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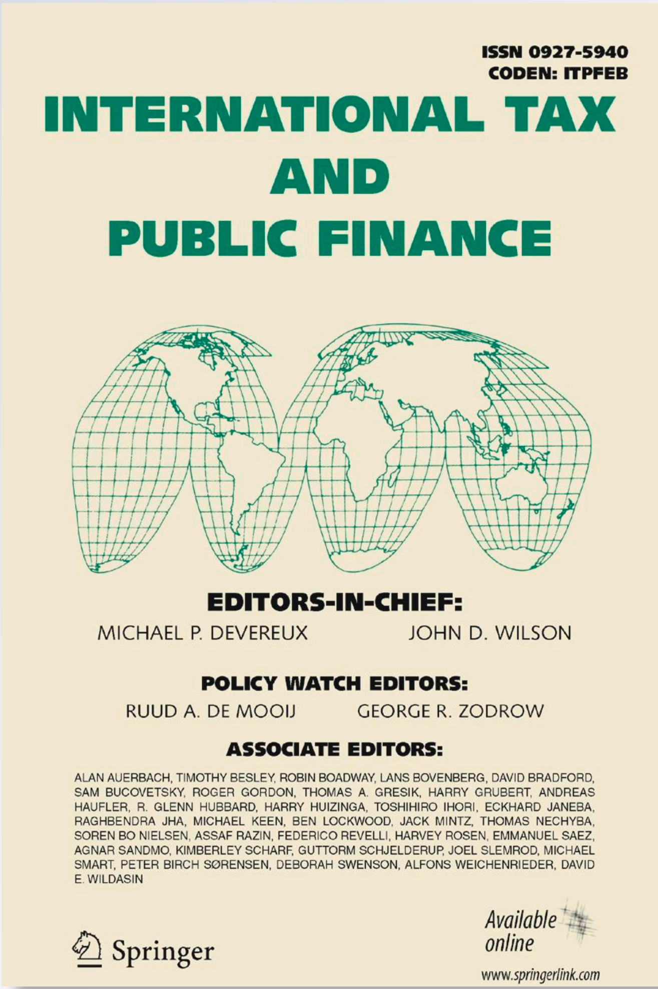

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Assessing the welfare change from a pension reform

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Abstract We study the welfare implications of a hypothetical reform of the Swedish public pension system where eligibility to pension benefits is delayed by 3 years. Using an option value model, we consider the labor supply responses to the reform and develop a compensating variation (CV) measure to analytically assess the individual welfare changes in a random utility framework. We find that a purely budgetary calculation (neglecting individual labor supply responses) overestimates the welfare loss by more than 65%. We also develop a method for testing between a binary and a multinomial option value model, where the binary one is nested in the multinomial model in a Generalized Extreme Value (GEV) model framework. The binary model cannot be rejected.

Keywords Compensating variation measure · Option value model · Random utility · Social security reform

JEL Classification C25 · D61 · H23 · H55 · J26

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1 Introduction

In response to the combined effect of the aging pattern in most Western industrialized countries and a trend toward earlier retirement, most countries have implemented—or are in the process of implementing—pension reforms, implying less generous pension benefits and/or stronger economic incentives toward delayed retirement. It has previously been recognized that purely "mechanical" evaluations of the economic impact of such reforms can be very misleading for several reasons. The most obvious, and probably the most important one, is that the proposed reforms are very likely to affect retirement behavior. For example, Gruber and Wise (2007) show the importance of considering labor supply when measuring the effects of such reforms on the finances of the public sectors in a study which includes calculations from 12 different countries. In this paper, we extend the approach of, e.g., Gruber and Wise (2007) by not only considering financial implications, but also welfare changes implied by the reform.

We estimate an option value model (see, e.g., Stock and Wise 1990) on Swedish panel data covering the cohorts born between 1940 and 1927 and simulate the outcome of a hypothetical reform of Sweden's income security system, where eligibility to pension benefits is delayed by 3 years. We pose three empirical research questions. First, do economic incentives affect individual (average) retirement behavior? Our results unambiguously suggest that they do, since the parameter estimates reflecting these incentives turned out to be significantly different from zero with the expected signs. Second, how large is the aggregate welfare change of the reform under study? Or, put slightly differently, is it important to consider welfare changes in addition to purely budgetary changes? Our results suggest the per individual (average) welfare loss to be 90.5 thousand SEK, as compared to the average of the present value of the budget gain of 150.2 thousand SEK. This means that, on average, there is a 59.7 thousand SEK welfare *gain* of the reform, corresponding to about 40% of the budget change, taking the behavioral adjustment into account. Third, what is the implication on the income distribution of the reform under study and how is it affected by the choice of measure for individual welfare change? Our results suggest that the reform is regressive in the sense that those with a relatively low lifetime income carry a larger burden of the reform than what would be proportional to their income. The magnitude of the regressiveness is only marginally affected by the choice of welfare measure. If anything, an analysis based on income changes predicts a less regressive reform, since the difference between predicted welfare and income change is largest for high income workers.

The study contains two methodological contributions. First, based on Dagsvik and Karlström (2005), we develop a compensating variation (CV) measure of individual welfare changes in a retirement choice model. The traditional log-sum formula (see McFadden 1999a, 2000) is theoretically not valid when income effects are present, which is obviously the case when analyzing a pension reform. Second, we test the binary option value model (see Stock and Wise 1990) against a multinomial option value model, using a Generalized Extreme Value (GEV) modeling framework. The result shows that the binary option value model cannot be statistically rejected.

Our empirical strategy contains several limitations in assessing the general equilibrium welfare effects of a pension reform. First of all, changes in private savings in response to a reduction of benefits are disregarded, which implies that the true welfare gain is systematically underestimated, since changes in savings will offset some of the welfare loss. The reason for this limitation is simply to avoid major computational difficulties and is left to further research in this area.[1] The approach taken in this paper is also partial in the sense that we only measure the welfare loss for the 1927–1940 cohorts. Our analysis can thus be seen as a stepping-stone to a full intergenerational analysis of a pension reform. In such an analysis, effects of possible changes in payroll taxes on saving and labor market behavior, as well as effects of anticipated benefit changes for other cohorts, should be included.

The idea of incorporating preferences in the evaluation of social security reforms is not a new one. Previous studies are more general than ours in the sense that they also take general equilibrium effects of reforms into account (see, e.g., Fuster et al. 2003). In that literature, models have been made increasingly realistic by including uncertainty about health, savings, general equilibrium effects, etc. However, realism has been obtained on the expense of computational tractability and transparency. The idea of our approach is to depart from a more restrictive model that still captures the key aspect of utility maximization and which enable us to implement the reforms of the social security that we are interested in.

The rest of the paper is organized as follows. Section 2, the theoretical part, describes how the timing of the retirement decision is modeled and how the compensating variation welfare measure is calculated. The technique is demonstrated in a numerical example with one individual and a hypothetical pension reform. Section 3 describes Sweden's income security system. Then Sect. 4 presents the data, and Sect. 5 the empirical specification. Section 6 reports the results: first, the estimates of the retirement choice model; second, the estimates of the welfare gain of the pension reform; finally, the results from the income distribution analysis. Section 7 concludes.

2 Modeling the retirement decision and measuring welfare

2.1 Modeling retirement

We use a random utility formulation based on Stock and Wise (1990) option value model. The expected indirect utility in period t of retiring at age r, is defined as

$$V(t,r) = \sum_{s=t}^{r-1} \beta^{s-t} U_W(Y_{ts};\theta) + \sum_{s=r}^{\tau} \beta^{s-t} U_R(B_{trs};\theta), \quad (1)$$

where Y_{ts} is the expected net income before retirement in period s at time t; B_{trs} is the expected net income after retirement in period s at time t, if the individual retires at age r; θ is a vector of socioeconomic variables; $U_W(\cdot)$ and $U_R(\cdot)$ measure the individual's utility of income, allowing for different individual valuations of income

[1]For welfare analysis on savings and retirement, see, e.g., Blau (2007), French (2005) or Gustman and Steinmeier (1986, 2005).

depending on whether the income is received before or after retirement, i.e., the difference between these functions reflects the utility of leisure. Finally, τ is a maximum age considered.

It should be noted that in this formulation, as standard practice in random utility modeling, V in (1) is the indirect utility function. As such, it does not contain leisure or working hours as arguments. That is, individuals are assumed to have preferences for leisure and a time budget constraint. When solving the utility maximization problem we arrive at the indirect utility function as used in (1). The indirect utility will depend on the monetary budget constraint, which is different in the working state and the retired state, respectively.

As is common in random utility modeling, we use a linear indirect utility function specification. Linear indirect utility functions is often derived as a first-order Taylor expansion of the indirect utility function (see, e.g., Bates 1987, or McFadden 1999b). However, in our application, it is important to allow for different indirect utility function specifications in the retirement state and in the working state, respectively. We argue that since the amount of leisure in the two states is quite different it is natural to use different expansion points in the two different states.

In particular, it may be important to allow for different marginal utilities of money in the two states, while we constrain the marginal utilities of other attributes to be identical in the two states. Hence, we arrive at the following indirect utility function specification:

$$
\begin{aligned}
V(t,r) &= \alpha_W \sum_{s=t}^{r-1} \beta^{s-t} Y_{ts}\, p(s \mid t) + \alpha_R \sum_{s=r}^{\text{max age}} \beta^{s-t} B_{trs}\, p(s \mid t) + \gamma_{tr}' x_{tr} \\
&= \alpha_W \widetilde{Y}_{tr} + \alpha_R \widetilde{B}_{tr} + \gamma_{tr}' x_{tr}, \qquad (2)
\end{aligned}
$$

where $p(s \mid t)$ is the survival probability, conditional on survival at age t; β is the subjective discount rate; x_{tr} is a vector of socioeconomic characteristics and γ_{tr} a parameter vector.

The marginal utility of money associated with working (α_W) and retirement (α_R) may be different implying a marginal valuation of leisure greater than zero.[2] Our model is only locally linear, allowing for nonlinear utilities. It should be emphasized that this is an important feature, since there is evidence that utility is quite concave in consumption; see survey by Attanasio and Weber (1995).

In our random utility model, the individual may have different idiosyncratic preferences for retirement at different points in time. There are different sources for such a random utility component. In our framework, the econometrician predicts the individual's future income (including pension benefits) on the basis of population level probabilities and ex post observed values (income). The subjective probabilities actually governing individuals' decisions will, however, differ. Furthermore, the individual may have idiosyncratic preferences toward retirement at different time periods, thereby implying that the choice appears to be random for us as researchers, whereas

[2] In the option value model, a parameter $k = \alpha_R/\alpha_W$ is often estimated or assumed; see, e.g., Stock and Wise (1990) or Samwick (1998).

the utility is known to the individual. In this random utility framework, the individual achieves the utility

$$V(t,t) + \epsilon_{tt}. \tag{3}$$

The individual compares this utility with the utility associated with retiring in a future time period, r, given by

$$V(t,r) + \epsilon_{tr}, \tag{4}$$

where, once more, $V(t,r)$ is the indirect utility of retiring at time r, evaluated at time $t < r$, and ϵ_{tt} and ϵ_{tr} reflect the random utility components. Throughout this paper, reflect the random utility components are assumed to be known to the individual, but unknown to the researcher.[3]

The individual faces the problem of retiring or remaining in the labor force in each year $(1, 2, \ldots, \tau)$ over the period of time observed in the data. The random utility formulation asserts that the probability of retiring at a particular point in time t can be written as

$$\Pr\{V(t,t) + \varepsilon_{tt} \geq V(t,r) + \varepsilon_{tr}; \forall r \geq t\}, \tag{5}$$

where we have assumed the random utility components to follow a joint cumulative continuous distribution function $F(\epsilon_{11}, \epsilon_{12}, \ldots, \epsilon_{\tau\tau})$ with density everywhere, and with zero probability for ties.

We assume ϵ_{ts} and ϵ_{ij} to be independent for any $t \neq i$; that is, in every time period, the random utility components are redrawn. All random utility components are assumed to follow a multivariate extreme value distribution:

$$H(y_1, y_2, \ldots, y_n) = \exp\left(-G\left(e^{-y_1}, e^{-y_2}, \ldots, e^{-y_n}\right)\right), \tag{6}$$

where G is termed the *generating function.*[4] Such a distribution is sometimes termed a Generalized Extreme Value (GEV) distribution. A GEV model is then fully specified and the choice probability of alternative i is given by

$$P_i = \frac{e^{V_i} G_i(e^{V_1}, \ldots, e^{V_n})}{G(e^{V_1}, \ldots, e^{V_n})}, \tag{7}$$

where G_i denotes the partial derivative with respect to argument i.

The assumption of no serial correlation can, however, be regarded as strong, since it is intuitively plausible that the idiosyncratic random utility component for retiring in a future year r can be correlated with retiring in a year s, at least if r and s are close in time. In particular, similar alternatives may share unobserved characteristics, giving rise to a correlated error structure across alternatives.

To allow for serial correlation in the error terms across different future retirement dates, i.e., to allow for ϵ_{ts} and ϵ_{tr} to be correlated, we also estimate a traditional nested logit model. We will estimate a model with only two nests, one for the current

[3] This is in conjunction with the standard random utility framework; see, e.g., McFadden (1999a, 2000).

[4] The generating function must fulfil certain properties; see McFadden (1978).

period and one for all future time periods. Hence, our nested logit model is given by the generating function

$$G(y_{t,t}, y_{t,t+1}, \dots, y_{t,\tau}) = y_{t,t} + \left(\sum_{s>t} y_{t,s}^{\frac{1}{\lambda}}\right)^{\lambda}, \tag{8}$$

where the first term on the right-hand side is associated with the current period. This nested logit model thus allows random utility components to be correlated across future time periods.

In this framework, the probability of retiring at a particular point in time t, i.e., leaving the labor force in the period succeeding period t, can be written as

$$P_R(t) = \frac{e^{V_{tt}}}{e^{V_{tt}} + e^{\sum_{r>t} \frac{V_{tr}}{\lambda} + \lambda \log \sum_{s>t} V_{ts}/\lambda}}, \tag{9}$$

where λ is a dissimilarity (log sum) parameter ($\lambda \in (0, 1]$) which can be estimated.[5] If λ is one, the choice alternatives are seen as independent and the model degenerates into the standard multinomial logit (MNL) model.

Note that if $0 < \lambda < 1$, there is a positive correlation of the temporal error structure. However, as λ approaches zero, the random utility component ϵ_{ts} becomes perfectly correlated for all $s > t$. As the dissimilarity parameter λ approaches zero, only the alternative r with the highest indirect utility is of importance. This case corresponds to the maximum criterion of the option value model (see, e.g., Stock and Wise 1990), and the corresponding model boils down to a binomial logit model. In this specific case, the probability of retiring at time t becomes

$$P_R(t) = \text{Prob}\left\{V_R(t) + \epsilon_{tt} \geq V_W(t) + \epsilon_{tr_{\max}}\right\}, \tag{10}$$

where we have defined $V_W(t) \equiv V(t, r_{\max}) = \alpha_W \widetilde{Y}_{tr_{\max}} + \alpha_R \widetilde{B}_{tr_{\max}} + \gamma'_{tr_{\max}} x_{tr_{\max}}$, $V_R(t) \equiv V(t,t) = \alpha_R \widetilde{B}_{tt} + \gamma'_{tt} x_{tt}$, and $r_{\max} \equiv \text{argmax}_{r>t}\{V(t,r)\}$. In this sense, the common binary option value model is a specific case of a multiperiod GEV model.

2.2 Measuring welfare in a multiperiod random utility model

It should be emphasized that in a random utility framework, utilities are random and will affect welfare measures such as Hicksian consumer surplus (compensated or equivalent variation). In the case where marginal utility of money is not constant, it will not be theoretically sound to simply calculate expected utility and calculate compensation such that expected utility is restored. This would not yield a theoretical sound welfare measure. This problem was noted by McFadden (1999a, 2000, and 2004). In this section, we develop a method for calculating expected compensating variation in a random utility framework based on Dagsvik and Karlström (2005) and Karlström (1998). In general, this methodology is important if there are good reason

[5] A dissimilarity parameter outside the unit interval is not consistent with stochastic utility maximization, assuming weak complementarity.

to believe that income effects are truly present. In many cases, income effects are probably small and, therefore, it is appropriate to use expected utility (Marshallian consumer surplus). However, we do believe that income effects may be real in the present situation, where the individual face a retirement decision under imperfect markets.

Since our empirical model disregards savings, it is useful to decompose the welfare effects into separate time periods. From a theoretical perspective, if savings were included in our model, consumption in different time periods might be considered as different commodities, and there would be no need for an intertemporal decomposition of compensating variation. In this respect, our approach is somewhat similar to that of Keen (1990), who considers the intertemporal decomposition in a *deterministic* utility framework.

To describe our approach for measuring welfare in a binomial option value model, we start with a simple model. Let us assume that we want to evaluate a policy decreasing the benefits received when retired, but leaving the income from work unaffected. The policy will create a loss for most individuals, and will not be perceived as an improvement by anyone. The indirect deterministic utilities associated with the original state are given by

$$V_W^o(t) = \alpha_W \widetilde{Y}_{tr^o_{\max}} + \alpha_R \widetilde{B}^o_{tr^o_{\max}}, \tag{11}$$

$$V_R^o(t) = \alpha_R \widetilde{B}^o_{tt}. \tag{12}$$

The policy to be evaluated decreases the benefits, such that $\widetilde{B}^1_{tr} \leq \widetilde{B}^o_{tr}\ \forall t, r$. The indirect utilities associated with the state after the change are therefore given by

$$V_W^1(t) = \alpha_W \widetilde{Y}_{tr^1_{\max}} + \alpha_R \widetilde{B}^1_{tr^1_{\max}}, \tag{13}$$

$$V_R^1(t) = \alpha_R \widetilde{B}^1_{tt}. \tag{14}$$

In a given time period t, the individuals can be classified into three different groups on basis of how they react to the reform. These are:

- Group A: Individuals who retire in period t, both before and after the change.
- Group B: Individuals who will retire in period t under the pre-reform regime, but will delay their retirement after the reform.
- Group C: Individuals who do not retire in period t, neither before nor after the reform.

With a slight abuse of notation, we will include policy variables (pension benefits) in the argument of the indirect utility functions and for instance write $V_R(\widetilde{B}^o_{tt}; t)$ to denote the determinist utility component of retiring and receiving the benefits $\widetilde{B}^o_{tt}$ before the change, in other words $V_R^o \equiv V_R(\widetilde{B}^o_{tt}; t) \equiv \alpha_R \widetilde{B}^o_{tt} + \gamma'_{tt} x_{tt}$. Now, for individuals in group A, the compensation needed to restore the achieved lifetime utility is defined by

$$V_R\big(\widetilde{B}^o_{tt}; t\big) + \epsilon_{tt} = V_R\big(\widetilde{B}^1_{tt} + c_{\max}; t\big) + \epsilon_{tt}. \tag{15}$$

We assume that the random utility components are not changed by the policy reform.[6] Therefore, the random utility terms cancel out, and the compensation $c_{\max}$ needed to restore the achieved utility is deterministically precisely the difference in the present value of the expected benefits under the pre and post-reform regimes, i.e.,

$$c_{\max} = \widetilde{B}^o_{tt} - \widetilde{B}^1_{tt}. \tag{16}$$

Note that this is the maximum compensation needed for any individual choosingto retire at time t under the pre-reform regime. The minimum compensation is given to the individuals belonging to group C. Since they are not affected by the benefit levels in the pension system in period t, they will not require any compensation to remain at the pre-reform utility level in this period, i.e., $c_{\min} = 0$.

The compensation for group B is bounded by the amount of the compensation for individuals in groups A and C. To calculate the compensating variations in group B, we need the choice probability of switching from being retired to working (being in group B), i.e., we need to find the compensated (Hicksian) choice probability. The compensating variation c for these individuals is given as the solution to the implicit equation

$$V_R\big(\widetilde{B}^o_{tt}; t\big) + \epsilon_{tt} = V_W\big(\widetilde{B}^1_{tt} + c; t\big) + \epsilon_{tr^1_{\max}}. \tag{17}$$

Since, by definition, $r^1_{\max} \neq t$, the compensating variation c is a stochastic variable in this case.

The stochastic variable c is bounded from below by the compensation to individuals who, before the reform, were indifferent between working and retiring at time t. The minimum compensation, $c_{\min}$, needed for these individuals is given by

$$\alpha_W \widetilde{Y}_{tr^o_{\max}} + \alpha_R \widetilde{B}^o_{tr^o_{\max}} = \alpha_W \widetilde{Y}_{tr^1_{\max}} + \alpha_R \widetilde{B}^1_{tr^1_{\max}} + \alpha_R c_{\min}. \tag{18}$$

Hence, $c_{\min} = (V^o_W - V^1_W)/\alpha_R$. Individuals who are indifferent between working or retiring under the pre-reform regime would not have to be compensated, if the alternative to work is unaffected by the policy change. Like those in Group C, these individuals require zero compensation ($c_{\min} = 0$). The other extreme cases are those who are indifferent between working and retiring under the post-reform policy and who require the same compensation as the individuals in Group A to remain on the same utility level.

To be able to calculate the expected compensating variation, we need to find the density distribution of the stochastic variable c supported by the extreme bounds described above. For this purpose, we consider a hypothetical choice situation between retiring under the pre-reform and working under the post-reform system. Suppressing subscript t, let the utility associated with pre-reform retirement is given by V^o_R, whereas the utility associated with working after the reform (and hypothetical compensation c) is given by $V^1_W + \alpha_R c$. Thus, using the logit formulation, the choice

[6]This is a standard assumption in welfare evaluation in a random utility framework. It is difficult to see why a policy reform should change random utilities for any individual.

probability of retirement in this hypothetical situation is given by

$$\widetilde{P}_r(c) = \frac{e^{V_R^o}}{e^{V_R^o} + e^{V_W^1 + \alpha_r c}}, \quad c_{\min} < c < c_{\max}. \tag{19}$$

This expression gives the density distribution of the compensating variation.[7] To see this, consider an individual choosing to retire in the hypothetical choice situation, achieving a utility of $V_R^o + \epsilon_R$. By revealed preference, this individual would not be fully compensated by the amount c, since he prefers to have the original utility level instead of the utility level in the new state. However, if the individual chooses work in the hypothetical choice situation, he can achieve a higher utility than in the original state by delaying his retirement and being compensated by the amount c. Therefore, the probability of the individual choosing to retire in the original state, i.e., needing more than c to be compensated, is identical to $\widetilde{P}_R(c)$, given by (19).

The expected compensating variation is given by

$$\mathrm{E}[cv] = c_A + c_B + c_C, \tag{20}$$

where c_i is the expected compensated variation associated with the three groups $i = A, B, C$, where $c_C = 0$. For group A, those who stick to the retirement alternative both before and after the change, we have

$$c_A = P_R^c c_{\max}, \tag{21}$$

where P_R^c is the compensated (Hicksian) choice probability, i.e., the probability of choosing retirement under the post-reform regime after being compensated. The compensated choice probability can easily be calculated by noting that it is the probability of at least $c_{\max}$ being needed to be compensated. Therefore, $P_R^c = \widetilde{P}_R(c_{\max})$.

Finally, we need to calculate the expected CV for those postponing retirement (Group B). For these individuals, we have

$$c_B = -\int y \frac{\partial \widetilde{P}_R(c)}{\partial c}\, dy, \tag{22}$$

since $-\frac{\partial \widetilde{P}_R(c)}{\partial c}$ is the density distribution of the compensating variation. In a more general case, this integral may not have an analytical solution. Note, however, that even in the case with multiple alternatives, the integral is finite and one dimensional in the case of GEV (such as logit) models. On the other hand, if the marginal utility of money is constant, the associated integral does have an analytical solution, collapsing into the well-known log-sum formula (see McFadden 1999a).

Hence, in general, there is no analytical solution unless the marginal utility of money is constant. However, an analytical solution also exists when we only have

[7] An intuitive interpretation of this formula in a one-period model can be found in Karlström and Morey (2001).

two alternatives. The indefinite integral in (22) does have an analytical solution in our case, since (ignoring the integration constant) in our model

$$c_B \equiv \int \alpha_R c \frac{e^{V_W^1+\alpha_R c}}{e^{V_R^o}+e^{V_W^1+\alpha_R c}} \frac{e^{V_R^o}}{e^{V_R^o}+e^{V_W^1+\alpha_R c}} dc$$
$$= \frac{1}{\alpha_R}\big(V_W^1 - \ln\big(e^{V_R^o}+e^{V_W^1+\alpha_R c}\big)\big) + c - c\widetilde{P}_R(c). \quad (23)$$

Thus, in our model, we can attain an analytical solution using (21) and (23). In the GEV modeling framework, expected utility is given by the logsum formula and can be used as a proper welfare measure if one can normalize with a constant marginal utility of money. Generally, this is not possible in the case with income effects (nonconstant marginal utility of money). In our application, marginal utility of money is choice specific. Interestingly, one can still arrive at a closed-form expression (expressed with the logsum formula) in our case, and it turns out that this holds since we in effect have a binary choice model,[8] in which case we can normalize with the marginal utility associated with the alternative to which the individual switch.

3 Sweden's income security system

As described in the previous section, benefits after retirement, B_{trs}, are determined by institutional rules in the income security system. Sweden's income security system consists of two main parts: the old-age pension system and the compulsory labor market insurance programs. Both these parts are, to about the same extent, used to finance exits from the labor market. In this sub-section, we give a brief description of how these programs are constructed.[9] We start with the public old-age pension programs and the occupational pension schemes. Then we describe the disability, sickness and unemployment insurance programs.

3.1 The old-age pension system

Sweden's public old-age pension system consisted of two main parts during the period studied:[10] a basic pension and a supplementary pension (ATP). All Swedish citizens are entitled to the basic pension, which is unrelated to previous earnings. The normal retirement age for this pension is 65, but it can be claimed from the age of 60 with a permanent actuarial reduction of 0.5% for each month of early withdrawal. If the pension is claimed beginning after the age of 65, the level is permanently increased by 0.7% for each month of delayed withdrawal up to the age of 70.

[8]This is, in turn, a special case of the situation where individuals switch to only one alternative after the change. In this situation, we can normalize with the marginal utility of money associated with that alternative and, therefore, the analytical solution will be a scaled log-sum formula, similar to our case.

[9]For a more complete description, see Palme and Svensson (1999 or 2004).

[10]The description is based on the rules pertaining to individuals covered in the study. Sweden successively introduced a reform of the public old-age pension system in the 1990s.

All social insurances in Sweden are indexed by the basic amount (BA), which follows the CPI very closely. The level of the basic pension is 96% of the BA for a single and 78.5% for a married pensioner. In the year 2010, one BA amounted to 42,400 SEK.[11] The basic pension also contains a survivor's pension.

The supplementary pension is related to the worker's previous earnings. The amount of the benefit is calculated using the following formula:

$$Y_i = 0.6 \cdot \mathrm{AP}_i \cdot \min\left(\frac{N_i}{30}, 1\right) \cdot \mathrm{BA},$$

where AP_i is individual average pension points, BA is the basic amount, N_i is the number of years the individual has recorded a income greater than zero. The pension point average is calculated as the average annual earnings below the social security ceiling of 7.5 BA of the worker's fifteen best years. The normal retirement age for the supplementary pension is 65. The actuarial adjustments for early and delayed withdrawal are the same as for the basic pension.

Sweden has a highly unionized labor market. Around 95% of all employees are covered by central agreements between the unions and the employers' confederations, which regulate occupational pension programs and other insurances for the employees. There are four main agreements, each with a respective pension scheme. The private sector has one scheme for blue- and one for white-collar workers. In addition, there is one scheme for employees in the central government and one for employees in local governments. Since the occupational pension schemes covers almost the entire labor market, we have included them in the option value calculations.[12]

3.2 Labor market insurances

There are three important labor market insurances: disability insurance (DI), sickness insurance (SI), and unemployment insurance (UI). Eligibility for *disability insurance* requires that the individual's working capacity is permanently reduced by at least 25%, due to permanent health problems. Full compensation requires the capacity to be completely lost. Work capacity is, in general, determined by a physician, and eligibility for disability insurance is finally determined by the local social insurance administration. Between 1970 and 1991, disability insurance could be granted for labor market reasons.

The disability benefits consist of a basic pension and a supplementary pension (ATP). The level of the basic pension is the same as for the old-age scheme and the supplementary pension is determined in the same way as for the old-age scheme, with no actuarial reduction for early retirement. "Assumed" pension points are calculated for each year between the date of retirement and the age of 64.

Sickness insurance replaces a share of lost earnings due to temporary illnesses up to the social security ceiling. The replacement level in the insurance has been changed

[11] In 2010, the exchange rate was 1 US$ ≈ 6.9 SEK.

[12] See, e.g., Palme and Svensson (2004) for a more detailed description of the occupational pension schemes.

on several occasions during the time period covered by this study. In a reform in 1987, the replacement level was set to 90% of the worker's insured income. Since then, the replacement has been decreased on several occasions, the first time in a reform in 1991. In 1996, it was set to 75% of the insured income for long sickness spells and in 1998, it was raised to 80%.

The *unemployment insurance* benefit consists of two parts: one basic part unrelated to the worker's insured income, and one part requiring membership in an unemployment benefit fund and related to the worker's insured income. Unemployed workers actively searching for a new job are eligible for compensation. The replacement rate for unemployment insurance has also been changed on several occasions during the time period analyzed in this empirical example. These changes have roughly followed the changes in the sickness insurance.

3.3 Income taxes and housing allowances

Sweden went through a major income tax reform in 1991. Before the reform, all income was included in the same tax base and taxed at a proportional local government tax (around 30% depending on the municipality) and a progressive national tax. The maximum marginal tax rate was set to 75%. The main feature of the 1991 tax reform was that the tax base was divided into capital income and earned income. Income from capital is taxed at the national level at a rate of 30% and earned income is subject to a local government tax and, above a certain break-point, a 20% national tax. The marginal tax rate was considerably reduced.

Old-age, disability, and survivor's pensioners with low incomes are entitled to a housing allowance. In 1995, this allowance was 85% of the housing cost up to a ceiling, at most. About 30% of all old-age pensioners received housing allowances in 1995.

4 Data[13]

We use the Longitudinal Individual Data (LINDA) panel, which is a pure register sample. It contains data from Statistic Sweden's Income and Wealth register, which is a register containing data from the income tax returns for the entire Swedish population; the Population Census, which is primarily data on occupations and housing conditions from mailed questionnaires to the entire population every 5 years; and the National Social Insurance Board registers, which contain data on contributions to the public pension schemes. The sample size of LINDA is about 300,000 individuals. Detailed income components are available from 1983 and data on earnings below the social security ceiling is obtained back to 1960 from the pension register.

We have selected men born between 1927 and 1940, excluding individuals aged less than 50. Since, e.g., the youngest cohort, born in 1940, is just 43 years old in

[13] A more detailed description of the data and different selection procedures is given in Palme and Svensson (2004).

1983, we exclude the first seven observations for each individual from this cohort. We have also excluded the self-employed, since the quality of the income data for this group can be questioned.[14] Furthermore, the data does not contain information on their pension rights.

Using the selection criteria described above, 15,619 observations remained from the originally 22,375 for the cohorts included in the study, giving a total number of observations of 127,390. Finally, due to the very large number of possible individual income paths inherent in the option value model, computer memory restrictions forced us to radically limit the sample size. Therefore, a random sample of 1,442 individuals, yielding 13,072 observations, was made from the original sample.

5 Empirical specification of the retirement choice model

With information on the institutional rules determining the retirement benefits and data on the date of retirement, it is straightforward to estimate the parameters in (2) using maximum likelihood (see, e.g., Stock and Wise 1990). However, a problem in the estimation is the possible endogeneity of the benefit levels conditional on retirement age. A large fraction of those permanently exiting from the labor market at a relatively early stage use the labor market insurances as their main source of income after retirement. The level of the benefits is, in general, higher for the labor market insurance programs as compared to the old-age pension system, which is an exit alternative at the age of 60. If benefits from labor market insurance programs were available for all workers in the sample, their benefit level should be used for the variable measuring the benefit levels. However, this is obviously not the case since a health test is required to be eligible for both the sickness and the disability insurance, and a requirement of active job search for being eligible for the unemployment insurance.

If the benefit levels of the labor market insurance programs were used, they would result in larger economic incentives for leaving the labor market than those on which a large share of the sample actually act. In turn, this would lead to a downward bias of the effect of economic incentives on retirement. On the other hand, if the more generous benefit level of the labor market insurances are allocated only to those using these insurances when retiring, we would have an endogeneity problem: we assign more generous economic incentives from the income security system to workers tending to leave the labor force at an early stage. This would, in turn, lead to an upward bias of the effect of economic incentives.

We use a pseudo-IV, or probabilistic, approach to deal with the problem of possible endogeneity of benefits. This requires that in calculating the benefit variable, we assign the probability of each path out from the labor force actually seen in the data. Since we discovered a very large number of different such paths in the data[15]

[14] The self-employed can always accumulate wealth within their own business.

Table 1 Percentage share of the pathways to permanent exit from the labor market, showing main source of income (more than 50% from the indicated source); cohorts born 1927–1932

1.	State old-age pension	33.70
2.	Occupational pension	13.68
3.	Disability pension (DI)	6.55
4.	Survivor's pension	–
5.	Wife's supplement	0.02
6.	Severance payments from employer	0.60
7.	Private pension	0.86
8.	Sickness insurance	20.53
9.	Unemployment insurance	8.35
10.	Partial retirement benefit	10.04
11.	No income source of more than 50%	5.67

Note: The 10.02% of the sample who are not yet retired by the end of the panel are included in source 1. Source 5 also includes some other minor benefits in addition to the wife's supplement

we follow, for practical reasons, a simplified approach. In the first step, we construct a "synthetic" insurance path. We use the observation that the most common route for those retiring by using labor market insurance program is to use the sickness or unemployment insurance for some time, before switching to disability insurance, where the time period on sickness or unemployment insurance decreases with the worker's age.[16] To facilitate things, we use the benefit level of the sickness insurance for both, since these levels are quite similar.

In the second step, we estimate a probit regression for which the dependent variable is being eligible for a labor market insurance and the independent variables are a polynomial in age and indicator variables for county of residence, socio-economic group, and education level. Then we predict the probability for each individual of getting compensation from a labor market insurance. Finally, we calculate the benefit variable as

$$\widetilde{B} = \widetilde{B}_{\mathrm{OAP}} + p\big(\widetilde{B}_{\mathrm{LI}} - \widetilde{B}_{\mathrm{OAP}}\big), \tag{24}$$

where $\widetilde{B}_{\mathrm{LI}}$ is the expected present value of net benefits for the "synthetic" labor market insurance path to retirement, $\widetilde{B}_{\mathrm{OAP}}$ is the corresponding measure of the old-age pension alternative and p is the predicted probability of being eligible for a labor market insurance.

Table 1 shows the distribution of the main income source the year after the worker's exit from the labor market. It is notable that almost 35% of the newly retired receive their main income from labor market insurances—in particular the sickness and unemployment insurance. A closer analysis of how their main income source changes after retirement shows that those using the sickness and unemployment insurance as their main income source immediately after retirement switch to disability insurance after, on average, about 2 years. This analysis also shows that, on average, older workers switch more quickly to disability insurance.

[15] The total number of permutations found in the data is 911.

[16] See Palme and Svensson (2004) for a more detailed description.

Table 2 Parameter estimates. $n = 13{,}072$ (from 1,442 individuals). β set to 0.95

	$\widehat{\theta}$	$\widehat{\theta}/\widehat{\sigma}_{\theta}$
Constant	−3.4637	−15.29
α_R	0.0909	2.37
α_W	0.0947	6.79
Married	0.1146	1.16
Education level 2	0.3568	1.78
Education level 3	0.6690	5.99
Education level 4	0.4768	3.45
Education level 5	0.4018	2.25
Education level 6	0.4716	2.92
Occupational group 2	−0.1868	−1.75
Occupational group 3	0.0952	0.73
Occupational group 4	−0.6073	−4.06
Age	0.1568	9.95
Age 65	1.4929	9.43
Log likelihood	−2435.8	

Note: 24 indicators for counties also included in the specification

6 Results

6.1 Estimates of the retirement choice model

For the most general model, we use a nested multinomial logit model, which is estimated using maximum likelihood. To discriminate between the multinomial retirement model and the binomial maximum approach, we use a nested logit model. The estimates show that the hypothesis of the dissimilarity parameter, λ, being equal to zero at any significance level cannot be rejected.[17] We conclude that we have empirical support for the hypothesis that the *maximum* of future utilities is the adequate variable when modeling the timing of retirement. Therefore, using a binomial retirement choice model is sufficient.

All parameters but one in model (2) can be simultaneously estimated. We have tried a large set of reasonable values on the discount parameter, β, and have chosen the parameter value 0.95 on the basis of maximum loglikelihood value. Table 2 shows the results from the estimation of the binary logit model, where β is set to 0.95.

The estimates of parameters α_W and α_R both differ significantly from zero, and with the expected signs. An interpretation of this result is that economic incentives are of importance for the retirement behavior of the workers in the sample. The estimate of the ratio between α_W and α_R does not differ significantly from one, i.e., the possibility of the individuals in the sample having a zero marginal utility of leisure in

[17] As pointed out by a referee, in our setting, the hypothesis test inloves criterion on the boundary of the parameter space. That is, we test whether the dissimilarity parameter is different from zero, which is on the border of the feasible parameter set (see footnote 5). Note also that we have to use constrained maximum likelihood techniques. Since our sample is quite large, we have used the LM-statistical test. For further discussion of this problem, see, e.g., Feng and McCulloch (1992).

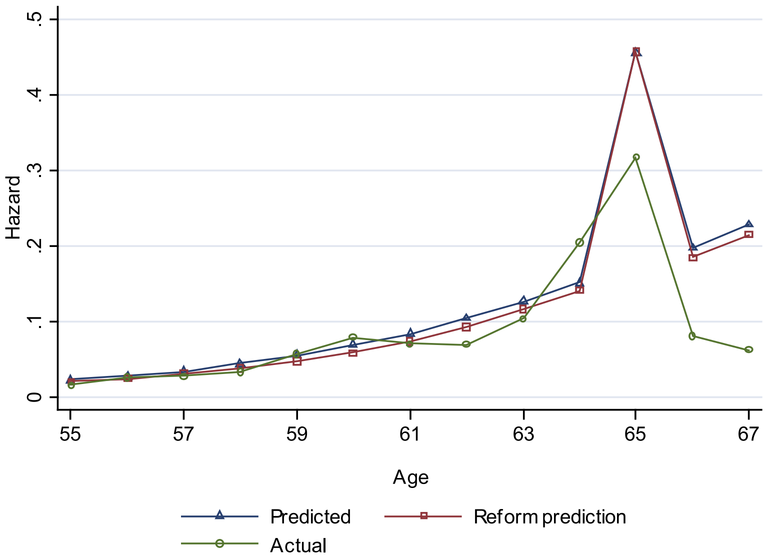

Fig. 1 Predictions of hazard rates and actual hazards for retirement by age

retirement cannot be rejected. Moreover, we cannot reject that the individuals in the sample have a constant marginal utility of consumption.

Figure 1 shows the actual hazard rates observed in the data along with predictions from the model under the actual income security system and the predictions when we changed the economic incentive variables according to the hypothetical reform described in the section below. Overall, it can be seen that the model gives a good prediction of the actual retirement behavior. The reason behind the overestimate of the spike at the mandatory retirement age at age 65 is that a comparatively large share of those who work their last year when they turn 65 retire so early during that year that they earn below the earnings threshold. They are then classified as retiring at age 64.

6.2 Welfare analysis of a hypothetical reform of Sweden's income security system

We simulate the outcome of a hypothetical reform of the Swedish income security system in the sample. In this hypothetical reform, eligibility and normal retirement ages are delayed by three years for all pension schemes. The probability of having access to labor market insurances (Disability, Unemployment, and Sickness insurance) is also delayed by 3 years; that is, all economic incentives to exit from the labor market are delayed by 3 years, but the age specification of the model, which is used as a proxy for changes in preferences due to deterioration in health by age and institutions on the labor market in the retirement choice equation, is maintained.

There are several reasons for choosing this particular reform. First, it has an unambiguous effect of decreasing the replacement level for each individual in the sample at each hypothetical retirement age. This decrease corresponds to changes in the probability of being eligible for labor market insurances before the eligibility age of the old-age pension schemes, and the actuarial adjustment in the old age pension schemes after that age. As we will see in the income distribution analysis below, this decrease has an interesting interpretation, since it is proportional to the overall replacement rate in the income security system. Second, it is quite realistic in the sense that it is in line with what has been proposed in several countries as a means of obtaining financial stability in the social security systems. Third, it is identical to the reform analyzed from a labor force participation perspective for different countries in Gruber and Wise (2004) and the finances of the public sector in Gruber and Wise (2007). Thus, it is possible to compare the results obtained in this study with those of previous ones.

As in the numerical example shown in Sect. 2, we use three different measures of change in individual welfare, resulting from the hypothetical reforms in the social security system:

- The predicted change in lifetime income when changes in retirement behavior are not taken into account.
- The predicted change in lifetime income, taking changes in retirement behavior into account.
- The predicted compensating variation measure.

As argued in Sect. 2, the first two measures are the most common in the public policy discussion of the income distribution implications of pension reforms. By including them in the comparison, we can evaluate whether the outcome of the analysis is affected by including a measure also considering the valuation of leisure time, as does the compensating variation measure.

6.2.1 Efficiency

A social security reform may have an effect on overall efficiency. The fact that the worker can counteract the welfare loss of the benefit cut by delaying retirement implies that the effect of the reform on the budget of the social security system may exceed its aggregate welfare loss. This difference can be interpreted as a "welfare gain."

The mean expected compensating variation in the sample is 90.5 thousand SEK (variance of 75.5 thousand SEK) and the mean budget change is 150.2 thousand SEK (variance 260 thousand SEK) for the hypothetical reform. This means that there is a mean "welfare gain" of 59.7 thousand SEK from the reform in the sample, an amount corresponding to almost 40% of the total budget change.

In the Appendix, we show that an alternative way to assess the efficiency of a pension reform is to relate it to a reform that implements an actuarial fair income security system. It is shown that a reform improves efficiency if benefits are decreased and the net budget gain for the public sector is positive when retirement is delayed to $r_{\max}$. The contour plot of the sample in Fig. 2 shows that the latter requirement is fulfilled, since most observations are in the positive quadrant of the G and $c_{\max}$ relation. However, the post reform system is not actuarial fair either. To show this, consider the thick line in the figure that represents a reform the implements actuarial fairness, i.e., fulfills the requirement that the net government budget gain for those who delay retirement to $r_{\max}$ should be equal to the change in the value of their benefits

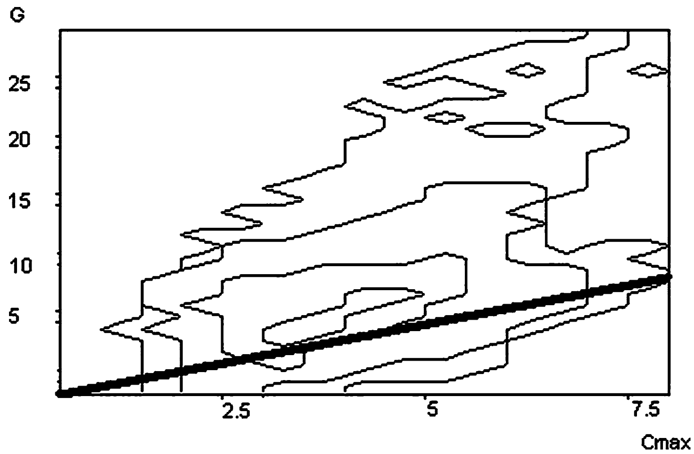

Fig. 2 The optimal pension reform path ($c_{\max} = G$) along with contour plots of the joint distribution of the predicted net budget gain and maximum welfare loss in the sample

($G = c_{\max}$). Put differently, if the reform would have implemented actuarial fairness, the contour plot would have shown that all the density mass were concentrated on this thick line. Therefore, there is still room for efficiency improvements, also after the reform.

6.2.2 *Income distribution*

The figures in Fig. 3 show box-plots of the distribution of CV, predicted changes in retirement probabilities and the approximation error by quintile groups by labor income at the age of 55. These results are displayed for two different age groups—those aged 59 and 64, respectively. The first set of results shows that the welfare loss from the reform, in particular among the 64-year olds, seems to be largest among the group of high income earners. The results of the approximation error, the difference between the CV measure and $c_{\max}$, shows this discrepancy to be increasing in labor income. Once more, this is particularly apparent in the oldest age group. The lowest panel, showing the behavioral adjustment in retirement, gives the background to this result: the adjustment in retirement is once more an increasing function of labor income.

To sum up, the welfare loss, in absolute amounts, is largest among high income earners and in that sense, this group has the largest welfare loss from the reform. If the approximative welfare measure is used, the reform would look like being even more disadvantageous for high income earners, since this group do, to a larger extent, counteract the welfare loss from the reform by delaying retirement.

Let us now turn to the question of how the welfare loss relates to labor income during the period when the workers were still active on the labor market—i.e., the relative welfare loss—and the economic significance of the result that the approximation error is larger among high income earners. For this purpose, we depart from a measure of the relative income distribution and to avoid the aggregation problem of summarizing the information from an entire income distribution, we use Lorenz and

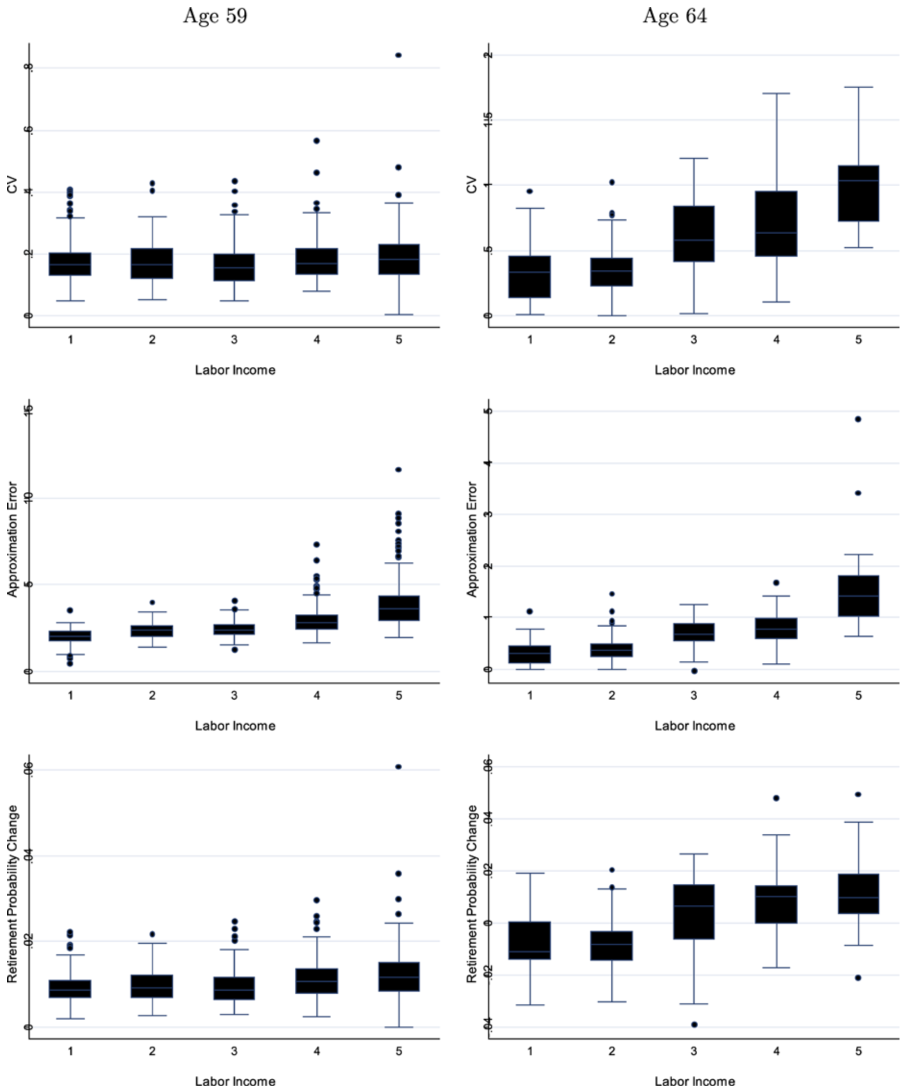

Fig. 3 Box-and-whisker plots of the distribution compensating variation measure of welfare change, distribution of approximation errors (the difference between CV and the predicted income change following the reform) and change in retirement probability by quintile groups of labor income at the age of 55. Two different age groups: those aged 59 and 64, respectively

concentration curves. These measures display the impact of the reform on the entire income distribution.

Figure 4 shows three curves; first, the Lorenz curve for labor income at the age of 50 and second, the concentration curve for the individual CV measure of the welfare effect of the reform. This curve shows the cumulative share of total CV *maintaining the ordering* of the individuals obtained for the Lorenz curve. Third, there is the corresponding concentration curve for the approximative measure of welfare change,

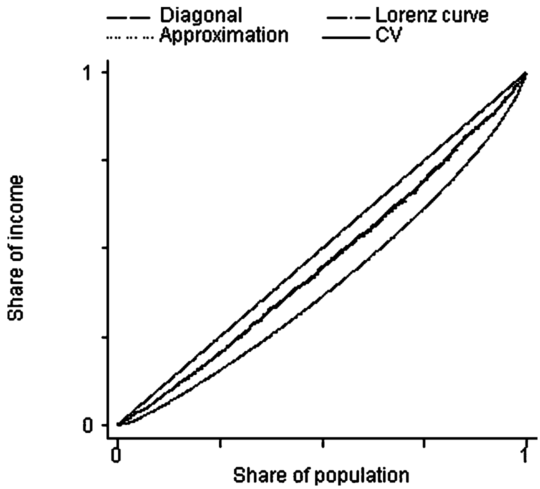

Fig. 4 Lorenz curve for labor income at the age of 50 along with concentration curves for CV and the approximative measure of welfare change from the hypothetical pension reform

i.e., the lifetime income change when we do not consider that workers may change their retirement behavior.

If the concentration curve is located below the Lorenz curve for labor income, the welfare loss experienced by the relatively poor is smaller than what is proportional to their income, i.e., the reform redistributes from the rich to the poor. On the other hand, if the concentration curve is located above the Lorenz curve, it shows that the poor, on average, experience a larger welfare loss than what is proportional to their income, i.e., a regressive reform in the sense of redistributing income from the relatively poor to the relatively rich (see, e.g., Lambert 1989, for a more detailed description of this measure of redistribution).

Figure 4 reveals two interesting results. First, irrespective of the welfare measure, the reform is regressive in the sense that low income individuals experience a larger welfare loss than what is proportional to their labor income before retirement, although the loss is smaller in absolute amounts for these individuals. The background to this result is likely to be the fact that the Swedish income security system is progressive in the sense of redistributing income from high to low income earners. Second, the concentration curve of the CV measure of welfare change is very close to the corresponding line for the approximative welfare measure. In fact, the curves almost intersect in all points. The small difference that can be recorded is that the concentration curve of the CV measure is closer to the diagonal line, i.e., the reform would appear to be less regressive if we ignore the behavioral response to the reform, but the difference is so small that it has very limited economic significance.

7 Conclusions

In this paper, we have shown how individual welfare, based on compensating variations, can be measured in a random utility framework (e.g., an option value or dynamic programming model) for the retirement decision. This means that we can consider the welfare implications of a social security reform, taking individual retirement decision responses to the reform into account. This method is then applied to the analysis of a hypothetical reform of the Swedish income security system where the eligibility ages are delayed by 3 years in all programs.

Previous research, summarized in, e.g., Lumsdaine and Mitchell (1999), has shown the importance of the design of social security schemes for individual retirement behavior. It has also shown the importance of considering retirement behavior for the public finance effects of social security reforms (see, e.g., Gruber and Wise 2007). This study shows the importance of considering the behavioral response for measuring the overall welfare effect of such reforms. In fact, we show that the welfare loss to the cohorts which had a reduction in their benefits due to the particular reform decreased by 40% when retirement behavior was taken into account in the welfare analysis.

Behavioral responses do also affect the measures of the welfare distribution effects of social security reforms. Potentially, this could be of great importance, since different groups on the labor market are likely to respond more or less in their retirement behavior, due to differences in health status, work environment and other job characteristics. We found that the hypothetical reform considered in this study would be regressive in the sense of those with lower labor earnings at the age of 50 carrying a larger burden of the total welfare loss than what would be proportional to their income, irrespective of the welfare measure, thereby reflecting the income redistribution of the current Swedish income security system. Our results also suggest that the choice of measure of individual welfare change has a very limited effect on the analysis of the income distribution effect of the reform.

This study leaves several areas for further research. One of these is to compare how the welfare analysis is affected by the choice of how to model the retirement choice behavior. As noted above, although we have chosen to show how the welfare measure can be implemented in, and applied to, the Stock and Wise (1990) option value model, it can be used in a dynamic programming framework. Lumsdaine et al. (1992) have shown that the option value model underestimates the value of postponing retirement, relative to a dynamic programming model. It is, however, an open question how this result transforms into a welfare analysis of a social security reform.

Another important area for further research is to also consider the welfare implications of individual responses in private savings to a social security reform. As described above, a welfare enhancing response to a cut in social security benefits, in addition to delayed retirement, is increased individual savings. Our results should therefore be interpreted as upper bounds of the true welfare loss of a social security benefit cut.

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Appendix

In this Appendix, we look at the interrelation between the "deadweight gain" and actuarial fairness. To simplify the theoretical analysis, we assume $\widetilde{B}_{r_{\max}}$ to be unaffected by the reform. We define "deadweight gain" as the difference between the budget gain and aggregate CV change. The optimal reform[18] can be characterized as one maximizing deadweight budget gain, i.e.,

$$\max_{\theta}\left\{-c_A - c_B + P_R^c(\theta)\theta + \left(P_R^o - P_R^c(\theta)\right)G\right\}. \tag{25}$$

Suppressing the subscript t, $\theta = \widetilde{B}^o - \widetilde{B}^1$ denotes the reduction in benefits at time t, and $G = g + \widetilde{B}^o - \widetilde{B}_{r_{\max}}$ is the net (government) budget revenue associated with those who delay their retirement from time t to time $r_{\max}$, where g is the net gain from other transactions than pension benefits, typically income taxes. The net budget gain G is received from $(P_R^o - P_R^c(\theta))$ individuals who delay their retirement to year $r_{\max}$.[19]

From Sect. 2.2, we know that

$$c_A = P_R^c(\theta)\theta, \tag{26}$$

$$c_B = -\int_0^{\theta} c\frac{\partial P_R^c}{\partial c}\,dc, \tag{27}$$

and, therefore, our maximization problem (25) can be rewritten as

$$\max_{\theta}\int_0^{\theta} y\frac{\partial P_R^c}{\partial y}\,dy + \left(P_R^o - P_R^c(\theta)\right)G. \tag{28}$$

Note that marginal welfare loss and marginal budget gain are always equal for group A, i.e., individuals who do not change their behavior as a result of the pension reform. By straightforward differentiation, we obtain the result that in optimum, the marginal welfare loss should be equal to the marginal budget gain for individuals delaying their retirement, i.e.,

$$\frac{\partial P_R^c(\theta)}{\partial\theta} = \frac{\partial P_R^c(\theta)}{\partial\theta}G. \tag{29}$$

Hence, assuming[20] that $P_R \neq 0$,

$$\theta = G. \tag{30}$$

The overall deadweight gain is entirely determined by those changing states, labeled as group B in Sect. 2.2. In this group, the conditional marginal welfare loss

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[18] For a discussion of an optimal reform in a random utility framework, see de Borger (2000).

[19] It is the compensated choice probability P_r^c that enters here, but in our empirical example, $P_r^c = P_r^1$. Note that this is not a result of no income effects, but of the binary choice model.

[20] Naturally, if $P_r = 0$, we cannot affect welfare or the budget. On the other hand, if $P_r = 1$, there is a direct correspondence between net budget gain and welfare loss, and there is no room for welfare improvements, so the deadweight gain equals zero.

is θ and the conditional marginal public sector budget gain is G. Hence, we should decrease post reform benefits as long as the net budget gain for the public sector is positive. In particular, we cannot improve upon an actuarial fair system, i.e., when the net budget gain for the entire public sector (including income taxes) should be equal to what the individual expects to lose in future benefits.

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