

MEMORANDUM

No 10/2003

Retirement in Italy and Norway Hohh

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21 March 2003

Retirement in Italy and Norway

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Abstract

A structural model for retirement and employment based on a flexible, parametric utility function is developed. The model requires only cross section data and is estimated on survey data for Italy and register data for Norway. The estimates indicate that the preference structure among middle-aged Italian males and Norwegian males and females who are approaching retirement has strong similarities. The utility function estimates from a model with no consumption smoothing, seem more reasonable than estimates from a model with a perfect credit market. Policy simulations indicate a somewhat stronger response to cuts in pension benefits in Norway than in Italy.

JEL Classification: D10, H55, J26.

Keywords: Retirement, inter-temporal interpretation, estimates and policy simulations, Italy, Norway.

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1. Introduction

Today, nearly all industrialized countries are aging. An increasing number of individuals are becoming eligible for retirement, and the maturing of the pensions system gives increasing pension levels. Also, the fertility rates have declined sharply. With the present pension rules, an increasing burden of work and tax payments will have to be born by a declining number of individuals in the work force over the coming decades. Restoring viability of the pension systems usually require use of a number of policy measures, among which may be measures to increase the labour force participation of older persons. Applying such measures requires knowledge of labour supply responses among older persons. Many studies of this have been conducted on data sets for single countries, using both cross section and longitudinal data sets. Since pensions systems usually change only slowly over time, such studies are dependent on the variation one finds among individuals, caused by differences in age and labour force participation, and changes in the pension system. Such changes usually occur with long intervals, so that large groups of individuals have lived under more or less the same pensions regime. The empirical basis for assessing labour supply responses and predicting results of such reforms in a single country is therefore limited in many respects.

Cross-country comparisons on the other hand can provide large differences both in incentives and responses, since cohorts in different countries may have accumulated rights under different regimes, thus providing a source of independent variation in potential pension in relation to previous earnings. However, there is a need to control for other differences.

The pension systems in Italy and Norway are fairly different, as are the labour force participation of older persons. In Italy, in the period studied here, the early retirement option is in fact a seniority pension system with no requirement with respect to age when retiring, while the Norwegian early retirement scheme makes it possible for some to retire only a few

years before the statutory age in the public old age system. The average retirement age in Italy is much lower than in Norway, probably the lowest one in Europe. Moreover the replacement ratios (after tax pension benefits relative to after tax wage income) tend to be higher in Italy than in Norway. There are also other differences between the two countries. In order to be able to assess and compare the impact of incentives, these differences should be accounted for. In this paper, we strive to construct comparable micro cross-section data sets of the retirement patterns in Italy (1993) and Norway (1996). The reason for using Italian data from 1993 is that prior to 1993/92 the pension system has essentially been the same since the late 1960s. In the 1990s three reforms have been introduced (Amato, 1992; Dini, 1995 and Prodi, 1997) with a complex implementation of the new rules.

In order to estimate labour supply responses among older people we have employed a very simple model of retirement decisions that can be estimated on a single cross-section sample, and still be given a structural interpretation in terms of inter-temporal decisions.

Empirical models of retirement typically use flow data (i.e. containing information on change of status) and adopt some version of the stochastic dynamic programming approach (e.g. Lumsdaine et al. 1992, Stock and Wise, 1990 and Rust and Phelan, 1997). Here we follow a much simpler research strategy, which exploits the first order conditions of a standard inter-temporal optimisation problem (as in Burtless and Moffitt, 1985 and Gustman and Steinmeier, 1986). The model can be estimated on a single cross-section sample, as in Zweimüller, Winter-Ebmer and Falkinger (1995), and can still be given a structural interpretation in terms of inter-temporal decisions.

We have estimated the models under two alternative assumptions with respect to constraints in the credit market. In the first alternative we assume that the agents are facing liquidity constraints to the extent that total consumption in each period (year in this study) is equal to current disposable income (no consumption smoothing). This non-smoothing

assumption is standard in econometric models of retirement. In the second alternative we go to the other extreme and assume that the credit markets are perfect (perfect consumption smoothing). In the Italian data set consumption is based on consumer surveys linked to labour market data and income data, while in the Norwegian dataset income and savings are observed. In reality the credit markets are neither totally perfect nor totally imperfect. However, it is hard to observe the factual credit constraint that each household is facing and our estimates reported below are only meant to illustrate the empirical importance of the credit constraint assumption.

In chapter 2 we present the models from which we derive the optimal point in time for retirement, given the institutional structure described for the two countries in *Appendix 1*. The empirical specification of the models, summary statistics and estimates of the deterministic part of the utility functions are presented in chapters 3-5. We find that the estimates of some parameters of the utility function are significantly affected by the assumption regarding how perfect the credit market is. In chapter 6 we give the results of micro simulations with the models of a 10 per cent reduction in pension benefits. The impact in terms of increases in the labour force turns out to be modest, but not irrelevant from the perspective of giving the individuals an incentive to postpone retirement. Although the responses to the policy simulation tend to be stronger in Norway than in Italy, the responses are surprisingly similar, given the difference in institutions and labour market participation.

2. A model of individual retirement decisions

2.1 Imperfect credit markets, no consumption smoothing

In this case annual consumption, denoted C , has to be less than or equal to annual after tax income. If retired, annual after tax income is denoted R and if working, annual after tax income is denoted W . Because utility will be assumed to be strictly increasing in

consumption and because of the assumption of no saving or borrowing, utility is derived from current disposable income (and from other variables dependent on the employment or retirement status, such as the amount of leisure). Thus annual consumption entering the utility function is replaced by annual disposable income.

Let us define

(1) $U_{R_t}(R_t(\tau))$ = instantaneous utility of a retired individual receiving a pension $R_t(\tau)$ in year t , given that he retired in year τ , with $\tau \leq t$.

(2) $U_{W_t}(W_t)$ = instantaneous utility of the individual if working at year t and receiving an income W_t .

We then write the inter-temporal utility, $V(\cdot)$, as the sum of discounted future instantaneous utilities,

$$(3) V(\tau) = \int_0^{\tau} e^{-\delta t} U_{W_t}(W_t) dt + \int_{\tau}^D e^{-\delta t} U_{R_t}(R_t(\tau)) dt$$

where time is measured since the start of the working career, τ is the point in time of (irreversible) retirement, $e^{-\delta}$ is the discount factor, and D is the expected length of life².

The necessary condition for a maximum of $V(\tau)$ with respect to τ is

$$(4) U_{W_{\tau}}(W_{\tau}) = U_{R_{\tau}}(R_{\tau}(\tau)) - \Delta(\tau) \equiv U_{R_{\tau}}(R(\tau)) - \int_{\tau}^D e^{-\delta(t-\tau)} \frac{\partial U_{R_t}(R_t(\tau))}{\partial \tau} dt$$

If $V(\tau)$ is single-peaked the condition is also sufficient. The individual will be observed in retirement status in year t if and only if

$$(5) U_{W_t}(W_t) \leq U_{R_t}(R_t(t)) - \Delta(t)$$

² There are two simplifications here. The first is the assumption that retirement is irreversible; this is realistic, although there might be a significant (but unobserved) amount of paid work among retired people. The second one is the assumption that the individual maximises the intertemporal utility given the expected length of life instead of maximising the expected intertemporal utility (with expectation taken with respect to the

in employment status in year t if and only if

$$(6) \quad U_{W_t}(W_t) > U_{R_t}(R_t(t)) - \Delta(t).$$

Note that the term $\Delta(\tau)$ (evaluated at the time of retiring) is the (future) gain in utility by postponing retirement by one more year, which is positive if the future pension level then increases. This comes in addition to the utility of earnings U_{W_τ} and the two are compared to the utility of retirement U_{R_τ} . If one assumes that $\Delta(\tau)$ is negligible (either because it is small or because the individual is myopic), then the condition defining retirement versus employment status reduces to the comparison between the (actual or potential) instantaneous utilities in the two statuses. This is essentially the road chosen by Zweimüller *et al.* (1995), although they do not provide a structural interpretation of the empirical model. Given an empirical specification of the utility function the term $\Delta(\tau)$ can be computed or approximated, see *Appendix 3*. From the definition of $\Delta(\tau)$ in (4) we observe that

$$(7) \quad \Delta(\tau) = \int_{\tau}^D e^{-\delta(t-\tau)} \frac{\partial U_{R_t}(R_t(\tau))}{\partial \tau} dt = \int_{\tau}^D e^{-\delta(t-\tau)} \frac{\partial U_{R_t}(R_t(\tau))}{\partial R_t(\tau)} \frac{\partial R_t(\tau)}{\partial \tau} dt$$

In an actuarially fair pension system $\frac{\partial R_t(\tau)}{\partial \tau} > 0$, which implies that you get a higher future annual pension if retirement is delayed. Thus, there will be a loss if retirement is not postponed. In the Italian pension system there is such an element. So for Italy we will estimate and compare models both with (non-myopic) and without (myopic) the term $\Delta(\tau)$. In Norway the future pension benefits are not affected at all by the retirement decision. In fact if an individual retire early, future pension benefits are projected on the basis of the projection of future wage income, as if the individual were still working. Thus, in the Norwegian case

probability distribution of life length): this is just a computational simplification, although some might wish to interpret it as a bounded rationality assumption

$\frac{\partial R_t(\tau)}{\partial \tau}$ is zero, and hence $\Delta(\tau)$ also equals zero. Hence, in the Norwegian case the optimal

decision is given by the myopic model.

2.2 Perfect credit markets, perfect consumption smoothing

In this case the inter-temporal optimisation problem is

$$(8) \quad \max_{\tau, \{C_t\}} V(\tau) = \int_0^{\tau} e^{-\delta t} U_{W_t}(C_t) dt + \int_{\tau}^D e^{-\delta t} U_{R_t}(C_t) dt$$

s.t.

$$(9) \quad \int_0^D e^{-rt} C_t dt = \int_0^{\tau} e^{-rt} W_t dt + \int_{\tau}^D e^{-rt} R_t(\tau) dt$$

where C_t is consumption at time t and e^{-r} is the market discount rate. To this end we assume $\delta=r$.

Let \mathcal{L} be the Lagrange function associated with this problem and μ the Lagrange multiplier:

$$(10) \quad \mathcal{L} = \int_0^{\tau} e^{-rt} U_{W_t}(C_t) dt + \int_{\tau}^D e^{-rt} U_{R_t}(C_t) dt - \mu \left[\int_0^D e^{-rt} C_t dt - \int_0^{\tau} e^{-rt} W_t dt - \int_{\tau}^D e^{-rt} R_t(\tau) dt \right]$$

The first order conditions are:

$$(11) \quad e^{-r\tau} U_{W_{\tau}}(C_{\tau}) - e^{-r\tau} U_{R_{\tau}}(C_{\tau}) + \mu \left[e^{-r\tau} W_{\tau} - e^{-r\tau} R_{\tau}(\tau) + \int_{\tau}^D e^{-rt} \frac{\partial R_t(\tau)}{\partial \tau} dt \right] = 0$$

$$(12) \quad \frac{\partial U_{W_t}(C_t)}{\partial C_t} = \mu \quad \text{for } t < \tau$$

$$(13) \quad \frac{\partial U_{R_t}(C_t)}{\partial C_t} = \mu \quad \text{for } t \geq \tau$$

From (12) and (13) we get $C_t = \bar{C}$ for all t , and hence from (11) we get

$$(14) \quad U_{W_{\tau}}(\bar{C}) = U_{R_{\tau}}(\bar{C}) - \Gamma(\tau)$$

where

$$(15) \quad \Gamma(\tau) = \mu \left[W_\tau - R_\tau(\tau) + \int_\tau^D e^{-\Gamma(t-\tau)} \frac{\partial R_t(\tau)}{\partial \tau} dt \right]$$

As mentioned above all three terms inside the bracket in (15) applies for Italy, while only the two first terms applies for Norway. From (12) and (13) we observe that μ can be calculated from the empirical specification of the utility function. We also observe that μ and hence $\Gamma(\tau)$ depend on the consumption level \bar{C} .

As in the no-smoothing case we now observe the individuals in

- retirement status at time t if $U_{Wt}(\bar{C}) \leq U_{Rt}(\bar{C}) - \Gamma(t)$
- employment status at time t if $U_{Wt}(\bar{C}) > U_{Rt}(\bar{C}) - \Gamma(t)$

3. Empirical specification

3.1 Imperfect credit markets, no smoothing of consumption

The instantaneous utilities are specified as follows:

$$(16) \quad U_{Wt}(W_t) = \alpha f(W_t + y_t) + \gamma g(L_{Wt}) + \varepsilon_{Wt}$$

$$(17) \quad U_{Rt}(R_t(\tau)) = \alpha f(R_t(\tau) + y_t) + \gamma g(L_{Rt}) + \varepsilon_{Rt}$$

where $f(x)$ is a concave function of x and:

- $R_t(\tau)$ = after-tax pension received in year t if decided to retire in year τ . This will be equal to 0 if the individual exits the employment status but is not eligible to receiving either the old age pension, or the seniority pension (Italy) or early retirement pension (Norway). More explicitly, in the Italian case we could write, $R_t(\tau) = P_t(\tau)(A_\tau + S_\tau)$ where $P_t(\tau)$ is the potential pension computed ignoring eligibility, $A_\tau = 1$ if the individual is eligible for old-age pension in year t, $S_\tau = 1$ if $A_\tau = 0$ and the individual is eligible for seniority pension in year t. In the Norwegian case we let $R_t(\tau)$ be the after-tax pension when the pensioner is

either on old age pension or on pensions in the early retirement programme (AFP). The pension term in the utility function is given by $R_t(\tau)E_t$, where $E_t=A_t+S_t$, and where $S_t=1$ if the age equals 67 or above (old age pension) and S_t equals 0 otherwise, while $A_t=1$ if $S_t=0$ and the individual is eligible to retire early on AFP, otherwise $A_t=0$.

- W_t = after-tax employment income received in year t, if employed in year t.
- y_t = exogenous (with respect to the individual) income in year t, i.e. total household

net income minus the individual's employment or pension net income. Thus, y_t is equal to the after tax income of the spouse plus the after tax capital income.

- L_{Wt} = leisure if employed in year t.
- L_{Rt} = leisure in year t if retired.

The ε -s are stochastic components, type III identically and independently standard extreme value distributed with a scale parameter which will be absorbed in the scale coefficients of the utility function (the α and the γ -s)

α and γ are parameters to be estimated. γ is expressed as a linear combination of a set of characteristics Z_t :

$$(18) \quad \gamma = Z_t' \beta$$

In this application we do not model the choice of hours of work. We therefore choose a convenient normalisation: $g(L_{Wt})=0$ and $g(L_{Rt})=1$.

We will present estimates of the model for the Box-Cox form, $f(x) = \frac{x^\lambda - 1}{\lambda}$ which includes the special cases $f(x) = \ln x$ (Cobb-Douglas) and $f(x) = x$ (Linear) for $\lambda \rightarrow 0$ and $\lambda = 1$, respectively. The utility in the two alternative states looks therefore as follows:

$$(19) \quad U_{Wt} = \alpha \frac{(W_t + y_t)^\lambda - 1}{\lambda} + \varepsilon_{Wt}$$

$$(20) \quad U_{Rt} = \alpha \frac{(R_t(\tau) + y_t)^\lambda - 1}{\lambda} + Z' \beta + \varepsilon_{Rt}$$

Note that according to the conditions (5) and (6) above, the relevant comparison between utilities in the alternative states is done for $\tau = t$.

With the Box-Cox specification and Italian rules for linking pension to earnings given in *Appendix 3*, it turns out that $\Delta(\tau)$ can be (approximately) computed as follows:

$$(21) \quad \Delta(\tau) = \alpha \left[(\omega - \rho)(D - \tau) + \frac{D - \tau}{\tau} \right] \frac{R_\tau(\tau)}{(R_\tau(\tau) + y_\tau)^{1-\lambda}}$$

where D is the expected length of life. ω is an annual rate of increase of employment income if employed and ρ is the annual rate of increase of the pension income (essentially due to indexation). The essential features set out in *Appendix 3*, are that all earnings years enter into the pension basis and that pensions are indexed. For indexation, we use the rate 0.02. With full actuarial adjustment for later retirement, the effect would of course have been even stronger. In our observation period, this was not the case, neither in Italy nor in Norway.

Let P_{Rt} be the probability of observing the individual in the retirement status at time t . From (5), (19) and (20) we then have

$$(22) \quad P_{Rt} = \Pr(U_{Wt}(W_t) \leq U_{Rt}(R_t(t)) - \Delta(t))$$

Given the distributional assumption made upon the ε , P_{Rt} is

$$(23) \quad P_{Rt} = \frac{\exp \left\{ \alpha \frac{[R_t(\tau) + y_t]^\lambda - 1}{\lambda} + Z_t' \beta - \Delta(\tau) \right\}}{\exp \left\{ \alpha \frac{[R_t(\tau) + y_t]^\lambda - 1}{\lambda} + Z_t' \beta - \Delta(t) \right\} + \exp \left\{ \alpha \frac{[W_t(\tau) + y_t]^\lambda - 1}{\lambda} \right\}}$$

3.2 Perfect credit markets, perfect smoothing of consumption

In this case the instantaneous random utilities are given by

$$(24) \quad U_{Wt} = \alpha \frac{C_t^\lambda - 1}{\lambda} + \varepsilon_{Wt}$$

$$(25) \quad U_{Rt} = \alpha \frac{C_t^\lambda - 1}{\lambda} + Z_t' \beta + \varepsilon_{Rt}$$

where C_t is consumption at time t , defined as household disposable income at time t minus households savings at time t .

From (14), (24) and (25) we get the probability that an individual is observed in retirement status at time t , P_{Rt}

$$(26) \quad P_{Rt} = \Pr(U_{Wt}(\bar{C})) \leq U_{Rt}(\bar{C}) - \Gamma(t)$$

where $\Gamma(t)$ is given in (15). From (24)-(26) we get

$$(27) \quad P_{Rt} = \frac{\exp\left\{\alpha \frac{\bar{C}^\lambda - 1}{\lambda} + Z_t' \beta - \Gamma(t)\right\}}{\exp\left\{\alpha \frac{\bar{C}^\lambda - 1}{\lambda} + Z_t' \beta - \Gamma(t)\right\} + \exp\left\{\alpha \frac{\bar{C}^\lambda - 1}{\lambda}\right\}}$$

which clearly reduces to

$$(28) \quad P_{Rt} = \frac{\exp[Z_t' \beta - \Gamma(t)]}{[\exp Z_t' \beta - \Gamma(t)] + 1}$$

As alluded to above, since $\Gamma(t)$ is proportional to the Lagrange multiplier μ , $\Gamma(t)$ depends on consumption \bar{C} . In the Italian case it also depends on the discount factor.

4. Data sources and summary statistics

4.1 Italy

The model requires that we know both W_t and R_t for each individual. In fact we observe only one of the two depending on the individual's status in year t . We solve this

problem by estimating income equations on relevant sub-samples. Predicted incomes are then imputed to everyone. The imputation procedure used and the estimates of the income equations are presented in *Appendix 4*.

The dataset is derived from the Bank of Italy Survey of Household Income and Wealth, SHIW93. We select into the estimation sample all the males and females who are

- either head or head's partner in the household, and
- at least 40 years old, and
- either employed or retired (on an employment pension); this condition excludes those who never worked.

The above selection criteria and the exclusions due to missing values produce a sample containing 4603 men and 2534 women. Table 1 reports means and standard deviations of the variables used in the estimation of α , λ and β .

In the non-myopic, no consumption smoothing model and in the perfect consumption smoothing model one needs a value for the discount rate. The real rate of interest r in Italy has been set to 0.02. The other variables used in the estimation can be seen in Table 1.

Table 1. *Summary statistics for sample used in estimation, Italy 1993*

Variable	Men		Women	
	Mean	Std dev	Mean	Std dev
$R_t(t)$	1.0993	0.7083	0.8492	0.5053
W_t	2.6937	0.8501	1.7167	0.6274
y_t	2.3262	2.2864	3.3111	3.1021
C	3.3765	2.1006	3.3622	2.2997
AGE/10 (β_{age})	5.73	1.44	5.77	1.89
PUBLIC = 1 if current or last job in public sector (β_{public})	0.28	0.45	0.34	0.47
SELF = 1 if self-employed in current or last job (β_{self})	0.21	0.40	0.21	0.40
CENTRE = 1 if the individual lives in Central Italy (β_{centre})	0.22	0.41	0.24	0.43
SOUTH = 1 if the individual lives in Southern Italy (β_{south})	0.35	0.48	0.26	0.44
Household size divided by 10	0.33	0.13	0.28	0.13
Number of observations	4603		2534	
Percentage retired	1.71		4.33	
- age 40-49				
- age 50-59	23.49		32.46	
- age 60-64	72.49		85.42	
- age 65-69	94.17		97.96	
- age 70 +	98.96		99.22	

Income variables are in 10,000,000 ITL. By mid 1996 10,000,000 ITL equalled 42 000 NOK.

5.2 Norway

Sample

In line with the selection of the Italian sample, we have extracted persons aged 55-68 in 1996 (born 1928-41). The reason why the lowest age is 55 and not 40 as in the Italian case is that in Norway there is generally no pension available for individuals in the 40s and early 50s. In contrast to the Italian case in which a survey is used, the registers allowed us to extract all

Norwegian residents aged 55-68. For the sample used in the analysis, we have included persons who were either:

1. Retired: Classified as a pensioner in July 1996 in a social benefit database in Statistics Norway (FD-trygd), and receiving an old age pension or an early retirement pension (AFP) of at least one G in 1996, according to the tax files
2. Working: Not retired and earnings of at least one G according to the tax files in 1996.

This means that we have excluded persons who were disabled, were on rehabilitation or were out of the labour force for other reasons, or had too low earnings. Adding the spouse's after-tax income (regardless of source) gave total household income.

Potential pension

For all persons in the sample, we impute potential old age public pension for persons age 67 and above, and early retirement pension for persons aged 64-67, by applying the appropriate formulae to the sequence of pension points, which are observed in our data (see Haugen, 2000, Røgeberg, 2000 and Hernæs et al., 2001).

Although the public pension system (old age public pension and AFP) is the most important source of income for most retirees, there are also other pension programmes, as mentioned above, which influences the budget constraints of potential retirees. So far we have not been able to impute the size of these occupational pensions, or directly observe eligibility. Instead we have represented this pension option by including among the covariates a dummy (FIRM) indicating whether the individual works in a firm assumed to operate a pension plan (other than AFP), based on observation of former employees receiving such a pension.

Potential earnings

In order to smooth out possible fluctuations in income the potential earnings assigned to each individual is the maximum of observed earnings in 1996, earnings in 1995 and the

average of earnings 1991-1995. This means that the longer a persons has been retired, the lower the potential earnings will be predicted to be. Persons who have not had earnings later than 1990, are all excluded. The after tax wage income of the spouse and household capital income after tax is observed for 1996. In the model these two incomes sum to the variable y_t , but in Table 2 both incomes are reported. To calculate household consumption we deduct household savings from household income after tax. Savings are observed as the value of financial assets at the end of the year 1996 minus the value of financial asset at the end of 1995, as reported to the tax authorities. Summary statistics for the sample used in estimating the models are given in Table 2.

Table 2. *Summary statistics for sample used in estimation, Norway 1996*

Variables	Males		Females	
	Mean	Std	Mean	Std
R_t	0.2266	0.4520	0.1589	0.3112
W_t	1.7010	0.7445	1.279	0.5276
After-tax spouse income	0.9620	0.6479	1.4130	0.9685
After-tax capital income	0.1571	0.4573	0.0713	0.2423
Household savings	0.1312	1.1404	0.0071	1.2777
Household consumption, C	2.6918	1.4714	2.6328	1.5578
Age/10	6.0498	0.4058	6.0487	0.4131
SOUTH = 1 if living in the South of Norway	0.8677	0.3388	0.8735	0.3324
Education in years divided by 10	1.0851	0.3136	1.0134	0.2665
FIRM =1 if current or last job in a company with an occupational pension	0.3474	0.4762	0.1859	0.3890
Number of observations		153 999		124 350
Percentage retired age 55-59		0.00		0.00
- age 60-67		13.29		13.97
- age 68-69		94.67		98.67

All economic variables are in NOK 100 000

Household size is not included among the Norwegian covariates, because the variation across households - in the cohorts studied here - is very low.

5. Estimates

The models are estimated (by maximum likelihood) using the cross-section data for Italy in 1993 and Norway in 1996. Let $d_{it}=1$ if the individual is in the retirement status at time t , and $d_{it}=0$ if the individual is in the retirement status. Then the log-Likelihood function to be maximised with respect to α , β -s and λ is $\ln \mathcal{L} = \sum_i d_{it} \ln P_{Rti} + \sum_i (1 - d_{it}) \ln(1 - P_{Rti})$.

To measure how well our models explain data we have computed a pseudo- R^2 as $1 - \frac{\ln \mathcal{L}^*}{\ln \mathcal{L}^0}$, where \mathcal{L}^* is the maximised likelihood and where \mathcal{L}^0 is the likelihood when choices of retirement is made at random, that is $P_{Rt}=(1-P_{Rt})=0.5$. Thus $\ln \mathcal{L}^0 = n \ln 0.5$, where n is the total number of observations. This pseudo- R^2 thus indicates how much better our structural model explains data relative to pure random draws of the choices.

5.1 Italy

The estimates are reported in Tables 3 and 4 (No Consumption Smoothing) and Table 5 (Perfect Consumption Smoothing). Starting with the no-smoothing model, we observe that the estimates of the forward-looking version and of the myopic version are essentially identical. This is somewhat surprising, since it implies that the imputed variation in future pension from postponing retirement does not influence the retirement decision. It might, however, have several interpretations. First, people might actually be myopic and evaluate only current pension level against current earnings, Secondly, the variation might be too small to show up in the results, or thirdly, our imputations of the variation may be too noisy. Either way, it facilitates comparison with the results for Norway, where the institutional setting implies that there is no effect on the future pension level from postponing retirement.

Although there are differences between males and females, in that we can reject the Cobb-Douglas restrictions only for males, we note that the linear restriction ($\lambda = 1$) can be rejected for males as well as for females in the no-smoothing model. In the perfect smoothing model, the linear restriction can be rejected only for females, and the estimated value of λ is larger both for men and women. This result is reasonable, since by assuming perfect smoothing the differences in consumption - given the intertemporal wealth - are attributed to the preferences, while by assuming no smoothing the consumer - apart from the decision to retire or not - is essentially constrained to consuming a period-specific exogenously

determined income. On the basis of the pseudo- R^2 , the no-smoothing model performs slightly better than the perfect-smoothing model, but the values of the maximised likelihood in the two models are so close that it seems hardly possible to discriminate between the two with the use of any likelihood-based test. However, since $\lambda < 1$ imply decreasing marginal utility in income, which we expect, we interpret the results as support of the no-smoothing model.

Table 3. *Maximum Likelihood Estimates of α, β and λ . No Consumption Smoothing, Italian men 1993*

Parameter	Forward-looking		Myopic	
	Estimate	Asymptotic-t	Estimate	Asmptotic-t
λ	0.769	7.86	0.780	6.63
α	1.409	4.52	1.423	3.77
β_{CONST}	-	-18.77	15.844	-20.27
	15.138			
β_{AGE}	3.107	26.60	3.184	27.345
β_{PUBLI}	-0.282	-2.03	-0.363	-2.67
β_{SELF}	-1.229	-8.76	-1.1031	-7.81
β_{CENTRE}	-0.817	-5.54	-0.807	-5.50
β_{SOUTH}	-1.146	-7.65	-1.136	-7.64
β_{N}	-1.018	-2.02	-0.960	-1.90
Mean $\ln(\pounds^*)$		-0.247415		-0.247669
Mean $\ln(\pounds^0)$		-0.693147		-0.693147
Pseudo- R^2		0.643		0.643
Number of observations		4603		4603

Table 4. *Maximum Likelihood Estimates of α , β and λ . No Consumption Smoothing, Italian women 1993*

Parameter	Forward-looking		Myopic	
	Estimate	Asymptotic t	Estimate	Asymptotic -t
λ	0.048	0.14	0.109	0.40
α	3.934	2.66	4.793	3.11
β_{CONST}	-14.744	-12.60	-14.714	-13.85
β_{AGE}	3.075	17.89	3.072	18.65
β_{PUBLIC}	-0.199	-0.79	-0.239	-1.19
β_{SELF}	-1.219	-7.04	-1.168	-6.78
β_{CENTRE}	-1.067	-5.40	-1.113	-5.73
β_{SOUTH}	-1.334	-6.14	-1.417	-7.02
β_{N}	-2.084	-2.62	-1.976	-2.57
Mean $\ln(\pounds^*)$		-0.235541		-0.234834
Mean $\ln(\pounds^0)$		-0.693147		-0.693147
Pseudo-R ²		0.660		0.661
Number of observations		2534		2534

Table 5. *Maximum Likelihood Estimates of α , β and λ . Perfect Consumption Smoothing, Italy 1993*

Parameter	Men		Women	
	Estimate	Asymptotic t	Estimate	Asymptotic t
λ	1.178	8.75	0.746	3.05
α	0.569	3.01	0.737	1.29
β_{CONST}	-16.439	-20.57	-16.148	-14.85
β_{AGE}	3.219	28.36	3.208	19.74
β_{PUBLIC}	-0.259	-1.88	-0.167	-0.82
β_{SELF}	-1.667	-8.27	-1.222	-7.16
β_{CENTRE}	-0.899	-5.49	-1.101	-5.51
β_{SOUTH}	-1.208	-8.20	-1.439	-7.07
β_{N}	-0.395	-0.80	-0.694	-0.88
Mean $\ln(\pounds^*)$		-0.247740		-0.238984
Mean $\ln(\pounds^0)$		-0.693147		-0.693147
Pseudo-R ²		0.643		0.655
Number of observations		4603		2534

Norway

Table 6 reports the Norwegian estimates of the no-smoothing model and Table 7 the estimates of the perfect consumption smoothing model. As expected with this huge dataset the coefficients are sharply determined, with the exception of the coefficients attached to the regional variable. In contrast to Italy there are no marked difference with respect to retirement behaviour between individuals living in different regions of the country. This might be the result of the imputation of potential pension and earnings on an individual level in the Norwegian data set. For Italy, we use earnings and pension functions, which may fail to capture all individual variation, some of which may be correlated with region.

For both genders and in both model specifications, the Cobb-Douglas specification of the utility function as well as the linear specification is strongly rejected for Norway. We note that in the no-smoothing case the estimate of λ is nearly the same for Norwegian males and females. These estimates are also not so very different from the estimate of λ for Italian males. However, the estimate of λ is larger than one in the perfect consumption model, implying increasing marginal utility of income. Furthermore, the magnitude of the estimate for males is fairly similar to that of Italian males, although now sharply determined (above one) due to the large number of observations. As for Italy, we interpret this as support for the no-smoothing model, for which the estimates imply declining marginal utility of income.

The significantly positive estimates of (β_{firm}) mean that working in a company with a company specific pension programme increases the probability of retiring. This underlines the importance of financial incentives for the retirement decision, and stresses the importance of obtaining better data on these company specific programmes in Norway. For this study, we have available only a dummy variable. The other estimate available only for Norway, $(\beta_{education})$ imply that for females, more education increases the probability of retirement. For males, the estimate is significant only in the perfect smoothing model, and not significant in

the no-smoothing model, which we tend to prefer. However, education is correlated both with age, earnings and pension. Hence, imperfect measurement of potential pension, as we know is the case with occupational pensions, may cause education to pick up the effect. A positive correlation between education and (imperfectly measured) pension will then produce the above result, even in the absence of any direct effect of education. The “true” effect of education might well be to reduce the probability of retirement, but this might be obscured in our results, only more so for females than for males.

We note that the propensity to retire is increasing with age for both genders and the effect is stronger than what it was for Italy. For Italy, eligibility is picked up in the data, whereas we know that eligibility for company specific programmes are imperfectly measured. Age might then capture the unobserved eligibility, stronger for Norway than for Italy.

The Pseudo-R² indicates that our model explains data much better than a model where choices are made at pure random.

Table 6. *Maximum Likelihood Estimates of α , β and λ . Norway 1996. No consumption smoothing*

	Men		Women	
	Estimate	t-values	Estimate	t-values
λ	0.427	16.074	0.563	17.677
α	4.460	36.720	5.542	31.437
β_{constant}	-73.704	-80.039	-85.594	-66.731
β_{age}	11.294	81.140	12.988	67.130
β_{south}	0.097	1.797	0.135	1.846
β_{firm}	0.732	20.383	0.608	10.769
$\beta_{\text{education}}$	-0.022	-0.390	0.751	8.596
Mean ln \pounds^*	- 0.0732		-0.0543	
Mean ln \pounds^0	-0.1067		-0.0862	
Pseudo-R ²	0.3139		0.3701	
Number of observations	153 999		124 350	

Table 7. Maximum Likelihood Estimates of α , β and λ . Norway 1996.

Perfect consumption smoothing

Parameters	Men		Women	
	Estimates	t-values	Estimates	t-values
λ	1.149	87.449	1.073	61.527
α	2.557	51.520	3.845	38.753
β_{constant}	-77.325	-83.343	-89.408	-69.032
β_{age}	11.755	83.807	13.506	69.148
β_{south}	0.123	2.281	0.159	2.175
β_{firm}	0.838	23.465	0.588	10.471
$\beta_{\text{education}}$	0.474	8.583	1.165	13.484
Mean ln \pounds^*	-0.0749		-0.0555	
Mean ln \pounds^0	-0.1067		-0.0862	
Pseudo-R ²	0.2980		0.3562	
Number of	153 999		124 350	

6. Policy simulation

In principle the estimated model can be used to simulate the effects of pension reforms or of socio-demographic changes. Here we limit ourselves to illustrate the implications of the models by showing the *ceteris paribus* effect of a change in one key variable. The simulation must be interpreted as a comparative static exercise: it shows how different the number of retired people would be, as a consequence of a permanent change in some variable or parameter. For each individual we compute the probability of being in retirement status before and after the exogenous change. The individual probabilities are then summed across the sample to get the estimate of the expected number of people in retirement status. The simulations are replicated for each of the estimated model versions. The results are illustrated in Tables 8 and 9.

6.1 Italy

Some general observations emerge from Table 8.

- Females are somewhat less responsive than males with respect to the parameters of the pension system³;
- under the assumption of *no-smoothing*, it makes little difference whether we assume forward-looking or myopic behaviour;
- the *perfect-smoothing* model implies smaller responses than the no-smoothing model.

A reduction in pension benefits by 10% focuses upon a parameter (elasticity of the number of retired people with respect to pension level) that has been almost ignored by the debate on pension reforms in Italy. Indeed, the elasticity turns out to be numerically small (between -0.06 and -0.21 depending on the gender and on the model version) but not irrelevant, especially in view of the sensitivity of the policy issues involved. For the purpose of illustrating this point, let us consider for example the standard static financial equilibrium condition for a PAYG pension system:

$$[\text{Contribution rate}] = \frac{[\text{Average pension}]}{[\text{Average employment income}]} \times \frac{[\text{N. of retired}]}{[\text{N. of employed}]}$$

Let us suppose a reform envisages a reduction of 10% of the average pension. If no account is taken of behavioural responses, the implied new equilibrium contribution rate would obviously decrease by 10%. Instead, if account is taken of an elasticity of retirement

³ This result seems to be somehow at odds with what is usually found in labour supply studies, which show that labour supply elasticity is higher for females than for males (e.g. Aaberge, Colombino and Strøm (1999) and Aaberge, Colombino and Wennemo (2002)). There might be some selection problem due to the fact that we exclude from the sample the women who never worked. On the other hand, it is dubious whether we should expect results close to what we get in standard labour supply studies: the decision whether to retire or not is not the same as the decision to participate or not.

w.r.t. pension of, say, -0.15, the implied new equilibrium contribution would decrease by⁴:

$$(10-1.5(1+ \frac{\text{N. of retired}}{\text{N. of employed}})) \%$$

Table 8. *Simulations. Italy*

Exogenous change	Percentage variation in the number of people in retirement status					
	Men			Women		
	No smoothing		Perfect smoothing	No smoothing		Perfect smoothing
Forward looking	Myopic	Forward looking		Myopic		
Pension reduced by 10%	-2.00	-1.94	-0.89	-0.84	-1.44	-0.55

6.2 Norway

The simulation results are given in Table 9. First, we note that like in Italy Norwegian females are less responsive than Norwegian males. Also, the difference in responses across gender is somewhat similar in the two countries. Secondly, the responses to cuts in pension benefits are somewhat stronger in Norway than in Italy. The implied elasticities for Norwegian males are simulated to be -0.55 (no smoothing) and -0.49 (perfect smoothing). For Norwegian females the simulated elasticities are -0.32 (no smoothing) and -0.31 (perfect smoothing). Differences in responses are nearly the same in Norway across the assumptions of consumption smoothing. In Italy responses are much weaker in the perfect smoothing case than in the no smoothing case.

⁴ The computation assumes that N. of retired + N. of employed is constant, therefore it ignores the possible direct effects of a reduced contribution rate upon the N. of employed.

Table 9. *Simulations. Norway*

Exogenous change	Percentage variation in the number of people in retirement status			
	Men		Women	
	No smoothing	Perfect smoothing	No smoothing	Perfect smoothing
Pension reduced by 10%	-5.5	-4.9	-3.2	-3.1

7. Conclusion

We have developed and estimated a very simple model of retirement, based on datasets for Italy and Norway. The model is essentially "static" in that the estimation only requires that we know whether the individual is in retirement or in employment status at the time of observation. The model can be given a structural interpretation in terms of inter-temporal optimisation. Of course this comes at the price of certain simplifying assumptions, including a parametric utility function and – in the no-smoothing model – that the discount factor equals the rate of return. One major advantage of this modelling approach is that it only requires stock datasets, which are typically easier to obtain and larger than flow datasets.

Of special interest with regards to the discussion of retirement and policy reforms are the assumptions regarding how perfect the credit market is. With a perfect credit market the individuals are able to achieve perfect smoothing of consumption over the life cycle. In this paper we have estimated the probability to retire under two extreme assumptions: one is a totally imperfect credit market, which implies that the consumption of the households has to be equal to current disposable household income; the other is a perfect credit market that allows the household to smooth consumption freely over the life-cycle. The estimates of the parameters in utility function in the smoothing model imply increasing marginal utility of income for Norwegian males and females and for Italian males. In contrast, the estimates in the no-smoothing model imply decreasing marginal utilities for all groups. We consider the

latter model to yield a more reasonable result and interpret the result as a support for a less than perfect capital market.

The estimates indicate that the preference structure among middle-aged Italian males and Norwegian males and females who are approaching retirement has strong similarities. This opens up for further investigation of the effect of various types of pension reforms.

The policy simulation indicates somewhat stronger responses to cuts in pension benefits in Norway than in Italy. But given the differences in institutions and labour market participation in the two countries, the responses are surprisingly similar.

The approach illustrated here could also provide a relatively simple way to supplement standard static labour supply models, which typically exclude from the sample individuals who are retired or are eligible for retirement. One could apply the same procedure used here, including also those individuals and treating their behaviour as generated by a "static" comparison between current incomes as employed or as retired, with the term $\Delta(\tau)$ accounting for the inter-temporal perspective.

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Appendix 1. Institutional settings

The description of pension and taxation rules that follows is not only meant to serve as an introduction to the paper. In fact, in the estimation of the retirement models all details of pension programs and taxation are accounted for.

Italy

Old-age pension originated in the 19th century for employees in the army. In 1889 a fully funded pension system was introduced for blue-collar workers in the private sector. The PAY-AS-YOU-GO (PAYG) system that now is in operation dates back to the 1960s. There are some additional pension funds, mainly for people working in banks and financial institutions, but these funds play a minor role compared to the mandatory old age PAYG system. The mandatory system covers employees in the private as well as in the public sector. Also the self-employed are covered. The Italian pension system has recently been reformed three times (the Amato reform in 1992, the Dini-reform in 1995 and the Prodi reform in 1997). Since our data are related to 1993 and before, the focus in the description here is on the system which was in operation before the Dini- and the Prodi-reforms. For more details about Italian old age insurance see Brugiavini (1997), Brugiavini and Fornero (1998) and Brugiavini and Peracchi (2001).

Pensions are financed through pay-roll taxes paid by the employees and employers. In 1993 in the private sector the total payroll tax was 24.5% of gross earnings of which 7.15% was falling on the employees and the rest on the employers. On top of the 24.5% pay-roll tax a further 7.4% tax is levied and kept by the employer in a fund and paid out as severance pay - or a lump sum benefit - when the employee retires. In the public sector the payroll tax is less. Deficits in the mandatory pension system are covered by the central government.

The public pension system includes an old age pension scheme as well as an early retirement option.

Before the Amato-reform in 1992 the retirement age in the old age pension system was 60 for males and 55 for females in the private sector. In the public sector it was 65 years for both sexes. Self-employed could retire at the age of 65 (males) and 60 (females). After the Amato-reform the retirement age was 65 throughout, except for females working in the private sector where it was 60. For self-employed women it was also 60.

For many people these old age pension requirements are irrelevant. The reason why is the early retirement option which in fact is a seniority pension programme, without any age requirement. Before the Amato-reform employees in the private sector, as well as self-employed, could retire after 35 years of tax payments. In the public sector the required length of tax payments was much less, 20 years for males and 15 for females. After the Amato-reform all employees, public and private, as well as the self-employed, are allowed to retire early if they have completed 35 years of tax payments. To meet the tax payment requirement in one year 52 weeks of tax payments must have been recorded by the Social Security Administration.

It is allowed to combine pension and earn income, but the earnings cut-off makes this choice less attractive and for practical purposes it can be ignored.

The pension benefit is 2% of so-called “pensionable earnings”, times the number of years in the system. The maximum number of years in the system is 40. Thus, the maximum replacement ratio defined as pension benefit to “pensionable earnings” is 80%, and in fact the Italian pension system is rather generous with high replacement ratios. In the private sector “pensionable earnings” is defined as the average of the last five years of earnings prior to retirement. In the public sector the “pensionable earnings” is the final salary prior to retirement.

Pension benefits are taxed the same way as employment income. After-tax replacement ratios are exemplified in Table A.1 below.

Table A.1 After-tax replacement ratios. Italy 1998. Males, private sectors, 35 years of contribution	
Annual earnings relative to median earnings	Net replacement ratios (%)
0.25	103.08
1.00	90.42
3.00	84.61
Source: Brugiavini and Fornero (1998)	

Norway

In 1937, the first mandatory public old age pension insurance was implemented. The system was universal in the sense that everyone was included. It was restricted to persons with relatively low income. The age of eligibility was set to 70 years. In 1957 the means testing was lifted and co-ordination with government pensions was introduced. An earnings based component was added to the basic amount in 1967 and the age of eligibility was lowered to 67 years, giving the structure of the National Insurance System (NIS), which is still in operation.

Pensions are financed through taxes levied on employers and employees as percentages of total earnings and on self-employed as a percentages of their income. There exists a central pension fund, but it is not required that this should meet future net expected obligations. The (PAYG) system is based on yearly contributions from the government. In what follows we will briefly describe the Norwegian pension system. If not otherwise stated all information refers to the year of analysis in this paper, 1996. More details can be found in Ministry of Social Affairs (2002) and Røgeberg (2000).

The public old age pension system

The mandatory public pension system (NIS) has two main components. One component is a minimum pension, paid to all persons who are permanently residing in the country. The pension is reduced proportionally with less than 40 years of residence.

The other main component is an earnings based pension. A crucial parameter in the system, used for defining contributions as well as benefits, is the basic amount. The basic amount (G) in 1996 was NOK 40 410. As of March 2003, 1 EURO is approximately NOK 7.8. In 1996, 1000 Italian lira was NOK 4,20.

The earnings based pension depends on the G and the individual earnings history in several ways. To give pensions points, earnings exceeding the G each year are divided by G. Earnings above 12 times G do not give points, and earnings between 6 and 12 times G (8 and 12 times before 1992) are reduced to one third before calculating pension points. Points calculated each year are then multiplied by a “Supplementary Pension Rate” of 0.45 (points obtained after 1992 are multiplied by a rate of 0.42), and the average yearly points over the 20 best years are calculated. These points multiplied by G give the earnings based component, and adding 1G gives the total public pension. If a person has had less than 40 years with earnings above the G, the earnings based pension is reduced proportionally.

The public pension system also has a number of additional regulations, which we will briefly recount here. First, since we are still in the process of phasing in the public pension system established in 1967, a special “overcompensation” program is in operation for persons born before 1928. Secondly, there is a supplementary pension for those without or with a low earnings based pension component, giving a minimum pension level of 1.605 times the G (1G). Because of the supplementary pension, income below 2.344 times the minimum pension does not contribute to the total public pension. Thirdly, there is a co-ordination of the

pensions for married couples, mainly resulting in a reduction (25% in 1996, 20% in 2003) of the couples joint pension compared to the sum for two single persons.

Keeping 1996 regulations constant, the maximum future public old age pension level will be 3.94 times the G. This pension level requires 20 year with earnings of at least 12 G and another 20 years with earnings of at least 1 G.

Government pensions

State and local government employees have occupation-based pensions, coordinated so that benefits as a main rule will be the maximum of the public old age pension and the government pension. The government pension is based on the earnings level immediately prior to retirement and not on the previous earnings history. The pension is 66 per cent of gross income the year prior to retirement up to 8 times G (the same basic amount as in the public system) and 22 per cent of income between 8 and 12 G. In 2000 rules were changed so that pension now is 66 per cent of gross income up to 12 G. As in the public system, income below 1G does not count. In the government sector there are some few groups that can retire early like individuals working in the police and the military.

Private sector (firm specific) occupation based pensions

In the private sector 36 per cent of the work force are covered by occupation based pension, from which benefits are received 'on top' of the public old age pension without any reduction. For employers to receive tax deductions for contributions, there are regulations, implying that the pension should include all employees and that the eligibility age is at least 65.

Earnings testing of pension benefits

Pensioners aged between 67 and 70 in the public old age pension system (previously employed in the private sector), who continue to work in another job than they had when they

retired, will have their pension reduced if earnings from work exceed a certain level. The same happens to pensioners in the government sector who start working in other jobs in the government or local government. However, if the government pensioners get a job in the private sector their income does not influence their pension. For pensioners aged 70 years or more there are no reductions in benefits regardless of what system one receives pension benefits from.

Personal savings

Individuals can save for their retirement age. These savings are tax deductible and widespread. In 1996 a total of 167 000 individuals received tax deductions due to private pension savings.

Early retirement

Finally, in 1989 employers and unions negotiated an **early retirement scheme** (AFP). Under this scheme, persons working for employers who are participating (in 2001 about 43 % of private employees and all employees of central and local government) and meeting individual requirements can retire at an earlier age than the ordinary 67, for details see Hernæs et al (2001)). The age at which persons become eligible for AFP has been gradually lowered since the first agreement in 1989. Table A.2 gives a summary of this. We observe that in the years before 1996 the eligibility age was lowered from 66 to 64 years.

Table A.2. The age limit for AFP eligibility

Introduced	Age limit
01.01.1989	66 years
01.01.1990	65 years
01.10.1993	64 years
01.10.1997	63 years
01.03.1998	62 years

The pension under the AFP scheme is calculated in much the same way as the ordinary public old age pensions except for some differences due to the age at which one choose to retire and which sector one is working in. Individuals working in the private sector who choose to retire early get the public old age pension as described above and an additional tax-free AFP lump sum of NOK 11 400 a year.

In the government sector, both state and local, the rules are different. First, the occupation-based pension, described above, is part of the AFP scheme from the age of 65. Before that age the public sector retirees get the same pension as those retiring from the private sector. Secondly, the AFP lump sum is different. Retired people between 62 and 65 get a *taxable* AFP lump sum of NOK 20 400 a year, whilst from the age of 65, when they receive the occupation-based pension, they do not get the AFP lump sum. Moreover, early retirement is not penalized in the sense that future AFP-pension is not affected by when the individual retires.

Taxation

In *Appendix 2* we report how different types of income were taxed in 1996. Taxation of wage income is progressive and hence re-distributive. From the tax functions in *Appendix 2*

we note that the marginal tax rates on pension income is not uniformly increasing with income and consequently the budget sets for retired individuals are non-convex.

Replacements ratios

Table A.3 reports replacement ratios for Norway in 1996. We show the replacement ratios for Norwegian singles, see Haugen (2000) for married people and for other years. After-tax replacement ratios are defined as the after-tax-pension income divided by the after-tax wage income.

Table A.3. After-tax replacement ratios. Single individuals. Norway 1996

Life time income, stable in terms of basic amount (G)		Old age NIS pension, age 67 and above		Early retirement pension (AFP) age 64-66		
In (G)	In NOK	Public pension	Government pension	Private sector	Government sector, age 64	Government sector, age 65-66
1 G	40410	1.89	1.89	2.23	2.43	1.89
2 G	80820	1.04	1.04	1.22	1.33	1.04
3 G	121230	0.84	0.95	0.97	0.99	0.95
4 G	161640	0.75	0.85	0.84	0.84	0.85
5 G	202050	0.68	0.82	0.76	0.76	0.80
6 G	242460	0.65	0.81	0.71	0.71	0.79
7 G	282870	0.64	0.82	0.68	0.68	0.80
8 G	323280	0.62	0.83	0.65	0.67	0.81
9 G	363690	0.59	0.78	0.61	0.63	0.76
10 G	404100	0.56	0.74	0.58	0.59	0.72
11 G	444510	0.53	0.70	0.55	0.56	0.68
12 G	484920	0.51	0.67	0.53	0.54	0.65

The Norwegian replacement ratios indicate that incomes after retirement are more evenly distributed than before retirement. The pension system, as well as the tax rules, contributes to this result. For individuals with very low wage income the replacement ratio, like in Italy, is even above 1. In 1996 the average income, among those working, was around 6G, and we observe that at this income level the replacement ratio ranges from 65% for individuals on old age pension to 81% for individuals on government pension. In the private

sector the replacement ratios tend to be higher for the early retiree than for the old age pensioners.

Appendix 2. Tax functions, Norway 1996.

Below we give the tax functions for Norwegian individuals in 1996. According to the rules regarding tax deductions and marginal tax rates there are 9 separate tax functions that are of relevance for our study. Individuals on old age pension get tax deduction for high age (67 or above). A single individual gets the same deduction for old age as a married couple where both spouses are above 67. Moreover, individuals on old age pension or who are retired according to the early retirement programme, AFP, do not pay taxes that exceed 55% of gross income before deductions. Taxes vary also with regards to whether the individual is married or not, and they also depend on the source of income for the spouse.

I. Individuals on old age pension, 67 years of age or above.

Table A.4. Single individual on old age pension, 1996

Income=R, NOK	Tax function, NOK
0-80 875	0
80 875- 129 688	0.44R- 35 585
129 688 – 149 000	0.254R- 11 463
149 000- 220 500	0.31R- 19 807
220 500- 248 500	0.405R- 40 755
248 500-	0.447R- 50 472

Table A.5. Married individual on old age pension, spouse also on old age pension, 1996.

Income=R, NOK	Tax function, NOK
0-63 063	0
63 063- 100 828	0.44R- 27 748
100 828- 149 000	0.254R-8 994
149 000- 220 500	0.31R- 17 338
220 500- 248 500	0.405R- 38 286
248 500-	0.447R- 48 723

Table A.6. Married individual on old age pension, spouse working, 1996.

Income=R, NOK	Tax function, NOK
0-63 063	0
63 063- 87 554	0.44R- 27 748
87 554 – 149 000	0.254R- 11 463
149 000- 220 500	0.31R- 19 807
220 500- 248 500	0.405R- 40 755
248 500-	0.447R- 50 472

Table A.7. Married individual on old age pension, spouse has no income, 1996

Income=R, NOK	Tax function, NOK
0-126 125	0
126 125- 149 000	0.44R- 55 495
149 000- 189 808	0.55R- 71 885
189 808- 267 500	0.31R- 26 331
267 500- 278 500	0.405R- 51 744
278 500-	0.447R- 63 441

II. Individuals on AFP

Table A.8. Single individual on AFP, 1996

Income=R, NOK	Tax function, NOK
0-80 875	0
80 875- 149 000	0.44R- 35 585
149 000-154 612	0.55R- 51 975
154 612- 220 500	0.31R- 14 868
220 500- 248 500	0.405R- 35 816
248 500-	0.447R- 46 253

Table A.9. Married individual on AFP, spouse either on pension benefit, old age pension as well as AFP, or working, 1996

Income=R, NOK	Tax function, NOK
0-63 063	0
63 063- 115 161	0.44R- 27 748
115 161 – 149 000	0.254R- 6 524
149 000- 220 500	0.31R- 14 868
220 500- 248 500	0.405R- 35 816
248 500-	0.447R- 46 253

Table A.10. Married individual on AFP, spouse has no income, 1996

Income=R, NOK	Tax function, NOK
0-126 125	0
126 125- 149 000	0.44R- 55 495
149 000 – 210 388	0.55R- 71 885
210 388- 267 500	0.31R- 21 392
267 500- 278 500	0.405R- 46 805
278 500-	0.447R- 58 502

III. Working individuals

Table A. 11. Working individual, either single or married with spouse working or receiving pension benefit, 1996

Income=W, NOK	Tax function, NOK
0-20 675	0
20 675- 149 000	0.302W- 6 244
149 000- 220 500	0.358W- 14 868
220 500- 248 500	0.453W- 35 816
248 500-	0.495W- 46 253

Table A.12. Working individual, married with spouse without income. 1996

Income=W, NOK	Tax function, NOK
0-43 205	0
43 205- 149 000	0.302W- 13 048
149 000- 267 500	0.358W- 21 392
267 500- 278 500	0.453W- 46 805
278 500-	0.495W- 58 502

Appendix 3. Computation of $\Delta(\tau)$ in the Italian case.

Ignoring unobserved variables employment income is given as

$$(A.1) \quad W_t = W_0 e^{\omega t},$$

where W_0 is an initial income that may depend on observed individual characteristics and ω is the income growth rate. Time is measured as years since starting employment.

Pension income at time t , given that retirement started at time τ , is given by

$$(A.2) \quad R_t(\tau) = \psi m(W_\tau, W_{\tau-1}, \dots, W_{\tau-M}) \tau e^{\rho(t-\tau)} \text{ if } A_\tau + C_\tau = 1$$

$$R_t(\tau) = 0 \text{ otherwise}$$

where,

$$(A.3) \quad m(W_\tau, W_{\tau-1}, \dots, W_{\tau-M}) = \frac{1}{M+1} \sum_{i=0}^M W_{\tau-i}$$

Thus, pension received at time t equals a proportion ψ of the average employment income over the last $M+1$ years, that is $m(\cdot)$, times the number of years of employment τ (=years of contribution). Pension also depends on time elapsed since the retirement decision, ρ representing the annual rate of increase of the pension income (essentially due to indexation). According to equation (4) in the main text, we have

$$(A.3) \quad \Delta(\tau) = \int_{\tau}^D e^{-\rho(t-\tau)} \frac{\partial U_t(\tau)}{\partial \tau} dt.$$

Now

$$(A.4) \quad \frac{\partial U_t(\tau)}{\partial \tau} = \frac{\partial U_t(\tau)}{\partial (R_t(\tau) + y_t)} \frac{\partial R_t(\tau)}{\partial \tau}.$$

With the Box-Cox specification

$$(A.5) \quad \frac{\partial U_t(\tau)}{\partial (R_t(\tau) + y_t)} = \alpha (R_t(\tau) + y_t)^{\lambda-1}.$$

Let us now evaluate $\frac{\partial R_t(\tau)}{\partial \tau}$. From (A.1) and (A.3) we obtain

$$(A.6) \quad R_t(\tau) = \psi W_0 \left(\sum_{i=0}^M e^{-\omega i} / (M+1) \right) \tau e^{\rho t + (\omega - \rho)\tau},$$

from which we get

$$(A.7) \quad \frac{\partial R_t(\tau)}{\partial \tau} = R_t(\tau) \left(\frac{1}{\tau} + (\omega - \rho) \right)$$

From (A.5)-A(7) we have

$$(A.8) \quad \frac{\partial U_t(\tau)}{\partial \tau} = \alpha (R_t(\tau) + y_t)^{\lambda-1} R_t(\tau) \left(\frac{1}{\tau} + (\omega - \rho) \right)$$

and therefore

$$(A.9) \quad \int_{\tau}^D e^{-\delta(t-\tau)} \frac{\partial U_t(\tau)}{\partial \tau} dt = \alpha \left(\frac{1}{\tau} + (\omega - \rho) \right) \int_{\tau}^D e^{-\delta(t-\tau)} (R_t(\tau) + y_t)^{\lambda-1} R_t(\tau) dt$$

If we assume y_t is constant, then (A.9) reduces to:

$$(A.10) \quad \int_{\tau}^D e^{-\delta(t-\tau)} \frac{\partial U_t(\tau)}{\partial \tau} dt = \alpha \left(\frac{(1 + \tau(\omega - \rho))(D - \tau)}{\tau} \right) (R_{\tau}(\tau) + y_{\tau})^{\lambda-1} R_{\tau}(\tau)$$

The latter expression may be used in estimating the model. In practice we revert to discrete time by putting

$$(A.11) \quad \Delta(\tau) = \begin{cases} \alpha \left(\frac{(1 + (\tau + 1)(\omega - \rho))(D - \tau + 1)}{\tau + 1} \right) (R_{\tau+1}(\tau + 1) + y)^{\lambda-1} R_{\tau+1}(\tau + 1) & \text{if } (A_{\tau} + C_{\tau}) = 1 \text{ or } (A_{\tau+1} + C_{\tau+1}) = 1 \\ 0 & \text{otherwise} \end{cases}$$

Following a similar procedure we also get the expression for computing $\Gamma(\tau)$:

$$(A.11.a) \quad \Gamma(\tau) = \alpha [W_{\tau} - R_{\tau}(\tau) + \left(\frac{1}{\tau} + \omega - \rho \right) R_{\tau}(\tau) e^{-\lambda \rho \tau} \left(\frac{e^{(\lambda \rho - \delta)D} - e^{(\lambda \rho - \delta)\tau}}{\lambda \rho - \delta} \right)] \bar{C}^{\lambda-1}$$

The estimates reported in this paper is based on $\rho=0.02$.

Appendix 4. Imputation of incomes, Italy 1993.

Employment income is given in (A.1), but here we will account for observed individual characteristics and unobserved variables.

$$(A.12) \quad \begin{aligned} W_t &= W_0 e^{\omega t} u_{wt} \\ W_0 &= e^{Z_w \theta_w} \end{aligned}$$

where W_0 is a basic or starting employment income, which is in turn assumed to depend on a set of characteristics Z_w . Employment income grows at a rate ω (due to

experience, career mechanisms etc). As mentioned above time is measured in years since starting employment. Other unobserved variables influencing income are summarised by a log-normal random variable u_{wt} .

As described above pension income approximately mimics the rules used to compute pensions:

$$(A.13) \quad R_t(\tau) = \begin{cases} \psi m(W_\tau, W_{\tau-1}, \dots, W_{\tau-M}) \tau e^{\rho(t-\tau)} u_{Rt} & \text{if } A_\tau + C_\tau = 1 \\ 0 & \text{otherwise} \end{cases}$$

$$(A.14) \quad m(W_\tau, W_{\tau-1}, \dots, W_{\tau-M}) = \frac{1}{M+1} \sum_{i=0}^M W_{\tau-i}$$

The stochastic component u_{Rt} is assumed to follow a lognormal distribution.

The imputation consists of the following steps.

We define a “reduced form” index of propensity to be retired as $\pi'Z_{Pt} + u_{Pt}$, where Z_{Pt} is a vector of characteristics, π is a vector of parameters and u_{Pt} is a standard normal random variable.

We estimate the probability of being retired as

$$(A.15) \quad \Phi(\pi'Z_{Pt}) = \Pr(u_{Pt} > -\pi'Z_{Pt})$$

We select the sub-sample of employed individuals and we estimate the following equation, derived from expression (A.12) above,

$$(A.16) \quad E(\dot{W}_t) = \theta'_W Z_{Wt} + \omega t - \frac{\text{cov}(\dot{u}_{Wt}, \dot{u}_{Pt})}{\text{var}(\dot{u}_{Pt})^{1/2}} \frac{\phi(\pi'Z_{Pt})}{(1 - \Phi(\pi'Z_{Pt}))}$$

where the “dot” upon a variable indicate the natural logarithm transformation,

$\phi(\cdot)$ is the standard normal probability density function and the term $\frac{\phi(\pi'Z_{Pt})}{(1 - \Phi(\pi'Z_{Pt}))}$ is computed using the π estimated in step 2 above.

The estimated θ_W and ω are used to compute the expected employment income at time t , which is then imputed to every one in the whole sample.

The starting point to estimate pension income is expression (A.13)-(A.14) above.

Ignoring the u_w for simplicity, we obtain $m(W_t, W_{t-1}, \dots, W_{t-M}) = W_t \sum_{i=0}^M e^{-i} / (M+1)$ and then

$$\dot{R}_t(\tau) = k(M) + \dot{W}_\tau + \dot{\tau} + r(t-\tau) + \dot{u}_{Rt}, \quad \text{where} \quad \text{the} \quad \text{term}$$

$k(M) \equiv \ln(\psi) + \ln\left(\sum_{i=0}^M e^{-i} / (M+1)\right)$ depends on M, which in turn depends on the specific

retirement regime relevant to the individual (sector(s) of employment, type of jobs etc.). In the estimation, $k(M)$ is expressed as a linear combination of employment dummies. We also let the coefficient of W_τ to vary with the same dummies. This is done in order to introduce more flexibility into the approximation, for example to account for the fact that there might be discontinuity in the employment career, changes of sector and job etc. Summing up, the following equation is estimated on the sub-sample of retired individuals:

$$(A.17) \quad E(\dot{R}_t(\tau)) = \eta_0' J + (\eta_1' J) \dot{W}_\tau + \dot{\tau} + \rho(t-\tau) + \frac{\text{cov}(\dot{u}_{Rt}, \dot{u}_{Pt})}{\text{var}(\dot{u}_{Pt})^{1/2}} \frac{\phi(\pi' Z_{Pt})}{\Phi(\pi' Z_{Pt})}$$

where W_τ is computed with the estimates of step 3 above, J is a vector of (last) employment dummies, the η s are vectors of parameters.

Last, the estimates of η_0, η_1 and ρ are used to compute $R_t(t)$ and impute it to everyone in the whole sample. Note that $R_t(t)$ is the pension the individual would receive at time t where she to retire at the same time t . Note also that in computing $R_t(t)$ we have $\tau = t$ and therefore the term $\rho(t-\tau)$ cancels out.

Vector Z_{Pt} contains the following variables, both for men and women:

CONST, a constant term

EDUC = years of formal education divided by 10

N = Household's size

Y_t = “exogenous” income (= total household income – individual’s employment or pension income)

A_t , C_t , AGE_t , PUBLIC, SELF, CENTRE and SOUTH as defined in section 3

Vector Z_{wt} contains:

CONST, a constant term

$SENIOR_t$ = potential seniority (= (1993-last year in formal education)/10)

EDUC, PUBLIC, SELF, CENTRE and SOUTH as defined above and in section 3

Vector J contains:

CONST, a constant term

PUBLIC and SELF as defined in section 3

Tables A.13 - A.15 report the estimates of equations (A.15)-(A.17).

Table A.13 “Reduced Form” Retirement Probit

Variable	Men		Women	
	Parameter estimate	Asy-t	Parameter Estimate	Asy-t
CONST	-7.232	-19.47	-6.689	-15.09
C	0.264	1.63	0.188	0.91
A	1.163	5.55	1.683	7.33
AGE	1.329	19.05	1.177	14.96
EDUC	-0.678	-8.51	-0.452	-3.85
N	-0.677	-2.39	-0.657	-1.61
CENTRE	-0.406	-5.01	-0.519	-4.82
SOUTH	-0.369	-4.98	-0.616	-5.69
Y	0.067	3.43	0.046	3.33
PUBLIC	0.049	0.65	0.546	4.04
SELF	-0.516	-6.53	-0.406	-3.26
No of obs	6005		3522	

Note: Y is measured in 10,000,000 ITL. The samples include all the individuals of any age who in 1993 are either employed or retired on an employment pension scheme.

Table A.14. Employment income equation

Variable	Men		Women	
	Parameter Estimate	Asy-t	Parameter Estimate	Asy-t
CONST	9.205	202.64	8.673	116.63
SENIOR	0.136	10.32	0.162	5.99
EDUC	0.585	26.38	0.587	14.95
CENTRE	-0.079	-3.54	-0.120	-3.53
SOUTH	-0.206	-13.35	-0.235	-7.06
PUBLIC	0.08	3.89	0.276	8.01
SELF	-0.198	-9.48	-0.090	-2.37
Selectivity Correction	-0.243	-6.00	-0.107	-1.79
\bar{R}^2	0.242		0.226	
No of obs	3924		2181	

Note: Income is measured in 1,000 ITL. The samples include all the individuals of any age who are employed in 1993

Table A.15. Pension income equation

Variable	Men		Women	
	Parameter Estimate	Asy-t	Parameter Estimate	Asy-t
CNST	-0.474	-0.84	6.171	8.31
\dot{W}_τ	0.825	14.88	0.134	1.72
PUBLIC* \dot{W}_τ	-0.314	-3.61	0.785	6.75
SELF* \dot{W}_τ	-0.629	-5.99	-0.066	-0.46
PUBLIC	3.378	3.80	-7.387	-6.49
SELF	5.796	5.56	0.392	0.29
$t - \tau$	0.143	9.81	0.130	8.77
Selectivity Correction	0.428	19.14	0.327	11.30
\bar{R}^2	0.401		0.432	
n. obs	2062		1321	

Note: $t - \tau$ is measured in years divided by 10; Income is measured in 1,000 ITL. The samples include all the individuals of any age who in 1993 are retired on an employment pension scheme.