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The Timing of Retirement and Social Security Reforms: Measuring Individual Welfare Changes*

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Abstract

We develop a compensating variation (CV) measure of individual welfare change from reforms of social security schemes. Within a random utility framework for modeling the individual retirement decision (e.g. the "option value" or dynamic programing models), this measure takes the individual timing of retirement as a response to the reform into account. In the empirical part of the paper an option value model is estimated using Swedish panel data. This model is then used to simulate the effect of a hypothetical reform of Sweden's income security system where eligibility to pensions are delayed by three years. The individual welfare measure is used to assess the overall welfare change as well as the distributional effects.

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1. Introduction and Motivation

The global aging pattern, combined with a trend towards earlier retirement, threaten the financial stability of the social security systems in most Western industrialized countries. This has led to a widespread debate on social security reforms - in particular proposals for delaying eligibility ages and cuts in pension benefits. As is well known, a worker assigned to a pension scheme which will go through a reform where the benefits are being cut is able to offset some of the welfare loss from the reform by changing his labor supply and/or savings behavior. This implies that it is not sufficient to restrict the calculation of the individual welfare effect of the reform to just changes in the income streams. For a thorough welfare analysis it is necessary to model individual behavior and from such models calculate individual welfare measures.

Methods for modeling the timing of retirement response have developed rapidly over the last decade (see e.g. Lumsdain and Mitchell, 1999, for an overview). The dominating empirical strategies use the random utility modeling (RUM) framework (e.g. the option value or the stochastic dynamic programming models). Within this framework, the frequently used log-sum formula (McFadden, 1978)[1] is a theoretically sound welfare measure. This formula can not be used, however, when income effects are present, and since this is the case for the timing of retirement decision the log-sum formula is not a feasible approach.

An alternative strategy, which is frequently used in studies of the effect of

[1] Welfare economics in a random utility framework was developed together with the random utility methodology by, e.g., Ben-Akiva (1973), McFadden (1978), and Hanemann (1985). This framework is often used for welfare evaluations in environmental and transportation economics studies (see e.g. McFadden and Leonard, 1993, and Small, 1992, respectively).

income taxes and government benefits on labor supply where income effects may be important,[2] is to use simulation based methods to calculate individual compensating variation. In a multinomial choice framework this approach can be computationally burdensome. McFadden (1999) shows that the convergence rate can be quite slow, even with only three alternatives (see also Herriges and Kling, 1999). Since timing of retirement decisions, depending on modelling strategy, may involve considerably more than three alternatives, this strategy may not be feasible.[3]

In this paper we will develop a method for calculating expected compensating variation (CV) in an intertemporal random utility framework which is computationally feasible with arbitrarily many alternatives. In fact, in the context of a binary choice model, such as the binomial option value model, we arrive at an analytical expression for the expected compensating variation. This method is applied in the empirical analysis of this study.

In the empirical analysis we first estimate an option value model for the timing of the retirement decision on Swedish panel data. The data set includes about 15 000 Swedish male workers born between 1927 and 1940. Their retirement behavior is observed between 1983 and 1997, and their earnings histories are observed back to 1960. The entire public income security system is considered as well as occupational pension programs in the calculation of economic incentive measures. We use a probabilistic (IV) approach to deal with differences in access to disability pension as well as other labor market insurance programs.

[2] In the labor supply literature, the multinomial logit framework has been increasingly used in order to account for non-linear budget constraints. See e.g. Blundell and MaCurdy, 1999.

[3] Welfare economics in a random utility framework is not without complication. For a related discussion in a labor supply context, see Preston and Walker (1998).

In the option value model, an individual compares the utility of retiring in the current period with the option of delaying retirement. In the binomial option value model, the choice probability of retirement will not depend on utilities for all future years. Only the future date yielding the maximum utility matters. To empirically test this maximum criterion assumption, we apply a nested logit model in which we allow for the stochastic utility components to be temporally correlated. One main finding of this study is that we are not able to statistically reject the maximum criterion inherent in the binomial option value model.

The estimated model is then used to simulate the effects of a hypothetical reform of the social security system. In this reform the eligibility ages in all pension schemes and the probabilities of being eligible for the labor market insurances are delayed by three years. That is, the measures of economic incentives are delayed by three years although the specification for measuring changes in preferences by age, the polynomial in age, is maintained. The results from the simulation are then used for a welfare analysis using the proposed CV measure. We assess efficiency and redistribution of welfare implied by the hypothetical reform. We also compare the distribution of the welfare change with that of the predicted change in lifetime income of the individuals in the sample.

The estimation results support the hypothesis that economic incentives affect the timing of retirement behavior, since the estimated parameters reflecting the effect of economic incentives are significant and have the expected signs. An implication of this result is that delayed retirement in the simulation of the hypothetical reform was predicted in the sample. Overall welfare change is overestimated by 10.0 percent using the approximative welfare measure of the change in individual lifetime income (not considering changes in retirement behavior) and underestimated by 10.6 percent using predicted lifetime income when changes in behavior were taken into account.

The welfare measurement strategy also allows us to characterize the optimal pension reform in the same modelling framework as our empirical model. The result from that exercise shows that the optimal reform should be "actuarial fair" in the sense that, for each individual, the net budget gain for the public sector (including income taxes) should be equal to the individual expects loss in future benefits.

Finally, the analysis of the welfare distribution implications of the reform shows that the reform would have been regressive in the sense that individuals with relatively low income would have given up more of their welfare than what is proportional to their share of total labor income. An analysis based on income changes would have predicted a less regressive reform, since the difference between the predicted welfare and income change is largest for high income workers.

This study contains several limitations in assessing the general equilibrium welfare effects of a pension reform. First of all, changes in private savings as a response to a reduction in benefits are disregarded. This implies that we systematically overestimate the true welfare cost, since changes in savings will offset some of the welfare loss. However, which is noted in Rust and Phelan (1997) for the US population, the dominant groups of households in the population have very limited savings beyond savings in housing. This applies to the Swedish population as well. Therefore, the effect of disregarding savings is probably empirically small.

The approach taken in this paper is also partial in the sense that we only measure the welfare loss to 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 analysis effects of possible changes in payroll taxes on saving and labor market behavior, as well as effects from anticipated benefit changes for other cohorts, should be included.

The rest of the paper is organized into two main parts. Section 2, the theoretical part, describes how the timing of retirement decision is modeled and how the compensating variation welfare measure is calculated. Finally, the technique is demonstrated in a numerical example with one individual and a hypothetical pension reform. Section 3, the empirical part, reports the result from the estimation of the model and the welfare analysis from the outcome of the hypothetical reform of the Swedish income security system. Section 4 concludes.

2. Modeling Retirement and Measuring Welfare

2.1. Option Value in a Random Utility Model

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

$$V(t,r) = \sum_{s=t}^{r-1} U_W(Y_{ts};\theta) + \sum_{s=r}^{\max age} U_R(B_{trs};\theta), \tag{2.1}$$

where Y_{ts} is expected net income before retirement in period s at time t; B_{trs} is expected net income after retirement in period s at time t if the individual retires at age r; θ is a vector of socio-economic variables; $U_W(\cdot)$ and $U_R(\cdot)$ measures the individual s utility of income allowing for di erent individual valuations of income de ending on if the income is received before or after retirement, i.e., the di erence between these functions re ects the utility of leisure.

We will use a linear formulation of the indirect utility function:

$$\begin{aligned} V(t,r) &= \alpha_W \sum_{s=t}^{r-1} \beta^{s-t} Y_{ts} p(s \mid t) + \alpha_R \sum_{s=r}^{\max age} \beta^{s-t} B_{trs} p(s \mid t) + \gamma'_{tr} x_{tr} \\ &= \alpha_W \widetilde{Y}_{tr} + \alpha_R \widetilde{B}_{tr} + \gamma'_{tr} x_{tr}, \end{aligned} \tag{2.2}$$

where $p(s \mid t)$ is survival probability conditional on survival at age t; β is the subjective discount rate; x_{tr} is a vector of socio-economic characteristics and γ_{tr} a parameter vector. We allow the individual to have different marginal valuation of income after retirement. 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.[4]

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 the framework of option value modeling, an individual predicts his future income (including pension benefits). We will assume that the individual can project his future income deterministically, but it may be the case that we as researchers do not have sufficient information to do that. Also, the individual may have idiosyncratic preferences towards retirement at different time periods, implying that the choice appears random for us as researchers, whereas the utility is known to the individual. In this random utility framework the individual will achieve the utility

$$V(t,t) + \epsilon_{tt}. \tag{2.3}$$

The individual will compare this utility with the utility that is associated with

[4] 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).

retiring in a future time period, r, given by

$$V(t,r)+\epsilon_{tr} \tag{2.4}$$

where, again, $V(t,r)$ is the indirect deterministic utility of retiring at time r, evaluated at time $t<r$; ϵ_{tt} and ϵ_{tr} reflect the random utility components. Throughout this paper these will be assumed to be known to the individual, but unknown to the researcher. This is in conjunction with the standard random utility framework, see, e.g. McFadden (1999, 2000).

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

$$\Pr\left\{V(t,t)+\varepsilon_{tt}\geq V(t,r)+\varepsilon_{tr};\forall r\geq t\right\}, \tag{2.5}$$

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

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

$$H(y_1,y_2,...,y_n)=exp(-G(e^{-y_1},e^{-y_2},...,e^{-y_n})) \tag{2.6}$$

where G is termed the *generating function.*[5] Such a distribution is sometimes termed a Generalized Extreme Value (GEV) distribution. A GEV model is then

[5]The generating function must fulfil certain properties, see McFadden (1978).

fully specified and the choice probability is given by

$$P_i = \frac{e^{V_i} G_i(e^{V_1}, ..., e^{V_n})}{G(e^{V_1}, ..., e^{V_n})} \tag{2.7}$$

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

If the error terms are assumed to be independent, the common multinomial logit (MNL) model follows, and the probability of retiring a particular year can be written as

$$P_{(t)R} = \frac{e^{V(t,t)}}{e^{V(t,t)} + \sum_{r>t}^{\mathcal{T}} e^{V(t,r)}}, \tag{2.8}$$

Substituting for the functional form used in 2.2 we get

$$P_{(t)R} = \frac{e^{\alpha_R \widetilde{B}_{tt} + \gamma'_{tt} x_{tt}}}{e^{\alpha_R \widetilde{B}_{tt} + \gamma'_{tt} x_{tt}} + \sum_{r>t}^{\mathcal{T}} e^{\alpha_W \widetilde{Y}_{tr} + \alpha_R \widetilde{B}_{tr} + \gamma'_{tr} x_{tr}}}. \tag{2.9}$$

The assumption of no serial correlation can, however, be regarded as strong, since it is intuitively plausible that idiosyncratic random utility 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 will also estimate a traditional nested logit model, given by the generating function

$$G(y_{t,t}, y_{t,t+1}, ..., y_{t,\mathcal{T}}) = y_{t,t} + (\sum_{s>t} y_{t,s}^{\frac{1}{\lambda}})^{\lambda}. \tag{2.10}$$

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

$$P_{(t)R} = \frac{e^{V(t,t)}}{e^{V(t,t)} + e^{\sum_{r>t} \frac{V(t,r)}{\lambda} + \lambda \log \sum_{s>t} V(t,s)/\lambda}}, \tag{2.11}$$

where λ is a dissimilarity (log sum) parameter ($\lambda \in (0,1]$) which can be estimated.[6] If λ is one, the choice alternatives are seen as independent and the model for independent choices (MNL) developed above applies.

Note that if $0 < \lambda < 1$, there is a positive correlation of the temporal error structure. On the other hand, as λ approaches zero, the random utility components ϵ_{ts} becomes perfectly correlated for all $s > t$. In this case the conditional choice probability of having time r being associated with the highest (stochastic) utility at time t, conditional of not retiring (W), is given by

$$P_{(t)r|W} = \begin{cases} 1 & \text{if } r = r_{\max}, \\ 0 & \text{otherwise.} \end{cases} \tag{2.12}$$

where $r_{\max} = \text{argmax}_{r>t}\{V(t,r)\}$. That is, as the dissimilarity parameter λ approaches zero, only the alternative r with the highest indirect utility matters. 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

$$P_{(t)R} = Prob\{V_{(t)R} + \epsilon_{tt} \geq V_{(t)W} + \epsilon_{tr_{\max}}\} \tag{2.13}$$

where $V_{(t)W}(\cdot) = \alpha_w \tilde{Y}_{tr_{max}} + \alpha_r \tilde{B}_{tr_{max}}$ and $V_{(t)R}(\cdot) = \alpha_r \tilde{B}_{tt}$.

2.2. Measuring Welfare in a Multiperiod Random Utility Model

In this section we will develop a method to calculate expected compensating variation in a random utility framework based on Karlström (1998). 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

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

our model, consumption in different time periods may be considered as different commodities, and there is no need for an intertemporal decomposition of compensating variation. In this respect, our approach is somewhat similar to Keen (1992), who considers the intertemporal decomposition in a deterministic utility framework.

To describe our approach for measuring welfare in a binomial option value model we will start with a simple model in order to highlight the considerations that have to be dealt with in such a calculation. Let us assume that we want to evaluate a policy that decreases the benefits received when being retired, 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

$$V^o_{(t)W} = \alpha_w \tilde{Y}_{tr^o_{max}} + \alpha_r \tilde{B}^o_{tr^o_{max}}, \tag{2.14}$$

$$V^o_{(t)R}(t) = \alpha_r \tilde{B}^o_{tt}. \tag{2.15}$$

The policy to be evaluated will decrease 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

$$V^1_{(t)W} = \alpha_w \tilde{Y}_{tr^1_{max}} + \alpha_r \tilde{B}^1_{tr^1_{max}}, \tag{2.16}$$

$$V^1_{(t)R} = \alpha_r \tilde{B}^1_{tt}. \tag{2.17}$$

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

- Group A: Individuals that retire in period t both before and after the change

- Group B: Individuals who under the pre-reform regime retired in period t, but delay their retirement after the reform.

- Group C: Individuals that do not retire in period t, neither before nor after the reform.

For individuals in group A, the compensation needed to restore the achieved lifetime utility is defined by

$$V_{(t)R}(\tilde{B}^{o}_{tt}) + \epsilon_{tt} = V_{(t)R}(\tilde{B}^{1}_{tt} + c_{\max}) + \epsilon_{tt}. \tag{2.18}$$

We will assume that the random utility components are not changed by the policy reform.[7] 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.,

$$c_{max} = \tilde{B}^{o}_{tt} - \tilde{B}^{1}_{tt}. \tag{2.19}$$

Note that this is the maximum compensation needed for any individual who chooses to 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 on the pre-reform utility level in this period, i.e., $c_{\min} = 0$.

[7]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. However, in a repeated choice framework, the random utility components may change over time, which is a different setting than the one considered here.

The compensation for group B will be 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 work (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

$$V_{(t)R}\left(\tilde{B}^{o}_{tt}\right) + \epsilon_{tt} = V_{(t)W}(\tilde{B}^{1}_{tt} + c) + \epsilon_{tr^{1}_{max}}. \tag{2.20}$$

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

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

$$\alpha_W \tilde{Y}_{tr^{o}_{max}} + \alpha_R \tilde{B}^{o}_{tr^{o}_{max}} = \alpha_W \tilde{Y}_{tr^{1}_{max}} + \alpha_R \tilde{B}^{1}_{tr^{1}_{max}} + \alpha_R c_{min}. \tag{2.21}$$

Hence, $c_{min} = (V^{o}_{W} - V^{1}_{W})/\alpha_R$. Individuals who are indifferent between working or retiring under the pre-reform regime will not have to be compensated if the alternative to work is unaffected by the policy change. These individuals require, like those in Group C, zero compensation ($c_{min} = 0$). The other extreme cases are those who are indifferent between working and retiring under the post-reform policy. Those 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. To find this, we will consider a hypothetical choice situation between retiring under the pre-reform system and working under the post-reform one. The utility associated with retirement pre-reform is given by V_R^o, whereas the utility associated with working after the reform is given by $V_W^1 + \alpha_R c$. Thus, using the logit formulation, the choice probability of retirement in this hypothetical situation is given by

$$\tilde{P}_r(c) = \frac{e^{V_R^o}}{e^{V_R^o} + e^{V_w^1 + \alpha_r c}} \quad , \qquad c_{\min} < c < c_{\max}. \tag{2.22}$$

This expression gives in fact the density distribution of the compensating variation.[8] To see this, consider an individual who chooses to retire in the hypothetical choice situation, achieving a utility of $V_R^o + \epsilon_R$. By revealed preference, this individual will 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. On the other hand, 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 that the individual chooses to retire in the original state, i.e., needs more than c to be compensated, is identical to $\tilde{P}_r(c)$, given by equation (2.22).

The expected compensating variation is given by

$$\mathrm{E}[cv] = c_A + c_B + c_C \tag{2.23}$$

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 with the retirement

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

alternative both before and after the change, we have

$$c_A = P_R^c c_{\max}, \tag{2.24}$$

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 that at least $c_{\max}$ is needed to be compensated. Therefore, $P_R^c = \tilde{P}_R(c_{\max})$.

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

$$c_B = \int \alpha_R c \frac{\partial \tilde{P}_R(c)}{\partial c} dc \tag{2.25}$$

since $-\frac{\partial \tilde{P}_R(c)}{\partial c}$ 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, 1999).

Fortunately, there is also one special case where we have an analytical solution for the compensating variation. This case is when we only have two alternatives.[9] The indefinite integral in equation (2.25) does have an analytical solution in our

[9]This is, in turn, a special case of the situation where individuals only switch to only one alternative after the change. In this situation, we are able to 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.

case, since (ignoring the integration constant) in our model

$$c_B \equiv \int \alpha_r c \frac{e^{V_w^1+\alpha_r c}}{e^{V_r^o}+e^{V_w^1+\alpha_r c}} \frac{e^{V_r^o}}{e^{V_r^o}+e^{V_w^1+\alpha_r c}} dc =$$

$$= \frac{1}{\alpha_r}(V_w^1 - \ln\left(e^{V_r}+e^{V_w+\alpha_r c}\right)) + c - c\tilde{P}_r(c) \quad (2.26)$$

Note also that we can find the conditional compensating variation associated with group B by taking

$$\mathbf{E}[cv \mid B] = \frac{c_B}{\text{Prob}(inB)} = \frac{c_B}{P^o_{(t)R} - P^c_{(t)R}}. \quad (2.27)$$

Since the compensations in Group A is $c_{\max}$ and in Group C is zero, we can calculate all the compensations conditional on choices in each time period.

2.3. Numerical Example

To illustrate how the welfare analysis of a social security reform is carried out, we will consider a simple numerical example with one individual and three time periods. The set up of the example is summarized in Table 1. As can be seen in the table, the individual receives a net income (Y) of 10 units in each time period if he remains in the labor force. The pre-reform pension system replaces 70 percent of this income if he retires in period 2. If he decides to retire in period 1 there is a permanent actuarial reduction of 6 percent of the pension benefit and a permanent actuarial increase of the benefit if he decides to delay retirement to period 3. These rules are shown in column $B^o_{r=t}$ in Table 1.

The hypothetical reform, shown in column $B^1_{r=t}$, decreases the replacement level to 65 percent. The actuarial adjustment of 6 percent if the individual leaves the labor force in period 1 is maintained. In order to simplify, since we assume that the individual leaves the labor force with probability one in period 3, the level of the pension benefit is maintained in this period.

We use the linear value function, shown in equation (2.2). In this specification, the marginal utility of money is implicitly set to one. The subjective discount rate is set to 4 percent, i.e. $\beta = 0.96$. The parameter for the relation between the valuation of income received when the individual is in the labor force and income received when the individual is out of the labor force, k, is set to 1.5. This means that the individual values 2 units of income received as pension benefits as equivalent to 3 units of money received when the individual is in the labor force. Finally, the variance of the type two extreme value distributed error term is set to one.

The columns $\widetilde{B}^o_{tr_{\max}}$ and $\widetilde{B}^1_{tr_{\max}}$ show the present value of the retirement benefits if the individual chooses to retire when the value function reaches its maximum under the pre and post-reform regimes, respectively. The columns for V^o_R and V^1_R show the value function if the individual chooses to retire in the current period. The value function decreases after the reform if the individual chooses to retire in the first or second period. V^o_W and V^1_W show the value functions while working when it is assumed that the worker chooses to retire in the optimal time period. Since this is the third period, and we have set the retirement benefit in the third period at the same amount as under the two alternative regimes, the value functions take the same values under both regimes in this example.

Table 2 shows the results of the numerical example. The P^o_R and P^1_R columns show the predicted probabilities for the individual to retire under the pre and post-reform regimes, respectively. The result shows that the predicted probability for the individual to retire in period 1 decreases from 19 to 3 percent and in the

t	Y_t^o	$B_{r=t}^o$	Y_t^1	$B_{r=t}^1$	$\widetilde{B}_{tr_{\max}}^o$	$\widetilde{B}_{tr_{\max}}^1$	V_R^o	V_W^o	V_R^1	V_W^1
1	10	6.58	10	6.11	20.11	20.53	28.73	30.17	26.68	30.17
2	10	7.00	10	6.50	20.11	20.53	30.68	30.80	29.21	30.80
3	-	7.42	-	7.42	-	-	-	-	-	-

Table 1: Set up of the numerical example.

t	P_R^o	P_R^1	$c_{\max}$	$E(cv \mid B)$	$E[cv]$
1	0.19	0.03	1.36	0.60	0.14
2	0.47	0.17	0.98	0.45	0.29

Table 2: Results from the numerical example.

second period from 47 to 17 percent. This means that the probability for the individual to retire in the last period after the reform is 80 percent compared to 34 percent before the reform.

The $c_{\max}$ column shows the compensation in the event the individual does not change his retirement behavior, i.e., he will require the maximum compensation $(\tilde{B}_{tt}^o - \tilde{B}_{tt}^1)$ to remain at the pre-reform utility level. The $E(cv \mid B)$ shows the expected compensation for the more complicated case in the event that the individual chooses to delay retirement as a result of the reform. As is described in the previous section, this will require that we obtain the probability density function for the hypothetical choice between retiring under the pre-reform regime and continuing to work under the post-reform regime. The cumulative density function is implied by the choice probability displayed in Figure 1.

Finally, the $E[cv]$ column shows the expected compensating variation. Since there is a 34 percent probability that the individual will retire in the third period under both the pre and post-reform regimes, and as we have chosen not to change the pension system for those who retire in the third period, the compensation

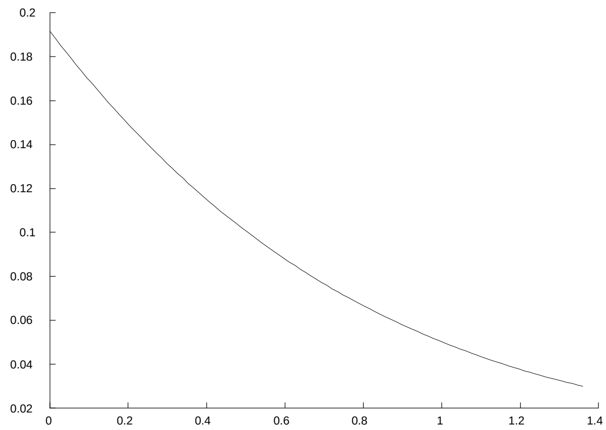

Figure 1: $\tilde{P}_R(c)$ in the numerical example.

under this event will be zero.

There are at least three different ways of evaluating how the economic welfare of this individual is affected by the reform. The first one, which is probably the most common in the public policy literature, is to compare the present value of the lifetime income assuming that the individual does not change his labor market behavior as a result of the reform. An obvious disadvantage with this measure is that it does not take into account the possibility that the individual may counteract the decrease in the pension benefit by increasing the probability of delaying retirement. Therefore, it will in general overestimate the welfare effect of the reform.

An intuitively attractive alternative to this measure is the change in lifetime income taking labor market response into account, i.e., that the probability of retiring later on may increase as a result of the reform. However, this measure fails to account for that this means that the individual also increases the probability of giving up valuable leisure time. Therefore, it will in general underestimate the true welfare effect of the reform.

Finally, the third measure is the present value of the expected compensating variations. The outcome of this measure will, for any reform, be bounded by the other two measures and the exact location will depend on the elasticity of the labor supply response.

For the data in the numerical example, evaluated in the first period with a discount rate on three percent, the first measure predicts a decrease of lifetime income by 0.71 monetary units. The second measure increases by 1.99. This, at first sight non-intuitive result is explained by the fact that the probability of retiring in the third period, which does not alter the benefit levels compared to in the pre-reform state, increases considerably. The third measure decreases by 0.42 monetary units, which is, as expected, between the first and second measures.

This example shows that these three welfare measures can give very different results, i.e., very different evaluations of the pension reform. The first measure gives an almost 70 percent higher welfare loss compared to the compensating variation measure and the second one gives a qualitatively different outcome. This shows that both considering behavioral responses as well as changes in welfare, rather than changes in income, may be important issues in evaluations of pension reforms.

3. Analyzing a Hypothetical Reform of the Swedish Income Security System

3.1. Sweden's Income Security System

The income security system in Sweden consists of two main parts: the public old-age pension system and the compulsory labor market insurance programs. Both these parts are, to about the same extent, used for financing exits from the labor market. In this sub-section we give a brief description of how these programs are constructed.[10] We start with the public old-age pension programs and the occupational pension schemes. We then describe the disability, sickness and unemployment insurance programs.

3.1.1. The Public Old-age Pension System

Sweden's public old-age pension system consisted of two main parts during the period studied:[11] a basic pension and the 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 age 60 with a permanent actuarial reduction of 0.5 percent for each month of early withdrawal. If the pension is claimed beginning after age 65, the level is permanently increased by 0.7 percent for each month of delayed withdrawal up to age 70.

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 percent of a BA

[10] For a more complete description, see Palme and Svensson (1999 and 2001).

[11] The description is based on the rules pertaining for persons covered in the study. Sweden has succesively introduced a reform of the public old-age pension system in the 1990s.

for a singled pensioner and 78.5 percent for married. In the year 2001 the level of one BA was 36 900 SEK.[12] 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

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

where AP_i is individual average pension points, BA is the basic amount, N_i is the number of years the individual has recorded covered income greater than zero. The average of pension points is calculated as the average of 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 adjustment for early and delayed withdrawal are the same as for the basic pension.

3.1.2. Occupational Pensions

Sweden has a highly unionized labor market. Around 95 percent of all employees are covered by central agreements between the unions and the employers confederations. These agreements regulate pension programs and other insurances for the employees. There are four main agreements, each with a pension scheme. The private sector has one scheme for blue and one for white collar workers. In addition to that, there is one scheme for employees in central government and one for employees in county and local governments.

The private sector blue-collar workers included in our sample are under two different occupational pension schemes. Those born 1927 to 1931 are covered by the STP scheme. The amount of the benefit in this scheme is calculated as 10

[12] In 2001 the exchange rate was 1\$ $\approx$ 10 SEK.

percent of the average annual earnings below the social security ceiling of the three best years of the five years between age 55 and 59. At least three years of earnings between age 55 and 59 are required to be eligible for the pension. The benefits is paid out starting when the worker is aged 65.

In 1996 the STP scheme was replaced by a fully funded scheme. The cohorts between 1938 and 1940 are covered by a transition scheme and those who are born between 1932 and 1937 are able to choose between STP and the transition scheme. The benefits in this scheme are calculated as 10 percent of annual earning under the social security ceiling after age 30 plus the amount which the worker receives from the fully funded system. The contributions to the fully funded scheme was 2.0 percent of annual earnings between 1996 and 1999. The amount were changed to 3.5 percent in 2000.

White collar workers in the private sector are in general covered by the ITP and ITPK schemes. The amount of the ITP pension is calculated as 10 percent of the worker's earnings the year before retirement up to the social security ceiling at 7.5 BA, 65 percent between 7.5 and 20 BAs, and 32.5 percent between 20 and 30 BAs. The normal retirement age for the ITP pension is 65, but it can be claimed with an actuarial adjustment from age 60. ITPK is a fully funded scheme which was introduced in 1977. The contributions to this scheme amount to 2 percent of gross annual earnings.

Up to 1992, employees in central government were covered by a gross pension scheme which replaced 65 percent of annual earnings the year before retirement. This scheme was replaced with a net pension which is quite similar to the ITP scheme. However, the benefit is determined on the average of annual earnings during the five years preceding retirement. The employees in central government are also covered by fully funded scheme which was introduced in 1992. The contribution to this scheme is 1.7 percent of the annual wage sum.

Finally, employees in county councils and local government are covered by a gross pension which is determined by the average of annual earnings of the five best years of the seven years preceding retirement. It replaces 96 percent below 1 BA, 78.5 percent between 1 and 2.5 BA, 60 percent between 2.5 and 3.5 BAs, 64 percent between 3.5 and 7.5 BAs, 65 percent between 7.5 and 20 BAs, and 32.5 percent between 20 and 30 BAs. It can be claimed with an actuarial adjustment from age 60.

3.1.3. 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 capacity to work is permanently reduced by at least 25 percent. Full compensation requires that the capacity is 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 consists 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 age 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 on several occasions during the time period covered by this study. In a reform in 1987 the replacement level was set to 90 percent of the worker's insured income. Since then, the replacement has been decreased on several occasions. The first time was in a reform in 1991. In 1996 it was set to 75 percent of the insured income for long sickness spells and in 1998 it was raised to 80 percent.

The *unemployment insurance* benefit consists of two parts: one basic part, which is unrelated to the worker's insured income, and one part which requires membership in an unemployment benefit fund and is related to the worker's insured income. Unemployed workers who actively search for a new job are eligible for compensation. The main difference between the benefit level in the unemployment and sickness insurance is the ceiling. The ceiling of the latter is the same as for other parts of the social insurance system, while that of the former is subject to discretionary changes, and is lower than the ceiling for the sickness benefit. 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.

3.1.4. Income Taxes and Housing Allowances

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

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

3.2. Data

We use the Longitudinal Individual Data (LINDA) panel. LINDA 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 data primarily on occupation and housing conditions from mailed questionnaires made every five years to the entire population; 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. Data on earnings below the social security ceiling are obtained back to 1960 from the pension register.

We have selected men born between 1927 and 1940. We have excluded individuals younger than age 50. Since, e.g., the youngest cohort, born in 1940, are just 43 years old in 1983, we exclude the first seven observations for each individual from this cohort.

We have also excluded the self-employed. The reason for doing this is that the

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 more than 50 %	5.67

Note: The 10.02 percent of the sample who 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 wife's supplement.

Table 1: Percentage share of the pathways to permanent exit from the labor market showing main source of income (more than 50 percent from the indicated source); cohorts born 1927-1932; by gender.

quality of the income data can be questioned for this group.[13] Furthermore, it is not possible to obtain information on their pension rights from the data.

Using these criteria 15,619 observations remained from the originally 22,375 for the cohorts included in the study. The total number of observations is 127,390.

Table 1 shows the distribution of main income source the year after the worker's exit from the labor market. It is notable that almost 35 percent of the newly retired receive their main income from the labor market insurances - in particular the sickness and unemployment insurance. A closer analysis[14] of how they change main income source after retirement shows that those who use the sickness and unemployment insurance as a main income source immediately after retirement

[13] Self-employed are always able to accumulate wealth within their own business.

[14] See Palme and Svensson (2001).

switch after on average about two years to disability insurance. This analysis also shows that older workers on average switch faster to disability insurance.

3.3. Estimation

A problem in the estimation of the model is the possible endogeneity of the benefit levels conditional on retirement age. As is apparent from the previous section, a large fraction of those who permanently exit from the labor market relatively early on use the labor market insurances as main income source after retirement. The level of the benefits are in general higher for the labor market insurances compared to in the old-age pension system, which is an exit alternative at age 60. If the labor market insurances were available for all workers in the sample the benefit level of these should be used for the variable measuring the benefit levels. However, this is obviously not the case since there is a health test for being eligible for both sickness as well as the disability insurance and a requirement of active search for being eligible for unemployment insurance.

If the benefit levels of the labor market insurances were used they would result in larger economic incentives for leaving the labor market than what a large share of the sample actually act on. In turn, this would lead to underestimation 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 who use these insurances when retiring we will get an endogeneity problem: we assign more generous economic incentives from the income security system to workers who tend to leave the labor force early on. This will, in turn, lead to overestimation of the effect of economic incentives.

We use a pseudo-IV, or probabilistic, approach to deal with this problem. 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[15] of different paths out of the labor force in the data, we will, for practical reasons, follow a simplified approach. In the first step, we construct a "synthetic" insurance path. We use the observation that the most common route for those who retire by using labor market insurances is to use the sickness or unemployment insurance for some time before they switch to disability insurance, where the time period on sickness or unemployment insurance decreases with the worker's age.[16] For each age we use the predicted time period before the switch to disability insurance from the polynomial in age, i.e., we assume that, at this age, the worker can expect the predicted time with the higher benefit level from the sickness or unemployment insurance before he switch to the disability insurance, provided that he is eligible for getting compensation from a labor market insurance. Since the benefit levels of the sickness and unemployment insurance are quite similar, we will, to facilitate, use the benefit level of the sickness insurance for both.

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. We then predict the probability for each individual to get compensation from a labor market insurance. Finally, we

[15] 911 in the entire sample.

[16] See Palme and Svensson (2001), which uses the same approach, for a more detailed description.

calculate the benefit variable as

$$\widetilde{B} = \widetilde{B}_{OAP} + p\left(\widetilde{B}_{LI} - \widetilde{B}_{OAP}\right), \tag{3.1}$$

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

Due to the very large number of possible individual income paths inherent in the option value model, computer memory restrictions forced us to limit the sample size radically. Therefore, a random sample of 1,442 individuals, yielding 13,072 observations, was made from the original sample.

3.4. Estimation Results

To discriminate between the multinomial retirement model and the binomial maximum approach we use a nested logit model. The estimates show that we cannot reject the hypothesis of the dissimilarity parameter being equal to zero. For numerical reasons it is difficult to estimate this parameter close to zero. The estimation result shows that the dissimilarity parameter is not significantly different from zero. 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.

We are able to estimate all but one parameter in model 2.2 simultaneously. We have tried a large set of reasonable values on the discount parameter, β, and chosen the parameter value .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

	$\widehat{\theta}$	$\widehat{\theta}/\widehat{\sigma}_\theta$
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

Note: 24 indicators for counties also included in the specification.

Table 2: Parameter estimates. n=13,072 (from 1,442 individuals). β set to .95.

to .95.

The estimates of the parameters α_W and α_R are both significantly different from zero, and with the expected signs. An interpretation of this result is that economic incentives matter for the retirement behavior of the workers in the sample. The estimate of the ratio between α_W and α_R is not significantly different from one, i.e., we cannot reject the possibility that the individuals in the sample have zero marginal utility of leisure in retirement. This is unexpected, since it is generally assumed that retirees have a higher marginal valuation of leisure. However, it is hard to identify this parameter from the discount rate which is set to a comparatively high rate at 5 percent. Note also, that a non-unit ratio would not be consistent with optimal inter-temporal income allocation, which could have indicated the usefulness of incorporating saving into the model.

3.5. 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 to have access to labor market insurances (Disability, Unemployment and Sickness insurance) is also delayed by three years. That is, all economic incentives to exit from the labor market are delayed by three 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.

We have 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 of 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 mean for 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 (forthcoming).

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

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

As we argued in Section 2, the first two measures are the most common ones used in the public policy discussion of the income distribution implications of pension reforms. By including them in the comparison, we are able to evaluate if the outcome of the analysis is affected by including a measure that also considers the valuation of leisure time, as the compensating variation measure does.

3.5.1. Efficiency

A social security reform may have an effect on overall efficiency. The fact that the worker is able to 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. This amount corresponds to almost 40 percent of the total budget change.

Another way of studying the efficiency change from the reform is to compare it with an optimal reform, i.e., a reform which maximizes the aggregate welfare gain[17]. Since we have derived an analytical expression for CV in our model, we can analytically investigate how such reform may be characterized.[18] In our policy reform, eligibility was changed, primarily affecting lifetime benefits for early ages. To simplify the theoretical analysis, we will assume that $\tilde{B}_{r_{\max}}$ is unaffected by the reform. We define "deadweight gain" as the difference between the budget gain and aggregate CV change. The optimal reform can be characterized as one which maximizes deadweight gain subject to a specified budget gain, i.e.,

$$\max_{\theta} \left\{-c_A - c_B + Pr^c(\theta) + (P_r^o - P_r^c(\theta))G\right\}. \tag{3.2}$$

Suppressing subscript t everywhere, $\theta = \tilde{B}^o - \tilde{B}^1$ denotes the reduction in benefits at time t, and $G = g + \tilde{B}^o - \tilde{B}_{r_{\max}}$ 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 that delay their retirement to year $r_{\max}$.[19]

[17]In the context of optimal taxation, one could analyze a model with or without a constraint on required budget revenue. In the following, we will characterize an optimal reform in an unconstrained maximization of aggregate welfare.

[18]Optimal taxation models are rarely in a random utility framework. One exception is 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.

From Section 2.2 we know that

$$\begin{aligned} c_A &= P_r^c(\theta)\theta \\ c_B &= -\int_0^\theta c\frac{\partial P_r^c}{\partial c}dc \end{aligned} \quad (3.3)$$

and therefore our maximization problem (3.2) can be rewritten as

$$\max_\theta \int_0^\theta c\frac{\partial P_r^c}{\partial c}dc + (P_r^o - P_r^c(\theta))G. \quad (3.4)$$

Note that marginal welfare loss and marginal budget gain is always equal for group A, individuals that 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 who delay their retirement, i.e.,

$$\frac{\partial P_r^c}{\partial c}(\theta)\theta = \frac{\partial P_r^c}{\partial c}(\theta)G. \quad (3.5)$$

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

$$\theta = G. \quad (3.6)$$

The deadweight gain is entirely determined by those who change states, labeled as group B in Section 2.2. In this group, the conditional marginal welfare loss is θ and the conditional marginal welfare gain is G and the result θ should be equal to G for an optimal reform do not depend on any elasticities as long as there is a positive choice probability of retirement less than one in each time period.

[20] Of course, 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 deadweight gain equals zero.

Setting $\theta = 0$ in equation (3.6), the optimal reform can be summarized by the following expression:

$$\widetilde{B}_{\max} = \widetilde{B}^{o} + g, \tag{3.7}$$

where g is net government tax revenue. This gives us a straightforward interpretation of the result: the optimal reform should be equal to an "actuarial fair" pension scheme in the sense that the net budget gain for the public sector (including income taxes) should be equal to what the individual expects to lose in future benefits.

Figure 1 relates the optimal reform to the outcome of the hypothetical one. The thick line shows the path of the optimal reform, i.e., where the government revenue gain is equal to $c_{\max}$. The contour plot shows the joint distribution of the predicted government gain and $c_{\max}$ for all individuals in the sample. Overall, the results displayed in Figure 1 show that there is an apparent correlation between the predicted government budget gain and $c_{\max}$ in the sample and the reform is close to being optimal for the individuals in the highest density segment of the sample. However, the contour plot also shows that there is a large dispersion within the sample, with a large share being comparatively far away from the optimal reform path.

3.5.2. Income Distribution

As we described in Section 2.2, the expected CV measure can be calculated for each individual in each point of time. Figure 2 shows the distribution of the predicted expected CV measures for the hypothetical reform for four different age groups. The Figures show that both the mean and the variance of the CV distribution

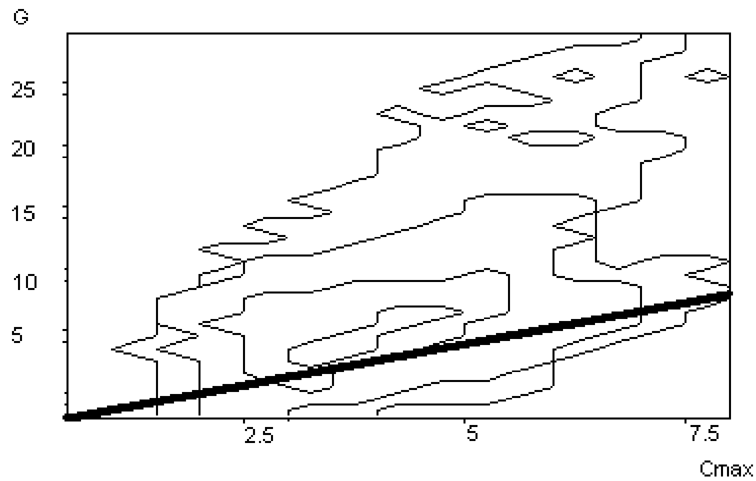

Figure 1: The optimal pension reform path ($c_{\max} = G$) along with contour plots of the joint distribution of the predicted net budget gain and maximum welfare loss in the sample.

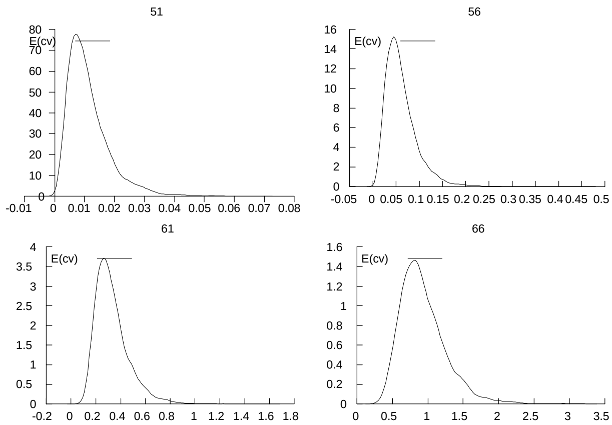

Figure 2: Distribution of the predicted expected welfare change at age 51, 56, 61 and 66 respectively.

increase with age. This pattern is due to the fact the predicted probability of retiring is relatively low for all workers at young ages. This implies that very few require the maximum compensation in the group of workers who are retired under both the pre- and post-reform regimes. Furthermore, the workers will be predicted to have a very small probability to change states as a result of the reform. As they age, the predicted probability of being retired, as well as switching states as a result of the reform will increase. This will, in turn, increase both the mean and the dispersion of the expected compensations.

The figures in Table 3 show box-plots of the distribution of predicted pre-reform retirement probabilities, predicted changes in retirement probabilities, c_{max} and CV in quintile groups by labor income at age 50 for three different age groups (age 54, 59 and 64, respectively). To get an intuitive understanding, note that the first three measures build up the fourth one, CV, shown in the fourth row. In

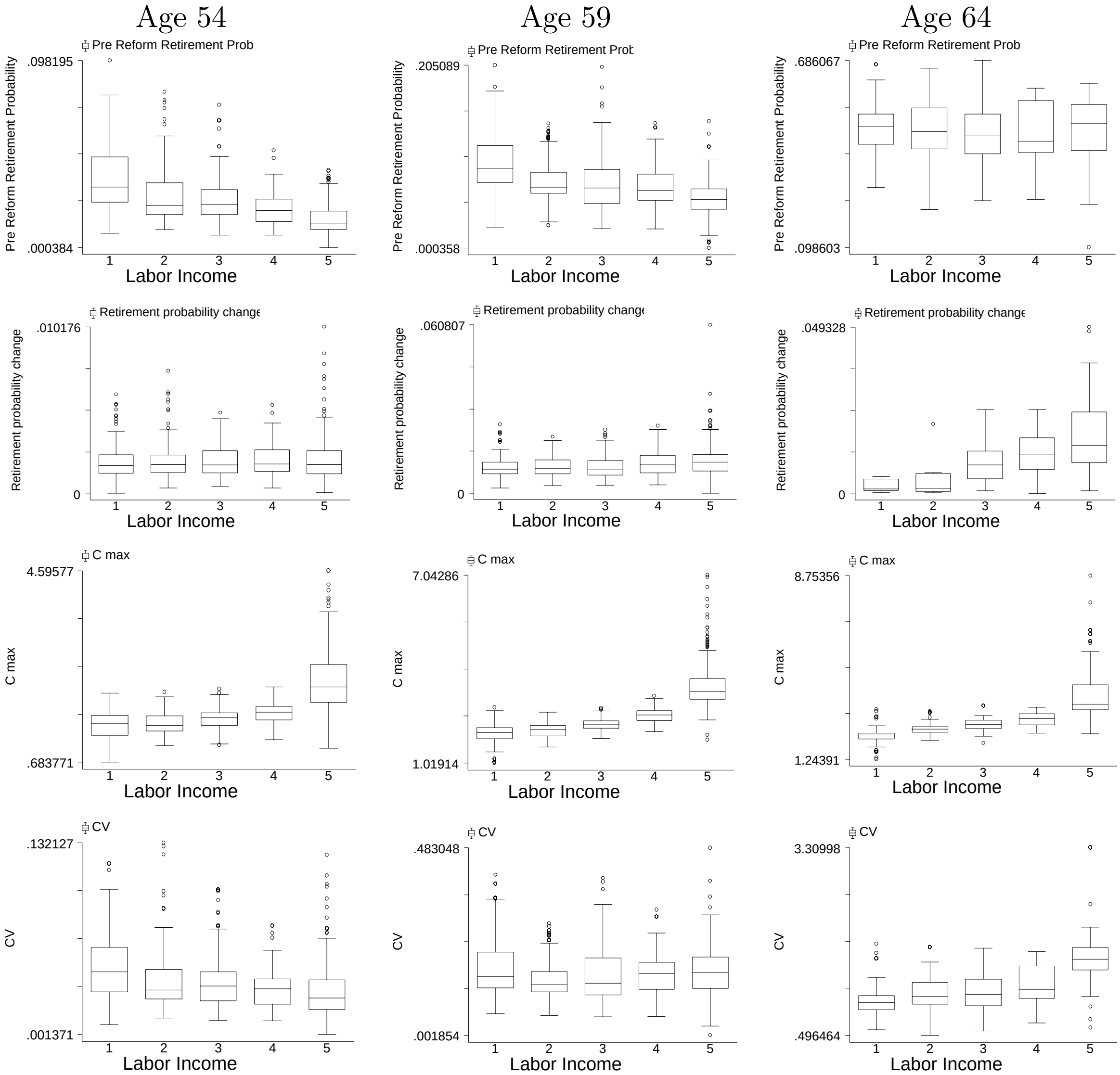

Table 3: Box -and-whisker plots of the distribution of pre reform retirement probabilities, retirement probabilitiy change from the reform, maximum welfare loss of the reform and compensating variation by quintile groups of labor income at age 50. Three different age groups: 54, 59 and 64 year olds.

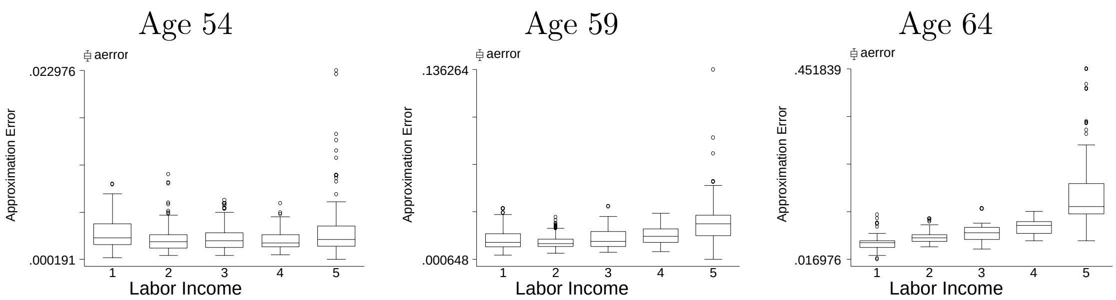

Table 4: Box-and-whisker plots of the distribution of approximation errors (the difference between CV and the predicted income change following the reform) by quintile groups of labor income at age 50. Three different age groups: 54, 59 and 64 year olds.

addition to what we already know from the analysis in Figure 2, that the mean and variance of the CV distribution increase with age, the forth row panels in Table 3 show that median CV is fairly constant in different income groups in the first two age groups (age 54 and 59), but increases with income among the 64 year olds.

The determinants of this result can be seen in the first three rows. In the first two age groups, the higher level of c_{max} in the high income groups due to relatively higher levels of pension benefits, is counteracted by higher pre-reform retirement probabilities in lower income groups.[21] Among the 64 year olds, the retirement probability is very high among all income groups and the second row shows that the group with high labor income is more likely to change retirement behavior as a result of the reform. This result, together with the higher level of c_{max} builds up the higher welfare loss from the reform for high income workers.

[21]This result is primarily due to higher probability to claim DI and other labor market insurances at young ages for low income workers.

The figures in Table 4 show box plots of the distribution of approximation errors, the difference between CV and the approximative measure of welfare change (the second measure described above), for the quintile groups by labor income for the three different age group. A distinct pattern of increasing approximation error by labor income can be seen in the two oldest age groups. There are two possible explanations for this result. First, high income workers may be able to counteract the welfare loss by changing their behavior to a larger extent and therefore experience a smaller welfare loss. Second, the welfare gain of changing the behavior can simply be larger for this group.

The second row panel in Table 3 shows that the change in the retirement probability is indeed largest among high income workers among the 64 year olds, i.e., at least some of the explanation to the observed pattern of the approximation error in this age group could be attributed the behavioral response to the reform. For the 59 year age group the pattern of increasing change in retirement probability is much weaker and, therefore, the explanation of the results in Table 4 is much weaker for this age group.

From the results discussed above, it is evident that workers with relatively high labor income experienced a larger welfare loss from the reform measured in *absolute* amounts. It is, however, not clear how it relates to their labor income during the period when they were still active on the labor market, compared to low income workers. If it is a larger share, the reform is likely to make the relative lifetime income distribution more equal, i.e., it is likely to redistribute lifetime income.

To assess equity we will use a measure for summarizing the relative income distribution. There exist several such measures. A common disadvantage with such measures is the loss of information in summarizing an entire distribution in a single number. Different measures weight different parts of the income distribution differently and what weights should be given to e.g. the lower end of the distribution is a matter of individual values. We will, therefore, use Lorenz and concentration curves, which display the entire distribution, to show the income distribution effects.

Figure 3 shows the Lorenz curve for labor income at age 50 along the concentration curves for CV due to the reform and the Approximative measure of welfare change, i.e., the lifetime income change when we do not consider that the workers may change their retirement behavior as a response to the reform. In a Lorenz diagram, the individuals are ordered in ascending order according to their income and the Lorenz curve shows the cumulative share of total income received by the lowest share depicted on the x-axis. If all individual have exactly the same income, the Lorenz curve will coincide in every point with the diagonal line in the Lorenz diagram. If the income distribution deviates from perfect equality, the Lorenz curve will be below the diagonal line.

The concentration curve, for e.g. CV, shows the cumulative share of total CV *maintaining the ordering* of the individuals obtained for the Lorenz curve. Unlike the Lorenz curve, a concentration curve can be located above the diagonal line. This corresponds to the case when low income individuals receive a larger fraction of the amount measured by the concentration curve. If it is located between the diagonal line and the Lorenz curve, the amount is allocated such that low income individuals receive a smaller share, but larger than proportional to their income. If the amount measured by the concentration curve is paid income taxes, such location of the concentration curve would correspond to regressive income taxes. Finally, if the concentration curve is below the Lorenz curve the amount measured by the is allocated such that low income individual receive a smaller share compared to their income. Again, if the amount measured by the concentration curve is paid income taxes, this latter location of the concentration curve would correspond to a progressive tax system.

As is evident from the location of the concentration curve for the welfare loss from the hypothetical social security reform in Figure 3, the reform is regressive in the sense that low income individuals experience a larger welfare loss than is proportional to their labor income before retirement, although the loss is smaller in absolute amounts for these individuals.

4. 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 programing model) for the retirement decision. This means that we are able to consider the welfare implications of a social security reform, taking individual responses in retirement decision to the reform into account.

This method is then applied, using Swedish micro-data, to the analysis of a hypothetical reform of the Swedish income security system where eligibility ages are delayed by three years in all programs. The results on aggregate changes show different aspects of the importance of taking retirement behavior responses to social security reforms into account. First, in addition to the direct effects of lower benefit payments on the budget of the public sector, there is also a substantial effect through higher tax payments due to delayed retirement. Second, due to the

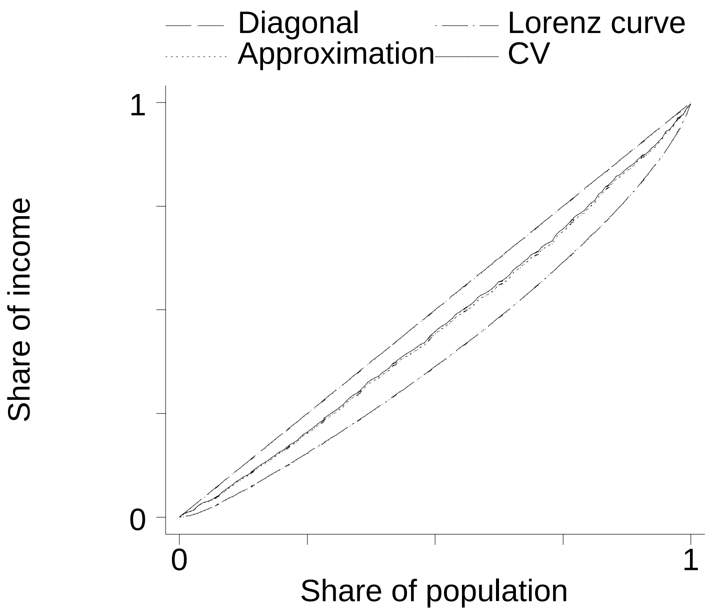

Figure 3: Lorenz curve for labor income at age 50 along with concentration curves for CV and approximative measure of welfare change from the hypothetical pension reform.

behavioral response to the reform, the budget effect of the reform will exceed the aggregate welfare loss from the reform. This welfare gain should be taken into account when effects on the intergenerational income distribution of cuts in social security benefits are analyzed.

The income distribution analysis of the hypothetical pension reform showed that high income workers on average would have experienced the greatest welfare loss from the reform. This is not surprising since they, given the construction of the Swedish income security system, would expect the largest absolute benefits from the system. However, the analysis shown in the Lorenz diagram shows that the welfare loss is smaller as an average share to their labor income at age 50 compared to low income workers. This means that the reform is regressive *vis-á-vis* the distribution of labor income at age 50.

The analysis also shows the difference between the CV welfare measure and the predicted income change is largest for high income workers. This means that if the income distribution analysis is based on income, rather than welfare change, the reform would appear to be less regressive than it actually is.

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 programing framework. Lumsdaine, Stock and Wise (1992) have shown that the option value model underestimates the value of postponing retirement relative to a dynamic programing model. It is, however, an open question as to 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 we described above, a welfare enhancing response, in addition to delayed retirement, to a cut in social security benefits is increased individual savings. Our results should therefore be interpreted as upper bounds of the true welfare loss of social security benefit cut. French and Jones (2001) shows how savings behavior can be included in a dynamic programing retirement choice model.

Finally, we showed how the closed form welfare measure can be used from a normative perspective, for designing changes in the social security system. This analysis was, however, restricted to efficiency considerations. An extended analysis can be based on a social welfare function which also considers the possibility of income redistribution through the social security system.

References

Ben-Akiva, M., 1973, "Structure of passenger travel demand models", Ph.D. dissertation MIT.

Blundell, R., and T. MaCurdy, 1999, "Labor Supply: a Review of Alternative Approaches" in O. Ashenfelter and D. Card, eds., *Handbook of Labor Economics* vol 3a, Elsevier North-Holland, Amsterdam.

de Borger, B., 2000, "Optimal two-part tariffs in a model of discrete choice", *Journal of Public Ecnomics*, 76, 127–150.

French, E., and J. Jones, 2001, "The Effects of Health Insurance and Self-Insurance on Retirement Behavior", paper presented at a Conference on Social Insurance and Pensions Research in Aarhus, November 2001.

Gruber, J., and D. Wise, forthcoming, *Social Security and Retirement around the World: Volume 2*, The University of Chicago Press: Chicago.

Hanemann, W.M., 1985, "Welfare Analysis with Discrete Choice Models", Department of Agricultural and Resource Economics, Working Paper, University of California, Berkeley, reprinted in Kling, C. and Herriges, J. eds., *Valuing the Environment Using Recreation Demand Models*, Edward Elgar, 1999.

Herriges, J.A., and C.L. Kling, 1999, *Nonlinear Income Effects in Random Utility Models*, Review of Economics and Statistics, 81, pp. 62-73

Karlstrom, A., 1998, *Hicksian Welfare Measures in a Nonlinear Random Utility Framework*, Working Paper, Department of Infrastructure and Planning, Royal Institute of Technology, Stockholm.

Karlstrom, A., and E. Morey, 2001, *Quickly and Accurately Calculating Welfare Measures in GEV Random Utility Models with Income Effects: a Primer*, Working paper, Department of Economics, UC Berkeley.

Keen, M., 1990, "Welfare Analysis and Intertemporal Substitution", *Journal of Public Economics*, 42, pp. 42–66.

Lumsdaine, R.L., and O. Mitchell, 1999, "Economic Analysis of Retirement", in O. Ashenfelter and D. Card, eds., *Handbook of Labor Economics* vol 3c, Elsevier North-Holland, Amsterdam.

Lumsdaine, R.L., J.H. Stock, J.H., and D.A. Wise, 1992, "Three Models of Retirement: Computational Complexity vaersus Predictive Validity" in D. Wise, ed., *Topics in Economics of Aging*, University of Chicago Press, Chicago.

McFadden, D., 1978, "Modeling the Choice of Residential Location", in Karlqvist, A., et al. eds., *Spatial Interaction Theory and Planning Models*, Amsterdam: North-Holland, pp. 75–96.

McFadden, D., 1999, "Computing Willingness-to-Pay in Random Utility Models", in J. Moore, R. Riezman, and J. Melvin, eds., *Trade, Theory and Econometrics: Essays in honour of John S. Chipman*, Routledge, London.

McFadden, D., 2000, *Disaggregate Behavioral Travel Demand's RUM Side: A 30-Year Retrospective*, Working paper, Department of Economics, UC Berkeley.

McFadden, D., and Leonard, G.K., 1993, "Issues in the Contingent Valusation of Environmental Goods: Methodologies for Data Collection and Analyssis", in Hausman, J.A., ed., *Contingent Valuation: A Critical Assessment*, Elsevier Science Publishers.

Palme, M., and I. Svensson, 1999, Social Security, "Occupational Pensions and Retirement in Sweden", in J. Gruber and D. Wise, eds., *Social Security and Retirement around the World*, The University of Chicago Press: Chicago.

Palme, M., and I. Svensson, 2001, *Income Security Programs and Retirement in Sweden*, Working Paper no. 422, Stockholm School of Economics.

Preston, I., and Walker, I., 1999, "Welfare measurement in labour supply models with nonlinear budget constraints", *Journal of Population Economics*, 2, pp. .

ust, ., and Phelan, ., , How ocial ecurity an edicare ect etirement aha ior in a orld of Incomplete arkets , *Econometrica*, 65, pp. 781–831.

Samwick, A., 1998, "New Evidence on Pensions, Social Security, and the Timing of Retirement", *Journal of Public Economics*, 70, pp. 207–236.

Small, K.A., 1992, *Urban Transportation Economics*, Harwood Academic Publishers.

Stock, J., and D. Wise, 1990, "Pension, the Option Value of Work, and Retirement", *Econometrica*, 58, pp. 1151–1180.

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