 to 47.5 is a 5.56 percent increase.

If the average earnings of employed women in the labor force is 66 percent of the average earnings of employed men (these annual earnings figures include all workers with some earnings, including part-time or part-year workers), then a 10 percent closure of the gap (the gap is 34 percent of men's earnings, 10 percent of which is 3.4) would bring women's earnings to 69.4 percent of men's, a 5.2 percent increase.

These figures, a 5.6 percent increase in employment and a 5.2 percent increase in earnings, are used throughout the estimates in the rest of this section.

If women are 45 percent of the employed labor force, and the employed women earn on average 66 percent of what the employed men earn, the women will receive about 35 percent of aggregate earnings (45 * 66 / [45 * 66 + 55 * 100] = 35.1).

Increase in employment

If women are 45 percent of all workers, then the 5.6 percent increase in women's employment will increase total employment by 45 percent of that, or about 2.5 percent.

Increase in aggregate earnings

If women's employment increases by 5.6 percent, but the average earnings of employed women does not change (the employment-only scenario), then a 5.6 percent increase in women's employment also will increase women's earnings by 5.6 percent.

The increase in total earnings, women's plus men's, will be smaller. If women's earnings are 35 percent of all earnings, then the increase in total earnings is 35 percent of the increase in women's earnings, or about 2.0 percent.

If women's employment does not increase but the average earnings of employed women increases by 5.2 percent (the earnings-only scenario), then their aggregate earnings also will increase by 5.2 percent. The increase in aggregate women's and men's earnings is 35 percent of this, or about 1.8 percent.

If women's employment increases by 5.6 percent and the average earnings of employed women increases by 5.2 percent (the combination scenario),

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themselves.

aggregate women's earnings will increase by 1.056*1.052 = 1.111, or 11.1 percent.

The increase in aggregate women's plus men's earnings will be slightly more than 35 percent of this, or about 3.9 percent.

Taxable Payroll and Payroll Tax Revenues

Any increase in earnings will lead to an almost proportionate increase in taxable payroll. (In actuality, the increase would be not quite proportionate, because increases in earnings above the maximum taxable earnings level will not increase the OASDI taxable payroll.) If payroll tax rates are kept constant, then the same proportionate increases will occur in payroll taxes. The approximate increases in aggregate women's and men's earnings from above will therefore also apply to aggregate taxable payroll and aggregate payroll tax revenue: a 2.0 percent increase under the employment-only scenario, a 1.8 percent increase under the earnings-only scenario, and a 3.9 percent increase if both earnings and employment increase.

National Average Wage Index

The increase in women's earnings also will affect the wage indexing series used to calibrate the level of payments in the OASDI system.

The average wage index is calculated by averaging together the annual earnings for all workers with non-zero earnings. To the extent that the distribution of earnings of women entering employment is lower than the distribution of workers already employed, the new workers will lower the average. The lower average wage will reduce the benefits of all subsequently eligible beneficiaries.

If women are 45 percent of the employed labor force and average women's non-zero earnings is 66 percent of the average non-zero male earnings, the combined national average earnings as a percent of the male average would be:

$$\{45 * 66 + 55 * 100\} / \{45 + 55\} = 84.70.$$

If the female employed labor force increases by 5.6 percent, but the average earnings stay at the same 66 percent of men's, the average earnings as a percent of male average earnings would then be:

$$\{1.056 * 45 * 66 + 55 * 100 \} / \{ 1.056 * 45 + 55 \} = 84.24.$$

This represents a 0.54 percent reduction in the national average wage.

If the female employed labor force stays at the same size but women's average annual earnings rise by 5.2 percent, the average wage would be:

$$\{45 * 1.052 * 66 + 55 * 100 \} / \{ 45 + 55 \} = 86.24.$$

This represents a 1.82 percent increase in the national average wage.

If both changes occur simultaneously, the average would be:

$$\{1.056 * 45 * 1.052 * 66 + 55 * 100 \} / \{ 1.056 * 45 + 55 \} = 85.83.$$

This represents a 1.34 percent increase in the national average wage.

How important is the decrease or increase in the national average wage? Because both the indexed average earnings and the bend points in the benefit formula are indexed to the national average wage two years before a beneficiary's year of eligibility, an increase of 1 percent in the national average wage will increase benefits by 1 percent for all beneficiaries who become eligible two or more years later than the national average wage increase. Since beneficiaries eligible before then are not affected by the wage increase, it takes some time for the increase in the national average wage to translate itself into a general increase in benefits, but eventually any given one-percent increase in the national average wage will work out to a one-percent increase in benefits.

If women, by returning in greater numbers to work, did actually lower the national average wage index, the effects could be paradoxical. Although the retired worker benefits that the returning women could now receive would rise, the effect of a smaller average wage on the husband's benefits of the married women would reduce the spouse benefits and widow benefits payable on the husbands' accounts. The net effect for many women of the return of women to the labor force would be a reduction in their total benefits.

It seems more likely that any negative effect on the national average wage from women's increased employment would be more than offset by the positive effect from the increase in their average earnings. For precise study of these questions, however, the macroeconomic effect of the enlarged labor force also have to be incorporated. Because this effect is not being calculated here, it should be remembered that only part of the picture is being presented.[10]

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[10]Under conventional Cobb-Douglas modeling of the production function, if labor income is about two-thirds of national income, then a 2 percent increase in the labor force would lead to an approximately 0.7 percent decrease in wage levels.

Women's AIME

An increase in employment without a change in average earnings will replace some years of zero earnings in individual histories with years of non-zero earnings. If the number of non-zero earnings years increased on average by 5 percent, then the AIME would increase by about 5 percent as well. However, the increase is likely to be less than 5 percent. Many women in the projection period will already have 35 years of non-zero earnings, so further reductions in their number of zero years will not affect their average. At the other end of the spectrum, some women do not have enough years of earnings to attain insured status, so any years of earnings added to their histories before they attain insured status will not affect the average AIME among insured women. The likely effect of a 5 percent increase in employment, therefore, would be something less than a 5 percent increase in AIME. We will use 3 percent just as a rough estimate.

An increase in average women's non-zero earnings with no increase in employment would have a proportionate effect on AIMEs for birth cohorts late enough to have experienced a full career of the higher earnings. A 5.2 percent increase in non-zero earnings will therefore translate into a 5.2 percent rise in AIMEs, at least in the latter part of the projection period.

The combined effect of an increase in employment and an increase in average non-zero earnings might therefore be on the order of the sum of the percentage increase in average non-zero earnings and half the percentage increase in employment. For our example values, a 5.6 percent increase in employment would increase women's AIMEs by about 3 percent; a 5.2 percent increase in women's earnings would increase their AIMEs by about 5 percent, and a combination of the two increases would increase women's AIMEs by about 8 percent.

Women's Retired Worker Benefits

A worker's average indexed monthly earnings (AIME) is translated into a "primary insurance amount" (PIA) using a three-bracket PIA formula.

In the bottom bracket of the PIA formula, in which the PIA is 90 percent of the AIME, a percentage change in the AIME translates into the same percentage change in retired worker benefits, even after allowing for early entitlement reductions. This, however, is the maximum effect on those who are already receiving worker benefits under the baseline. (For women who are uninsured under the baseline and insured under the alternative because only then do they work 10 years or more, the change in benefits, from zero to some positive amount, can't be given in percentage terms. These women will, however, contribute to the aggregate percentage change in retired worker benefits.)

In the second bracket of the PIA formula, each dollar increase in AIME increases the PIA by 32 cents. In percentage terms this translates into (calculations not shown here) a .36 percent increase in PIA for each percent increase in AIME at the bottom of the bracket and a .77 percent increase in PIA for each 1 percent increase in AIME at the top of the bracket.

In the third bracket of the PIA formula, each dollar increase in AIME increases the PIA by 15 cents. At the bottom of this bracket, a 1 percent increase in AIME increases PIA by .36 percent and rises slowly above that.

Each 1 percent rise in AIME, therefore, will average something less than a one percent rise in PIA (assuming that the effect of newly insured workers does not dominate). It is impossible to get a better fix on the aggregate increase in AIMEs without more knowledge of the distribution of women's AIMEs. The 3 percent, 5 percent, and 8 percent increases in AIMEs under, respectively, the employment-only, the earnings-only, and the combination scenarios, should lead to similar but somewhat smaller increases in women's retired worker benefits.

Women's Spouse and Widow Benefits

Many retired worker women beneficiaries who were married 10 or more years will be entitled to old-age spouse or widow benefits that are larger than their retired worker benefits. When women are receiving spouse or widow benefits, the total benefit received will be little affected or not at all affected by any small changes in the retired worker benefit: any increase in the retired worker benefit is offset by a reduction in the spouse or widow benefit, so that the total benefit remains the same. For widow benefits this is often exactly true. For spouse benefits with reductions for early entitlement, it is not exactly true, because the reduction applied to the retired worker portion of the benefit is slightly smaller than the reduction applied to the spouse portion, so that an increase in the worker portion reduces the overall reduction slightly.[11]

The determination of whether a retired worker can also receive spouse or widow benefits is made by comparing the PIA of the retired worker with the PIA of the other retired worker. A surviving worker will be eligible for a widow benefit based on the deceased worker's PIA if the surviving worker's PIA is less than the deceased worker's PIA. For workers of the same age, the surviving worker's PIA will be less than the deceased worker's PIA as long as the surviving worker's AIME is less than the deceased worker's AIME (some qualifications will be given below).

[11] The most important of the provisions affecting the calculations of retired worker, spouse, and widow benefits now and in the future are given in the appendix.

As long, therefore, as women's earnings tend to be less than their husbands', their PIAs will tend to be less than their husbands', and widows will tend to be eligible for widow benefits larger than their retired worker benefits. Even if perfect equality is approached on average, we would still expect to see about half the women have lower lifetime earnings and PIAs than their husbands and to therefore be eligible for widow benefits on their husbands' PIAs. (We would also, of course, expect to see half the men, if they survive as widowers, to receive widower benefits on their wives' PIAs.) That perfect equality, however, is far from being reached, so we can expect that under projections in which women continue to work less and receive less than men, considerably more than half the married women will be eligible as widows for widow benefits larger than their own retired worker benefits.

Two qualifications need to be mentioned. First, it is possible for a woman to have a smaller PIA than her deceased husband yet still take only a retired worker benefit. If the husband accepted benefits early but the wife postponed receiving any worker or spouse benefits to a later age than her husband's entitlement, then her own retired worker benefit, with its smaller reductions, could be larger than the widow benefit she would receive on her husband's account. These widows could receive no widow benefits even though their own PIAs might be smaller.

Second, wives tend to be younger than their husbands, and their AIMEs and PIAs are indexed to a later year, and benefit from several years more of real wage growth in the indexing. This indexing will increase the wives' PIAs by a few percent relative to their husbands', even if they had identical earnings year by year through their careers. The point of complete equality of average PIAs for women younger than their husbands would be arrived at when women still tend to have slightly lower earnings at each age.

Spouse benefits are more difficult to assess than widow benefits. The PIA rule for eligibility to spouse benefits is that a retired worker is eligible for spouse benefits on the account of another worker only if the retired worker's PIA is less than 50 percent of the other retired worker's PIA. Because of the progressivity of the PIA formula, when one worker's PIA is 50 percent of another worker's, the first worker's AIME can be considerably less than 50 percent of the other worker's AIME. Over a large range of lifetime earnings, a wife's PIA tends to approach 50 percent of her husband's when her AIME approaches about 30 percent of her husband's. Although most of today's retirees did not approach this level, many but not all of married women currently in the work force are likely to end up with AIMEs above this level. These women will receive retired worker benefits rather than spouse benefits. For the period in retirement during which their husbands survive, these women will receive total benefits that depend only on their own retired worker benefits. Once their husbands die, however, most of them will receive widow benefits on their husbands' accounts.

Overall, therefore, the effect of increased women's employment on women's worker benefits will translate into an increase in the actual total benefits they receive only for never-married women and for that growing portion of married or divorced women who receive worker benefits on their own account during the period of retirement in which their husbands are alive. For the remaining married or divorced women, and for most widows, the increased employment will have little effect on the total benefits they receive.

I have provided no rough calculations of the increase in total women's benefits after taking into account the masking of the increase in women's retired worker benefits by their larger spouse or widow benefits. Calculations from current retirees are not much guide to the proportions of future retirees who would be affected.[12] The effects in the future will be a complicated function not just of the distribution of women's earnings in the population relative to men's, but also on how the earnings are distributed for individual couples. This is a situation made to order for a microsimulation model. Although the future distribution of husbands' and wives' earnings is uncertain, a microsimulation model allows the effects on benefits conditional on a projected distribution to be calculated and thereby allows us to begin to explore the possible sizes of these effects and the sensitivity to the assumptions about future distributions.

Summarized 75-Year Changes in Taxable Payroll

If aggregate taxable payroll has increased after the first 25 years by 2 percent over the baseline taxable payroll, and if it remains 2 percent higher than the baseline payroll over the next 50 years, the overall increase in the summarized 75- year taxable payroll will be something less than 2 percent. If there were no present-value discounting in the calculation of the 75-year summary, we could estimate that the first 25 years average a 1 percent increase and that the final 50 years average a 2 percent increase, so that the average over 75 years would be about 1.7 percent. The present-value discounting, however, gives greater weight to the early years and reduces the increase in the discounted taxable payroll to somewhere less than 1.7 percent.

Summarizing for all three scenarios, the employment-only increase would increase the 75-year taxable payroll by something less than 1.7 percent, the earnings only increase (ultimately a 1.8 percent increase in taxable payroll) would increase the 75-year taxable payroll by something less than 1.5 percent, and the combination employment and earnings increase (3.9 percent) would increase the 75-year taxable payroll by something less than 2.9 percent.

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[12]Anyone attempting calculations for the current population from tables in the *Social Security Bulletin Annual Statistical Supplement* should bear in mind that in most of the tables, women who receive both retired worker benefits and spouse or widow benefits are classified as retired worker beneficiaries even though the size of their benefit is determined by their spouse or widow benefit.

75-Year Payroll Tax Revenues and Income Rates

With payroll tax rates assumed constant over the 75-year period, the percentage increases in the 75-year summarized taxable payroll translate into the same percentage increases in the 75-year summarized payroll tax revenues, namely something less than 1.7 percent for the employment-only scenario, something less than 1.5 percent for the earnings-only scenario, and something less than 2.9 percent for the employment-and-earnings scenario.

With the OASDI tax rate at 12.4 percent of taxable payroll, this means that the increase in the summarized 75-year payroll tax as a percent of the baseline taxable payroll will be about 12.4 percent of the percentage increase in the payroll tax. As a percentage of taxable payroll, therefore, the employment-only scenario should show an increase in taxes of something less than 0.21 of baseline taxable payroll, the earnings-only scenario something less than 0.19 percent of taxable payroll, and the combination scenario something less than 0.36 percent of taxable payroll.

These increases in the payroll tax of from 0.19 to 0.36 percent of taxable payroll are about 10 to 20 percent of the currently estimated 75-year summarized actuarial deficit of 1.86 percent of taxable payroll.

75-Year Benefit Expenses and the National Average Wage Index

The national average wage index was estimated above to fall by about half a percentage point under the employment-only scenario, to rise by about 1.8 percent under the earnings-only scenario, and to rise by about 1.3 percent under the combination scenario.

Over the 75-year projection period, benefits are about 15 percent of taxable payroll. A 1 percent increase in benefits, if it occurred immediately, would increase benefits to 15.15 percent of taxable payroll, an increase of 0.15 percent of taxable payroll. Because it takes time for a benefit increase to work itself out, the actual summarized 75-year effect would be something less than this.

Under the employment-only scenario, therefore, the 0.5 percent reduction in the national average wage would cause benefits as a percent of payroll to decline by something on the order of, but less than, 0.075 percent of payroll. The increase in the national average wage under the earnings-only scenario would cause benefits to increase over 75 years by something on the order of, but less than, 0.27 percent of payroll. The slightly smaller increase under the combination scenario would cause benefits over 75 years to increase by something on the order of, but less than, 0.20 percent of payroll.

These changes are small but not negligible. The smallest, the 0.075 percent of taxable payroll decrease under the employment-only scenario, is only about 4 percent of the currently-estimated 75-year actuarial deficit, but it reinforces, rather than offsets, the increase in taxes under that scenario. The largest, the up-to-0.27 percent of payroll increase under the earnings-only scenario, could more than offset the 0.19 percent of payroll increase in payroll tax revenues. The up-to-0.20 percent of payroll increase in the combination scenario would offset some of the 0.36 percent of payroll increase in payroll taxes.

Summarized 75-year changes in benefits

It was estimated above that AIMEs for women might rise by about 3 percent under the employment-only scenario, about 5 percent under the earnings-only scenario, and about 8 percent under the combination scenario, and that women's retired worker benefits would rise by some hard-to-determine smaller amounts.

We can use these estimates to set very rough upper bounds on the possible 75-year effects on benefits. Women's benefits are about 50 percent of total benefits. If total benefits are estimated to be about 15 percent of taxable payroll over 75 years, then women's benefits are about 7.5 percent of taxable payroll. If women's retired worker benefits rose proportionately to AIMEs, and if women's benefits were made entirely of retired worker benefits, then the 3 percent, 5 percent, and 8 percent increases in AIMEs would translate into percentages of 75-year baseline taxable payroll of 0.22, 0.38, and 0.60, respectively.

The actual increases, however, certainly would be less. Most of the benefits paid to widows and many of the benefits paid to spouses will mask the increase in the women's worker benefits. The full effect of the increases that do occur, furthermore, won't be felt until well into the 75-year projection period. Women who are 21 in 2035 and will have a full career of higher earnings under the alternative scenarios won't reach 62 until 2076, just after the end of the 75-year period. This lag alone might more than halve the 75-year effect once discounting is taken into account. The upper bounds for the three scenarios are therefore probably safely less than 0.11, 0.19, and 0.30 percent of 75-year baseline taxable payroll.

The calculations made in this section are summarized in Table 1 (for the percentage increase in the eventual effect) and Table 2 (for the summarized effects over 75 years as a percentage of summarized taxable payroll).

Table 1: Summary of Approximate End-of-Period Effects

	Percent Changes From Baseline		
	Employment Only	**Earnings Only**	**Combination**
Ultimate employment			
Women's	5.6%	0%	5.6%
Total	2.5	0	2.5
Ultimate taxable payroll			
Women's	5.6	5.2	11.1
Total	2.0	1.8	3.9
Ultimate payroll taxes			
Total	2.0	1.8	3.9
Women's AIMEs	~3	~5	~8
Women's Worker benefits	<3	<5	<8
Total benefits, women	<<3	<<5	<<8

Table 2: Summarized 75-Year Effects (relative to baseline taxable payroll)

	Percent of 75-Year Baseline Payroll		
	Employment Only	**Earnings Only**	**Combination**
Taxable payroll	1.7%	1.5	2.9
Payroll tax	0.21	0.19	0.36
Benefits	<0.11	<0.19	<0.30
Effect of NAW	-0.075	0.27	0.20
Net income	> 0	< 0	??

The net effect in the last row of Table 2 takes taxes as positive, benefits as negative, and the effect through changing the NAW as adding to benefits. Under the first scenario, the 0.21 percent increase in the payroll tax is reinforced by the 0.07 percent reduction in benefits from the national average wage decrease, which is more than enough to offset the increase in benefits of something less than 0.11. Under the earnings-only scenario, the large increase in benefits from the increase in the national average wage, together with whatever increase in benefits is not masked by spouse and widow benefits, is more than enough to offset the increase in payroll taxes, leading to a net increase in costs. The combination scenario is indeterminate: There is a large increase in payroll taxes, 0.36 percent of baseline payroll, which is more than enough to offset the fairly large increase in benefits from the national average wage increase, 0.20 percent of payroll. The net income after these two effects, however, could be more than offset by the increase in women's benefits, which is some unknown amount less than 0.30 percent of baseline payroll.

This is about as far as we can get with this level of analysis. More refined analysis of published data and tabulations of unpublished data would allow us to narrow the bounds of some of the effects and extrapolate them into the future. The Office of the Chief Actuary, given its tool bag of expert techniques and a few days to work on the problem, could come up with very precise estimates for each year over the 75-year period. For the macro modeling, however, we need something in between: much more detailed than the preliminary analysis above, but calculated more automatically, even if not as accurately, than the estimates that could be provided by the Office of the Chief Actuary. The solution is microsimulation.

V. The Microsimulation Model

The microsimulation model is built around a sample of workers and (for some workers) their spouses, representing a single birth cohort of workers and spouses.

The sample data contains life histories of earnings for each worker and spouse and sampling weights that allow tabulations from the sample to be aggregated into aggregate estimates for the whole birth cohort. Although the original sample represents a specific birth cohort of workers, if the data in the sample can be transformed systematically to represent the expected changes in the data in other birth cohorts, and if the sampling weights can be adjusted to represent changes in birth cohort sizes, the original cohort sample—successively transformed into birth cohort after birth cohort—can be used to build up calendar-year estimates of benefit and tax aggregates.

Because the sample is of individual workers, the Social Security benefit provisions can be applied to each worker (and couple) in the sample exactly as they are applied to real individuals, indexing the earnings histories, selecting the top 35 years of earnings, calculating the AIME and PIA, determining the spouse or widow benefits, and applying the early entitlement and dual entitlement reductions. The provisions, furthermore, can change from cohort to cohort exactly as current provisions are scheduled to change, or can be altered for specific cohorts exactly as proposed provisions are altered under alternative policy proposals. For the type of scenario being analyzed in this paper, in which it is the underlying employment trends and not the provisions that are being altered, the changes in the number of years of employment or in the average earnings employed will alter the current-law worker and spouse benefits in the changing cohort sample data just as the current-law benefits would change in a real population as the employment and earnings data changed.

The Basis Sample

The microsimulation component of the macro model is built around a sample of earnings histories meant to represent a single-year birth cohort of workers. This sample is referred to as the basis. The basis can be constructed in several different ways, but it ideally should possess several basic criteria, not all of which are met by the current sample.

First, the basis should be representative of the actual variability in the population of workers and their earnings histories. One way to get a representative basis is to sample worker life histories of earnings from the population. Another is to make use of regression studies of earnings histories and to generate simulated samples by adding simulated error terms to regression-predicted earnings histories.

Regression studies themselves require earnings histories, but if the sample is limited to partial career earnings histories (some start at age 16 but don't show the ends of the careers, and some end at retirement but don't show beginnings of careers), regression analysis provides one method of constructing complete-career earnings histories. Complete histories can also be constructed through splicing together partial-career histories with matching techniques.

Second, the basis should include earnings histories of spouses. The more complete the representation of spouses, the better. The lowest requirement for current-law analysis would be the earnings histories of the spouse in any marriage from which spouse or widow benefits would be paid. For current law analysis, this includes any marriage lasting at least 10 years. More complete basis information would include the earnings histories from shorter marriages, even those which don't pay benefits, and the starting and ending date of the marriages—information which is needed for simulating some alternative benefit proposals.

Third, the basis sample should include a representation of the disability experience of workers sufficient for simulating the DI component of OASDI benefits. It also should include a representation of workers who die before reaching retirement age, a representation that should be correlated appropriately with the disability sample.

Fourth, the basis should include members of the birth cohort that were born in other countries and immigrated to the U.S. These workers contribute taxes during some portion of their careers, and many of them receive benefits when they retire.

The basis sample used in the macro model at its current state of development is taken from a sample of workers taking old-age benefits or reaching age 70 (if later) in 1992. For a married worker, eligibility for the sample is determined by the year in which both the worker and the spouse have either accepted old-age benefits or reached age 70: if that year was 1992, the couple was included in the sample. Individual workers and couples selected in this way have one member of the couple born in 1930 or not much longer before then. For those who are not born in 1930, the data is transformed slightly to make the sampled workers look like they were born in 1930 and accepted old-age benefits in a later year than 1992. Couples are put into the basis sample twice: once as a male born in 1930 married to a female typically born later than 1930, and the other as a female born in 1930 married to a male typically born earlier than 1930. Except for couples born in the same year, this requires two sets of transformations to the 1930 birth year.

The current basis sample does not possess all the desired criteria listed above. It is missing workers who died before entitlement. (The taxes will be missing for these workers as well as the disability benefits that some of them might have received.) For workers who are divorced at entitlement, the earnings of their divorced spouses are not available. (The divorced spouse benefits are needed for those divorced persons, usually female, whose ex-spouses' average lifetime earnings were more than about three times their own average lifetime earnings.) For workers married at entitlement, only the earnings of the most recent spouse are available. (This is usually sufficient for current law analysis but does not cover the cases of long marriages followed by divorce and remarriage.)

For widows already widowed when they first become entitled ("early widows"), the earnings of their deceased spouses are not available. (By giving these early widows only their own worker benefit rather than the typically larger widow benefit that would be paid from their husbands' earnings, their benefits are underestimated. The change in their benefits if they work more is overestimated.)

Although the data set from which the basis sample was drawn includes disability entitlement information, that information was not used, and these workers are excluded from the current basis. They will be included once a sample of disabled workers who die before reaching old-age entitlement can be included.

The current basis sample does include immigrants. Their earnings records show zeroes for the years before they immigrated, and the individual taxes and benefits calculated for them will be accurate, but the lack of an indication of their immigrant status and the year in which they immigrated creates slight problems for the calibration of the micro model to employment aggregates.

All of these problems can be alleviated with further work on the basis sample. The most pressing is the development of a disability and early death sample, probably in a one-for-one match with a sample like the current basis sample. Using age-by-sex-by-year mortality tables, the probability of surviving into the current basis sample can be calculated. (These probability tables are currently used for simulating dates of death conditional on survival into the sample for each individual or couple in the sample.) For each such unit in the sample, one or more cases in which the worker or couple did not survive into the sample also can be calculated and given an appropriately-adjusted weight.[13]

Cohort Re-expression

The basis sample represents only one birth cohort accurately. For long term modeling, the cohort needs to be "re-expressed," or systematically altered to reflect other birth cohorts. The re-expression is applied to several demographic and economic variables.

Cohort Size

The simplest such re-expression is the adjustment of the cohort size, which is carried out for a fixed sample size simply by adjusting each sample weight in the sample basis by a ratio calculated from exogenous projections of the cohort birth size. The OCACT intermediate projections of the age-zero population are used for this adjustment.[14]

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[13]Suppose, for example, that a particular unit with a sampling weight of 1,000 accepts benefits when the male is 65 and the female is 62, and that calculations for the appropriate birth cohort indicate that such a couple would have had a 90 percent chance of surviving to that point. An additional unit or units would be created in which one or both members of the couple dies before that point. The weight or sum of weights for these new units would be 1,000*0.1/0.9, or 111.1. The "early widows" that are included in the current sample would under such a procedure be simulated as part of the deceased worker sample.
A procedure in which the extra basis sample is to include both disability cases and early deaths would be more complicated in that the relevant probability is the probability of surviving to entitlement without any disability episodes.
[14]These adjustments are not quite correct, since the U.S. age-zero population is used to determine the

Length of Lifetime

Almost as basic is the re-expression of the cohort to reflect declining mortality and increasing lifetimes. As already mentioned, for each individual in the basis sample, an age at death is simulated using cohort-specific mortality rates, taking into account the fact that the person or couple has survived to retirement. Each time the basis sample is transformed into another birth cohort, the age at death is resimulated for each person in the basis sample, using the appropriate projected cohort mortality rates, taking into account both the greater likelihood of surviving to retirement (which changes the sampling weight of the simulation unit) and the longer lifetime conditional on having survived to retirement (which increases the simulated age at death).

When the basis sample is expanded to include an early death sample, the weights on the early death units will decrease in later birth cohorts, reflecting the smaller probability of dying before reaching retirement.

Labor Force Participation

Because the current model is based on a sample of annual covered earnings, the observable employment concept in the microsimulation model is the annual covered employment rate (the percentage of workers with some covered employment during the year), which is not quite the same as the labor-force participation rate (the annual average of monthly participation rates, which includes non-covered employment and also persons looking for work, as well as persons actually working). The re-expression by cohort is applied using projected labor-force participation rates, rather than covered employment rates, so there is a slight conceptual mismatch. (The largest divergence in the two rates is for school-age workers.) It is not known how much of the discrepancy is ironed out through calibration.

The current implementation of the labor force participation re-expression is almost the simplest possible. In the basis sample, a standard normal random number is assigned at each age for each worker and spouse in the basis sample. The assignment is done conditional on the observed employment: At those ages at which a worker is observed to have covered earnings, the assigned random number is constrained to be positive. At those years in which the worker is observed to have no covered earnings, the assigned random number is constrained to be negative.

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ratios, rather than the slightly larger group that includes persons who will later immigrate to the U.S. Implicit in the use of the U.S. births is that the immigrant age structure will maintain a constant proportion to the national age structure.

For each age-sex-year cell over the period of the simulation, an adjustment factor is calculated that, when added to the random number for all workers in that cell, will cause the weighted proportion of adjusted random numbers to equal the target participation rate for that age, sex, and year.

The effect of this procedure under the simulation of increasing employment rates is that for all years in which an individual was observed to be employed in the original sample, employment will be observed in the projected sample. For the remaining years in which no earnings were observed in the original sample, more and more years will be given nonzero earnings in the projected sample.

For years that have zero earnings in the observed sample but that might be re-expressed as having non-zero earnings, an imputed earnings value needs to be supplied. In the current implementation, a simple imputation is used, making use of both the worker's average nonzero observed earnings and, when there are observed earnings on both sides of a gap in earnings, of an interpolation between the observed earnings on each side of the gap.

Nonzero Earnings

Earnings for each age-sex-year cell in the historical period are adjusted to match the patterns observed in tabulations of administrative data on earnings from 1951 through 1993. The 1993 pattern then is continued through the projection period.

In the baseline simulation, an overall wage index is calculated and calibrated in such a way that the national average wage index in the baseline grows at its projected rate under the intermediate projection. The growth in this baseline index varies around that of the national wage index because of the changing composition of the labor force. (In macroeconomic feedback modeling, in which changes in national saving change the average level of earnings, this overall wage index is the vehicle for transmitting feedback effects on wages to the age-year cells in the macro model and to the individual earnings histories in the micro model.)

Finally, in the non-baseline simulations the earnings for each age-sex-year cell in the projection period can be altered systematically using multiplicative adjustment factors that, over a specified period, will close a specified portion of the gap between male and female earnings at each age over a specified period.

Marriage Histories

Marriage histories are not re-expressed in the current implementation. (The initial basis sample is adjusted slightly through reweighting so that the proportions of never-married, married, divorced, and widowed persons in the sample match those in the population in the mid-1990s.) Later implementations will, once procedures have been worked out, allow a proportion of workers who are married in the current sample to have their marriage histories altered so that they either remain never-married or become divorced.

The Tax and Benefit Simulation

Part of the re-expression of each cohort's earnings includes the recalculation of each worker's total compensation to reflect aggregate growth in compensation. Nominal earnings are calculated from the worker's total compensation history by subtracting an adjustment for fringe benefits and subtracting the employer contribution for OASDHI taxes.

After checking for insured status, the resulting nominal earnings history is converted into an average indexed monthly earnings (AIME) using the procedures of current law (earnings before age 60 are indexed using the national average wage series, the indexed earnings then are sorted, and the highest earnings are averaged and divided by 12 to get the AIME). The benefit formula for the appropriate year of eligibility then is used to calculate the primary insurance amount (PIA) in the year of eligibility. This PIA—reduced, if necessary, for early entitlement—becomes the retired worker benefit for each worker, and a series of cost-of-living adjustment (COLA) indexed benefits from the year of eligibility to death is calculated.

For couples, the PIA for each member of the couple is COLA indexed to the year in which both are first entitled to benefits, and the appropriate comparisons of PIAs are made to determine the eligibility, and if eligible, the amounts, of the possible spouse and widow benefits. The benefits then are reduced, when appropriate, for early entitlement and for dual entitlement and COLA indexed through each year of remaining lifetime for both members, with spouse benefits (when appropriate) paid until one of the workers dies. If the higher PIA worker dies first, widow(er) benefits are paid for the survivor's remaining lifetime.

Both the taxes by age and the benefits by age are tabulated into age by sex cells for each simulation birth cohort and aggregated into calendar year cells across the overlapping birth cohorts.

Sequencing and Other Implementation Details

The birth cohort approach allows great flexibility in the basis sample size and in the use of interpolation between birth cohorts. The current test sample used for model development has 691 sample units (individuals or couples) in the basis sample. All numbers reported in this paper use the full 691 units, but it is easy to direct the simulation to use smaller samples, and much of the model development has been carried out with a sample size of 200.

The computer code also has been written so that the program can be directed to simulate every birth cohort by single year of birth or, alternatively, to skip birth cohorts, simulating every fifth or tenth birth cohort, interpolating the intervening cohorts at the end of the microsimulation before calculating the calendar year aggregates. Again, all the numbers used in this paper are from the every-year simulation, but much of the development has been carried out using every 10th birth cohort and interpolating. For the current uses of the model, this ability to shorten the simulation time is more convenient than it is necessary[15]; but for possible future uses of the model, involving repeated stochastic simulations or iteration to convergence the ability to shorten the time might be critical.

The current sequencing between the macro model and the micro model in a model run is as follows. ("Simulation" here refers to the baseline and each of the alternative scenarios being carried out in a single model run. In the runs described in this paper there is for each model run a baseline simulation and three alternative simulations.)

- The whole macro model baseline simulation is carried out, establishing baseline values for population cells (which do not vary by assumption) and establishing baseline values for wage growth, the national wage index, a CPI index, and other time series that are needed in the micro simulation. A preliminary portion of the macro model also is carried out for each separate simulation being run, establishing employment by cell and calculating a national wage index for each simulation.

[15]The simulation times depend on the number of policies or assumptions being compared and on how much output is being written by the simulation. On the day this footnote was written, the simulations for baseline and three alternatives extended from calendar year 1937 through calendar year 2100, requiring 264 birth cohorts from 1837 (aged 100 at the beginning of the simulation) through 2100 (aged zero at the end of the simulation). Each full set of simulations took 4 minutes and 25 seconds. (There were two such sets, one with the fixed NAW and one with the changing NAW.) If the macro model was run on the same four simulations in stand-alone mode, without the microsimulation, it took 45 seconds.

- The micro model then is carried out for each simulation, using the wage and price indexes from the baseline macro model for the microsimulation computations. The results from the simulation of each basis unit in each simulation cohort are tabulated in the computer memory as the simulation is carried out.

- At the end of each alternative simulation, the micro model aggregates are compared with the aggregates from the baseline micro model simulation, and the appropriate ratios of alternative to baseline for each age-year cell are saved for use by the macro model.

- The alternative simulations are then run for the macro model, using, for the OASI benefit calculations, the baseline values for each age-year cell from the earlier baseline run, multiplied by the ratios for the corresponding cells of alternative to baseline calculated by the micro model.

The macro model can also be run as a stand-alone unit, skipping the micro model calculations and using its own estimates of age and year cell values. (This is currently the procedure used for the DI program, for which the micro model simulation has not been implemented.)

There are alternative ways of threading these simulations together. The micro model currently can be done one whole cohort at a time, simulating all the basis units under one birth cohort before moving on to the next cohort, or one basis unit at a time, simulating all birth cohort re-expressions for a given basis unit before moving on to the next basis unit. The alternative simulations are currently carried out one at a time, simulating the baseline for all units and cohorts before moving on to each alternative simulation for all basis units and cohorts, but it also can be set up do the baseline simulation and all the alternatives for each unit before moving on to the next unit or birth cohort. The latter sort of thread allows the effects on individuals of different policies to be compared and tabulated, which, while sometimes important for distributional analyses, is not of much use for macro modeling. A thread that carries out for each calendar year the simulation for all units in all birth cohorts alive in that year before moving on to the next calendar year has not been implemented yet. Such a thread would be more analogous to microsimulation models like Dynasim and Corsim but would make greater demands on computer storage and processing.

VI. Sensitivity Exercise

The earlier discussions allow us to move fairly quickly through the simulations of the three alternative scenarios. In order to isolate the effects that operate through the effect of changing women's employment and earnings on the national average wage (NAW), the alternative simulations were run twice, one set with the NAW held fixed at its baseline value for the calculation of OASDI benefits, and the other set with the NAW in the benefit calculation changing according to the change in women's employment and earnings.

The following table (Table 3) gives the percentage change from the baseline value for several of the key variables. The benefits in this table are OASI benefits for beneficiaries over age 62, all estimated in the micro model.

Table 3: Percentage Changes in End-of-Period Values

	Percent Changes From Baseline		
	Employment Only	**Earnings Only**	**Combination**
Ultimate employment			
Women's	5.38%	0%	5.38%
Total	2.42	0	2.42
Ultimate taxable payroll			
Women's	5.36	5.46	11.13
Total	1.85	1.89	3.85
Ultimate payroll taxes			
Total	1.85	1.89	3.85
Ultimate NAW	-0.6	1.9	1.4
Women's AIME	3.48	5.44	9.14
Worker benefits (fixed NAW)			
Women	2.66	3.24	5.95
Total	1.09	1.33	2.45
Total benefits (fixed NAW)			
Women	1.55	1.68	3.40
Total	0.85	0.83	1.27
Worker benefits			
Women	2.43	4.01	6.55
Total	0.84	2.19	3.09
Total benefits			
Women	1.31	2.48	4.01
Total	0.60	1.69	1.91

Comparing these numbers with the approximate calculations given earlier, the growth in women's taxable payroll, which had been estimated to be, under the respective scenarios, 5.6 percent, 5.2 percent, and 11.1 percent, is approximately as predicted, at 5.36 percent, 5.46 percent, and 11.13 percent. (The assumptions behind the earlier approximations were, as mentioned then, selected with an eye to making these particular comparisons come out about right.) The increase in total payroll and in payroll taxes, 1.85 percent, 1.89 percent, and 3.85 percent, are also close to the estimates of 2.0 percent, 1.8 percent, and 3.9 percent.

The payroll and tax estimates are generated entirely by the macro model. The first estimates requiring the microsimulation model are those for the percent increase in women's AIMEs. The earlier estimates were very rough approximations, 3 percent, 5 percent, and 8 percent. The simulation gives 3.48 percent, 5.44 percent, and 9.14 percent, respectively.

The earlier approximations were not able to say anything beyond this except that the AIME increases placed an upper bound on the women's worker benefit increases and that the women's worker benefit increases placed an upper bound on the women's total benefit increases. The simulations observe these bounds, and allow us to calculate some percentages. Using the fixed-NAW simulations, which are not clouded by the simultaneous effect on benefit levels of a changing NAW, the ratio between the percentage increase in women's AIMEs and the percentage increase in women's worker benefits is, in the three scenarios, 0.76, 0.60, and 0.65, i.e., in the range of 60 to 76 percent. The ratio between the increase in women's total benefits and the increase in women's worker benefits, again using the fixed-NAW simulations, is 0.58, 0.52, and 0.57, i.e., in the 50 percent to 60 percent range.

Table 4 gives the changes in summarized values as a percent of taxable payroll. The benefits in this table are OASDI benefits. (DI benefits and the pre-62 OASI benefits are estimated by the macro model. The estimates for these components of benefits not directly affected by the change in women's earnings and employment, although they do include estimates of the effect of the changing NAW.) Payroll taxes are not shown directly in the table, but are included in the row for income, which includes revenues from the income taxation of benefits (and hence rise or fall slightly when benefits themselves rise or fall). Similarly, benefits are not shown directly, but are included under costs, which include administrative and other expenditures.

Table 4: Summarized 75-year Effects Relative to Baseline Taxable Payroll

	Employment Only	Earnings Only	Combination
Income (fixed NAW)	+0.18%	+0.18%	+0.37%
Income	+0.17%	+0.19%	+0.38%
Costs (fixed NAW)	+0.07%	+0.05%	+0.11%
Costs	-0.01%	+0.36%	+0.34%
Effect of NAW on costs	-0.08	+0.31	+0.23
Net change (fixed NAW)	+0.11%	+0.14%	+0.28%
Net change	+0.20%	-0.16%	+0.06%

The effect of the national average wage (NAW) is calculated here as the difference in the change in costs in the run in which the NAW was allowed to vary from the costs when the NAW in the benefit calculation was held fixed at its baseline value. There are actually slight additional differences (showing up in the two rows for income rates given in the table) having to do with the effect of the change in benefits on the income taxation of benefits.

The payroll tax and national average wage effects are pleasingly close to the approximate effects that were calculated above. The payroll tax increases, estimated earlier to be 0.21, 0.19, and 0.36 of taxable payroll, here turn out to be 0.17 percent, 0.19 percent, and 0.38 percent of taxable payroll. The effect of the national average wage change on benefits, estimated earlier to be about -0.075 percent, 0.27 percent, and 0.20 percent of taxable payroll, are simulated as -0.08 percent, 0.31 percent, and 0.23 percent of taxable payroll.

The line for "Costs (fixed NAW)" is conceptually closest to the estimate we were looking for of the change in worker benefits masked by the spouse and widow benefits. The earlier analysis had indicated that these should be less than 0.11 percent, 0.19 percent, and 0.30 percent of taxable payroll. The simulation estimates are 0.07 percent, 0.05 percent, and 0.11 percent of taxable payroll. These are, as expected, less than the bounds that had been estimated, with ratios to the bounds of, respectively, 64 percent, 26 percent, and 37 percent.

It is not clear why the latter two ratios are low compared to the first. The simulation output used here, percentage changes in ultimate values and changes as a percent of payroll, is not the best for a detailed assessment of the masking effect of spouse and widow benefits on women's retired worker benefits. A more detailed simulation output, to be produced in future work, will allow more focus on the three components of women's benefits, namely the retired worker benefit, the excess spouse benefit for those who have spouse benefits, and the excess widow benefits for those who have widow benefits, following the changes in these components over time under the alternative scenarios. Until this more detailed output is developed, this portion of the microsimulation model remains something of a black box.

Comparison With Trustees Report Sensitivity Analyses

The 75-year effects as a percent of taxable payroll in the three scenarios estimated here range from -0.16 percent to +0.20 percent. These can be compared with the sensitivity tests published in the 2001 Trustees Report. The effects estimated here are much smaller than the sensitivity to mortality assumptions (about 0.70), real rate of return assumptions (about 0.65), and real wage growth (0.50). They are somewhat smaller than the sensitivity to fertility assumptions (0.28) and disability incidence (0.28). They are similar to the sensitivity to price growth (0.22) and immigration (0.14).

The ranges of assumptions in these tests are selected to give an indication of possible variations, and are not necessarily scaled to each other terms of the probability of occurrence. Different choices of the range of assumptions would give different ranges in the sensitivity tests. In the scenarios simulated here, for example, if a 10 percent closure in the employment gap had been selected, the effects estimated in the first scenario would have been smaller. If a 25 percent closure in the earnings gap had been selected for the second and third scenarios, the estimated effects would have been larger. Readers will have to judge whether the selected scenarios are at the best distance from the baseline to give a reasonable indication of a likely variation. Women's employment and earnings have risen considerably more in the past 35 years than they are simulated to rise here in the next 35 years. On the other hand, the gap between men's and women's employment can't be closed as much in the next 35 years as it has closed in the last 35: there isn't enough gap left. The most potential for continued change seems to be not in employment relative to men's but in earnings relative to men's. The increase simulated here was equivalent to an increase in average women's earnings from 66 percent of men's to 69.4 percent. It is conceivable that it could go higher.

VII. Future Directions and Discussion

The goals of the microsimulation modeling described here are subordinate to the goal of developing a more accurate macro model. The further refinement of the embedded microsimulation model will to some extent depend on sensitivity tests. If a preliminary test indicates that the macromodeling is quite sensitive to the specification of a particular component of the micro model, resources can be devoted to making that component more accurate. If the test indicates that the macro model is fairly robust to changes in the micro specification, then further development of that specification can be postponed in favor of the more pressing needs of the macro model development.

As was indicated earlier, there are several parts of the micro model implementation that need to be completed before the framework can be considered complete.

- The basis sample needs to be augmented with a sample of workers who experience death or disability before old-age entitlement. (The macro model currently simulates DI benefits and the young survivors component of OASI benefits without any help from the micro model.) This basis sample of disabled and early decedent workers needs to be designed in such a way that the sample can be re-expressed with a changing history of disability incidence and recovery and with declining mortality over time.

- Divorced spouses and early widows in the current implementation need imputations for the work histories of their ex- or deceased spouses. In addition, procedures have to be developed for imputing and re-expressing marital histories to simulate some multiple marriages and to allow projections of fewer marriages and more divorces to be simulated.

Once these gaps in the framework have been closed, there is plenty of scope for refining the existing components of the model.

Meanwhile, the framework that has been developed so far has performed as hoped. The hybrid macro/micro model develops its micro estimates automatically. The model development, for example, was carried out entirely under the first scenario. The second scenario and the combination scenario were added only when development was complete, and they generated their simulations without a hitch.

Finally, a discussion—not of the model, but of one of the results—turned up in this paper. It was expected when this project was started that a large portion of the increase in women's worker benefits from an increase in women's employment and earnings would be masked by their spouse and widow benefits. The tendency of payroll tax revenues to increase more than benefits, thus generating net income to the trust fund, therefore would be reinforced by the masking of some of the benefit increases. An unexpected result was the effect that runs through the national average wage. As women's earnings rise, holding their employment rates constant, the national average wage increases, increasing benefits for everybody under the current indexing rules. As a result, the increase in women's earnings can have the effect of increasing, rather than decreasing, the actuarial deficit.

The fact that the actuarial balance is a bit sensitive to the average wage index points to the importance of being able to model endogenous changes in average wages. These effects have been turned off in the simulations explored in this paper, but they would tend to reinforce the average wage indexing effects from the increase in employment in the first two scenarios.

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Appendix

Summary of Dual-Entitlement Benefit Provisions

The rules for spouse and widow benefits can become quite complicated when retired workers or their spouses have accepted benefits before normal retirement age (NRA) and when the spouse or widow is also entitled to her own worker benefits. These complications are described here, but to keep things simple, some of the rarer combinations will be left out. The focus will be on old-age benefits, to which workers become entitled whenever they apply for benefits after reaching age 62, and to which spouses of workers become entitled as soon as the worker is entitled and the spouse has reached age 62 and applied for benefits.[16] Widows of deceased workers can become entitled as early as age 60.

When an insured worker dies or becomes entitled to retired worker benefits, a "primary insurance amount" (PIA) is calculated that determines the worker's benefit and any spouse or widow benefits paid on that worker's account. The requirement for insurance for old-age benefits is 40 quarters of coverage, which will have been earned by many workers by the time they have 10 years of earnings.

It was at one time quite common for the female spouses of male retired workers to not have enough years of earnings to receive their own retired worker benefit. In the future, dual insurance will be the norm, and both members of a couple will have their own PIAs.

If an eligible spouse of a retired worker has no PIA or has a PIA of less than 50 percent of the retired worker's PIA, the spouse is eligible for a spouse benefit based on 50 percent of the retired worker's PIA. This basic screen means that not more than one, and often neither, member of a couple can receive spouse benefits on the other member's account.[17]

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[16]Divorced spouses with at least 10 years of marriage to the retired worker also become eligible when both they and the retired worker have reached age 62. A divorced spouse does not have to wait until the retired worker applies for benefits.

[17]The PIA calculation does not include any adjustments for early or late entitlement. The PIA, however, is COLA-adjusted for inflation after the beneficiary reaches age 62. For comparing PIAs of members of a couple born in different years, the PIAs are COLA-adjusted to a common year of comparison. For example, if a male born in 1935 is married to a female born in 1938, and both retire in 2000, when he is 65 and she is 62, the PIA for the male will be calculated under the rules for a worker reaching age 62 in 1997 and will then have three years of COLAs applied. The PIA for the female will be that for a worker reaching age 62 in 2000, and will have no COLAs applied. The PIA for the female, furthermore, will not be adjusted downward for the early retirement. (That adjustment is made to the benefit, not to the PIA.) Because all PIAs rise at the same rate under successive COLAs, a spouse's PIA just under or over 50 percent of a retired worker's PIA will remain just under or over the other worker's PIA throughout retirement, unless one of the two, through continued work after retirement, changes the PIA.

If a spouse's lifetime average earnings approach 50 percent of the other retired worker's average lifetime earnings, the spouse's PIA will usually be more than 50 percent of the other worker's earnings because of the progressivity of the PIA formula. On average, a spouse's PIA will reach 50 percent of the other worker's PIA when the spouse's lifetime earnings are about 30 percent of the other worker's lifetime earnings.

A similar screen operates for widow benefits, but at 100 percent of the other worker's PIA, rather than 50 percent. Although many women in the future will have lifetime average earnings greater than 30 percent of their husbands, only a minority will have average lifetime earnings more than 100 percent of their husbands. We can expect widow benefits to remain common even if spouse benefits become infrequent.

Early Entitlement Reductions for Singly-Entitled Worker, Spouse, or Widow Benefits

When a beneficiary accepts benefits before the NRA, the benefits are reduced below the PIA-calculated level by a factor that depends on how many months before the NRA the benefits were accepted. The reduction factors are different for worker, spouse, and widow benefits.

The NRA[18] was 65 for workers and spouses who reached 62 before 2000; it is now increasing by two months per year until it reaches age 66 for workers and spouses who reach age 62 in 2005, and it will begin increasing again for workers and spouses who reach age 62 in 2017, reaching age 67 for workers and spouses who reach age 62 in 2022 or later.[19]

The benefit reduction rates were originally scaled in such a way that for benefit acceptance at age 62, the earliest possible age for workers and spouses, or at 60, the earliest possible age for widows, which were three and five years before the NRA, respectively, the reduced benefits were:

Worker benefit at age 62	80 percent of PIA.
Spouse benefit at age 62	75 percent of (50 percent of other worker's PIA).
Widow benefit at age 62	82.9 percent of (100 percent of deceased worker's PIA).
Widow benefit at age 60	71.5 percent of (100 percent of deceased worker's PIA).

[18]The NRA also is known as the Full Retirement Age (FRA). Neither term is entirely satisfactory. "Normal" in NRA does not mean "usual", but refers to a reference age from which benefits are calculated. The benefits at the NRA are not quite "full" benefits, since delaying acceptance past the NRA will increase the benefits still further.

[19]The NRA for widows is determined by the year in which they reach 60, rather than the year in which they reach 62. During periods in which the NRA is changing, it is possible for the NRA for a person's widow benefits to be four months less then the NRA for the person's worker and spouse benefits.

The monthly reduction rates can be calculated from the age-62 reduced benefits by dividing the percentage reduction at three years by 36. The 20 percent reduction in a worker benefit at age 62 is equivalent to a reduction of 20/36 percent of PIA per month of early entitlement.

When the NRA is increased above 65, the widow's benefit reduction is scaled in such a way that the benefit at age 60 will still be 71.5 percent of the deceased worker's PIA. The worker and spouse reductions, however, are increased. The same monthly reduction factors as before apply for the 36 months immediately preceding the NRA. When the NRA reaches 67, therefore, the reductions given previously apply for benefit entitlement at age 64. Early entitlement before the final 36 months causes further reductions at the rate of 5 percent of PIA per year, or 10 percent over two years. When the NRA reaches age 67, therefore, the percentages will be 70 percent for worker benefits (rather than 80 percent) and 65 for spouse benefits (rather than 75).

When the NRA is 67, accordingly, the reduced benefits at age 62 are:

Worker benefit at age 62	70 percent of PIA.
Spouse benefit at age 62	65 percent of (50 percent of other worker's PIA).
Widow benefit at age 62	79.6 percent of (100 percent of deceased worker's PIA).
Widow benefit at age 60	71.5 percent of (100 percent of deceased worker's PIA).

The reductions for a worker and the worker's spouse are applied separately. If a worker and a same-aged spouse both accept benefits three years early, the worker will receive benefits equal to 80 percent of the worker's PIA, and the spouse will receive benefits of 75 percent of the 50 percent spouse benefit, or 37.5 percent of the worker's PIA. The spouse benefit is in this case 46.9 percent of the worker's benefit. If a worker accepts benefits at the NRA and the worker's younger spouse accepts benefits three years early, the worker will receive a benefit of 100 percent of the worker's PIA and the spouse a benefit of 37.5 percent of the worker's PIA. If, on the other hand, the worker takes benefits three years early, but the spouse waits until the NRA to take benefits, the worker's benefit is 80 percent of the worker's PIA, the spouse's benefit 50 percent of PIA, or 62.5 percent as large as the worker's. The spouse benefit, therefore, can be as little as 37.5 percent as large as the workers or as much as 62.5 percent as large. (Delayed entitlement credits for the worker benefit can cause still larger differences.) When the NRA reaches age 67, the extremes will be 32.5 percent and 71.4 percent.

These relationships between reduced worker benefits and reduced spouse benefits are unaffected by the COLA indexing of the benefits. If a worker accepts benefits at the NRA of 100 percent of PIA, and the worker's much younger spouse accepts benefits 20 years later also at the NRA, the spouse's benefit is calculated from a worker PIA that includes all the years of COLA indexing since the worker reached 62. The worker's benefit will be 100 percent of this indexed

PIA, and the spouse's benefit will be 50 percent of the indexed PIA, so that the spouse benefit is 50 percent of the worker's benefit.

The reductions when a spouse is entitled to both a spouse benefit and a retired worker benefit are described later.

Widow Benefits and the RIBLIM

The worker and singly-entitled spouse reductions are applied separately: if a worker retires early, but the spouse waits until NRA before accepting benefits, the spouse benefits are not reduced. This is not true for widow benefits. If a worker accepts benefits early, then dies many years later, the proportional reduction to the PIA that was applied to his early entitlement benefit also is applied to the widow benefit calculated at his death, except that the reduced benefit can't be smaller than 82.5 percent of the deceased worker's PIA. (This reduction is called the RIBLIM.) For workers accepting benefits at age 62, who would have had an 80 percent of PIA benefit when the NRA was 65 (and will have a 70 percent of PIA when the NRA is 67), the widow benefit paid at their deaths is 82.5 percent of PIA, regardless of the NRA.

The widow's limit provision is quite important for evaluating the long-term effect of some spouse and widow benefit proposals. When a worker and a spouse have no early entitlement reductions, the joint benefit of 150 percent of the worker's PIA falls to a widow benefit of 100 percent of the PIA when the worker dies, a 33 percent reduction. A preponderance of couples, however, do not wait until the NRA to accept benefits, and in fact accept them at the earliest possible age, age 62. When both members of the couple have taken benefits at 62, the combined benefits, when the NRA is 65, are 117.5 percent of PIA, and the eventual widow benefit is, because of the widow cap, 82.5 percent of PIA, a 29.8 percent reduction from the combined benefit.

When the NRA reaches age 67, however, the combined couple benefit for entitlement at 62 will have fallen to 102.5 percent of PIA, rather than 117.5 percent, but the ultimate widow benefit will still be 82.5 percent of PIA, a 19.5 percent reduction from the combined.

Delayed Entitlement Credits

Benefits to retired workers are increased for each month of delayed entitlement after the NRA up to age 70. For workers who reached age 62 in 1979 through 1986, the credit is given at the rate of 3 percent of PIA per year of delayed entitlement for a maximum (65 through 70) of 15 percent of PIA. For later cohorts of workers, the annual credit has been increasing at the rate of half a percent every two years. For workers who reach age 62 in 2005 (the same workers for whom the NRA will first reach 66), the delayed entitlement credits are given at the rate of 8 percent of PIA per year of delayed entitlement, for a maximum credit (at age 70) of 32 percent of PIA (66 to 70). For workers who reach age 62 in 2022 or later, for whom the NRA is 67, the credit at age 70 is only 24 percent of PIA (67 to 70).

The delayed entitlement credits are not given to spouses who delay their own entitlement past the NRA. They are, however, added to a worker's PIA at death, so that a worker's widow will inherit the effect of the deceased worker's credit.

The delayed entitlement credits increase the range of possible worker to spouse ratios. For a worker who retires at age 70 and a spouse who retires at age 62, the worker benefit ultimately is 132 percent of PIA (credits for the delay from age 67 to age 70) and the spouse benefit 32.5 percent of PIA, or 24.6 percent of the worker benefit. Because the delayed entitlement credit is not given to spouses, the maximum ratio remains 71.4 for a worker who accepts benefits at 62 and a spouse who accepts benefits at 67 or later. The eventual full range for spouse benefits as percent of worker benefits is therefore 24.6 through 71.4.

The Dual Entitlement Reduction

Beneficiaries entitled to both a worker benefit and a larger spouse benefit, or to a worker benefit and a larger widow benefit, are called dually entitled. The larger benefit is reduced by the amount of the smaller worker benefit, so that the total benefit paid is equal to the larger spouse or widow benefit. The interaction with early entitlement reductions is described below.

Dual Worker/spouse Benefit Early Retirement Reductions

A retired worker who accepts benefits before the normal retirement age (NRA) has the retired worker benefit reduced by the factor described earlier, regardless of dual entitlement.

The spouse benefit reduction for a dually entitled spouse, however, is applied only to the excess of the unreduced spouse benefit over the unreduced worker benefit. The total reduced benefit is the sum of the reduced worker benefit and the reduced excess spouse benefit.

An example should make this clear: If the unreduced worker benefit (the PIA) is $500, and the unreduced spouse benefit (50 percent of the other worker's PIA) is $600—and the dually entitled worker has accepted benefits three years before the NRA—the reduced benefit is the sum of a $400 worker benefit (80 percent of $500) and a $75 spouse benefit (75 percent of the excess of $600 over $500), for a total of $475.

Dual Worker/Widow Early Entitlement Reductions

Widow/worker reductions differ from spouse/worker reductions in two regards. First, early widows are allowed some leeway in the timing of their widow and worker entitlement dates. A beneficiary who is eligible for both spouse and worker benefits either must delay accepting both or accept both simultaneously. A widow, however, can take reduced worker benefits at 62 until the NRA, then apply for unreduced widow benefits at the NRA. (Or, if the widow has a larger worker benefit, the widow can take reduced widow benefits at 62, then apply for unreduced worker benefits at the NRA.)

Second, the early entitlement reduction for the widow is applied to the whole of the widow benefit before the dual entitlement reduction, not just to the excess over the unreduced worker benefit.

The widow/worker dual entitlement provisions are more complicated than is being described here. If we distinguish between "early widows" (those who are widowed before becoming entitled to spouse benefits), "late widows" (those who become widows only after reaching the NRA although they might have been entitled to worker and/or spouse benefits before the NRA), and "mid widows" (those who become widows before the NRA but after a worker or spouse entitlement), the "late widows" are the most common type and the easiest to calculate. For them, there is no early entitlement reduction on their widow benefit (except for the widow's limit passed through from their deceased spouse's early entitlement), and the total benefit is equal to the larger of their widow benefit and their worker benefit. The worker benefit possibly is reduced for early entitlement, but that reduction becomes irrelevant to the total benefit amount once the larger widow benefit becomes available.

Figure 1: Proportion Employed, Baseline and Alternative, Selected Ages