Public Pension Programmes and the Retirement of Married Couples in Denmark

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Introduction

Over the last 40 years the labour force participation of older men in OECD countries has fallen in absolute terms and relative to older women. This is against a background of fairly constant participation of younger men and increasing participation of younger women. Such is true for example in Denmark, where a growing proportion of women are reaching their late 50's, having had a long labour market career. At age 55, 75% of persons are married, and of all ages, individuals in their late 50's are most likely to be married. Hence the retirement decisions of married couples are central to the analysis of the effects of public pension programmes.

Career married couples tend to retire close together in calendar time even though they are often of different ages. Several reasons have been suggested as to why this is the case, for example complementarity of leisure, correlated preferences, common shocks and shared finances. Many studies have found varying support for different combinations of these factors. In order for economists to interpret estimates of financial incentive effects on retirement behaviour, a structural model needs to be taken to the data.

In most empirical work there is a balance to be struck between complexity of the behaviour being represented and the amount of information contained in the data. The amount of useful variation depends upon sampling frame, variable list and institutional setting for the observational data. Most empirical retirement studies use the HRS (Health and Retirement Study), a very rich set of variables following a modest number of observations for a short panel in the US. The US context of employer provided health insurance, re-entry to the labour force after retirement from a career job, joint taxation and joint benefits, requires careful modeling of several simultaneous processes[1]. Furthermore, after what is often most of a lifetime of having lived and planned together, it is variation in couples' replacement rates which are used to identify retirement age elasticities, and to make inference about cross-spouse elasticities.

It is the aim of this study to address some of the difficulties that have hindered couples retirement studies to date. We set up a simple dynamic structural model of joint retirement decisions. This is applied to a 1% sample drawn from 25 years of population-based longitudinal data from Denmark. The Danish context is perhaps uniquely informative because of its combination of universal health insurance coverage, individual-based programme eligibility, largely independent taxation of income and rare labor market re-entry. This must be contrasted with the difficulties that researchers using US data in particular have to face: employer-provided health insurance which demands careful modeling of the eligibility status and relatively frequent labor market re-entry after retirement from a career job.

Furthermore, in Denmark a generous public pension programme (efterløn - PEW) has been introduced, with dramatic effects. Within a year, the participation rate for men aged 60-66 fell from 80 to 60%. Eligibility to PEW varied both within and between married couples, entitlement was all-or-

[1] For example van der Klaauw and Wolpin (2005)

nothing, and exit from the labour force before age of first eligibility, or re-entry after first receipt, meant permanent disqualification. An important contribution of this study is exploiting these discontinuities by way of carefully characterising income streams from potential future retirement ages, to provide exogenous income variation to identify the model.

Three broad approaches have been followed in the literature on the economic determinants of retirement. First, structural modeling of the household as a decision unit where all the elements deemed important to describe current and future retirement options are characterised in detail and embedded in a structural discrete choice model.

A second approach places more emphasis on the decision process within the household as the important determinant of association between the retirement dates. Within this approach, two different routes (maintained behavioural hypothesis) have been followed: some studies assume that spouses are involved in bargaining over the outcomes of their labor force participation decisions (Nash or otherwise), while others posit that decisions within the household always achieve Pareto optimality.

A third approach places less emphasis on structural modeling, or even on the details of decision making within household, and relies on reduced form dynamic (or even static) models of joint retirement ages as a response to variation in earnings in-work and income out-of-work. This has the advantage of allowing a more complete statistical description of the data of interest, at the expense of less transparent economic interpretation. In particular, these models must remain silent about the effects of out-of-sample policy reforms.

Following the seminal work of Rust & Phelan (1997), which explains the association between eligibility to health insurance and labour force participation of older individuals, Blau & Gilleski (2004) estimate a dynamic structural model of the joint employment decision of older married couples based on the HRS. Health insurance plans are bundled with the employment contract to a certain employer and the contribution of the paper is to model how aversion to the risk of uninsured medical expenditure affects employment transitions. Potential earnings and unearned income are assumed non-stochastic, though there is an exogenous stochastic layoff process. Divorce and death are assumed to follow an exogenous stochastic process, leading to assignment of a fixed terminal utility value for the couple, so individual members of couples are not modeled. Health (good, bad or dead) follows an exogenous process as a function of age, gender and lagged health. Finally saving is not allowed, so consumption equals income less out-of-pocket medical expenses. Total medical expenditure is a random draw from a discretized distribution, which is then mapped to out-of-pocket by the health insurance plan. For estimation, the value function is approximated by simulation and interpolation following Keane & Wolpin (1994). Assumptions on utility shocks yield a multinomial logit structure without unobserved heterogeneity. Their results seem to question the importance of eligibility to

Medicare as a determinant of employment of married couples, but emphasize the importance of eligibility to other health insurance and social security.

Again based on the HRS, van der Klaauw & Wolpin (2006) set up an ambitious structural dynamic model with uncertainty for older married couples where savings decisions are the central channel through which pension specific characteristics determine the joint retirement age. They find that changes in social security benefits do not lead to substantial changes in labour supply early, but that the main effect would arise between the ages of 62 and 69. Furthermore they simulate the removal of an early retirement option and find that this would have substantial effects on labour supply, while the effect is smaller on women than on men[2].

Gustman and Steinmeier (2000) represent one strand of the second approach. They estimate a forward-looking collective model where elderly married couples bargain non-cooperatively. Uncertainty is ignored and retirement ages are decided optimally at the beginning of the lifecycle. Retirement is an absorbing state. The incomplete estimation problem of multiple Nash equilibria is addressed by assuming the first spouse to retire commits the couple to his or her preferred equilibrium. The model is estimated on data from the US National Longitudinal Survey of Mature Women. The predictive power of the model is limited, in that the proportion of observed joint retirees is much larger than the predicted probability. They

[2] French and Jones (2004) provide further evidence of the importance of saving on the retirement decision in the case of single individuals.

conclude that the correlation between individual taste matters more than the correlation between incentives[3].

Michaud & Vermeulen (2004) represent another strand to the second approach which focuses on the characteristics of decision making within the household. They estimate a static structural collective model where elderly couples bargain cooperatively to reach pareto efficiency. They assume in particular that widow(er)s have the same preferences as married individuals, and that marriage only gives utility through externalities in leisure. Five discrete labour supply alternatives for each spouse are estimated as a multinomial logit with bivariate normal heterogeneity.

Finally, Blau (1997, 1998), which are representative of the third approach, estimates a “simpler” dynamic multinomial probit by simulated maximum likelihood. Forward looking behaviour is accounted for by including in the set of explanatory variables a small number of expected income streams corresponding to typical employment sequences. The dynamic programming problem is not solved however[4] [5].

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[3] This work is extended further in Gustman and Steinmeier (2002, 2005).

[4] Sedillot & Walraet (2002) follow Blau (1997 & 1998) for French couples. Mastrogiacomo, Alessie & Lindeboom (2005) estimate a reduced form multinomial logit with household-specific normal unobserved heterogeneity by simulated maximum likelihood for Dutch couples.

[5] Using a similar data source to ours, An, Christensen & Datta Gupta (2005) set up a reduced form dynamic model for the retirement of Danish couples. This is estimated as a bivariate mixed proportional hazard with trivariate normal heterogeneity (husband, wife and couple effects).

Our stochastic dynamic model of married couples retirement ages is such that individuals are forward-looking and we allow for a non trivial (although not general) consumption/saving behaviour. The household is the unit on which to base policy analysis because it is at this level that decisions are internalized. We do not set up a model of decision making within the household, and so implicitly take a unitary approach. However, our model structure allows us in principle to distinguish between alternative explanations of the joint timing of retirement within couples: correlated preferences due to leisure complementarity or substitutability, common shocks, and shared finances. In particular, we show the effect of changes in replacement rates (income flows in- and out-of-work) on the probability of each spouse retiring at each age.

The population-based longitudinal administrative data we use here spans 25 years and is immune to sample attrition[6]. Furthermore it brings the relevant planning horizon within the observed time period for many couples. In comparison to the HRS for example, our Danish dataset can credibly sustain a good degree of model complexity.

For identification of the economic parameters of interest we rely on a generous public pension programme (PEW) which was introduced in 1979 and reformed during our sample period. An important contribution of this study is exploiting these discontinuities by way of carefully characterising

[6] Emigration of older workers is negligible, and what remains is "natural" sample attrition due to separation, divorce and death.

income streams from potential future retirement ages and providing exogenous income variation to identify the model.

The rest of the paper is structured as follows. The next section describes the institutional specifics of the Danish social security system and provides a simple description of the observed couples' retirement process. The third section presents our empirical model of couples' retirement. Section four presents and interprets the estimation results and provides some counterfactual policy analysis. Finally we conclude.

2. Institutional Background And Data Description

2.1. Income Security Programmes For The Elderly

There are six transfer programmes relevant to the elderly population: old age pension, social & disability pension, social assistance, unemployment insurance benefit, post employment wage (PEW) and public employees pension (PEP). Only social assistance is means-tested against family income and the rest are individual-based. This sub-section outlines the relevant features of these programmes with the aim of illustrating that the PEW and PEP programmes are the most relevant early exit routes. Furthermore, amongst this variety of programmes, reforms of PEW and PEP offer important variation in replacement rates which can help identify the behavioural effects of financial incentives.

The publicly financed old age pension (*folkepension*) is available at 67, covers everyone regardless of previous attachment to the labour market, and was worth 38 (40)% of average production worker earnings (APWE) in 1980 (2000). Social Assistance (*bistandshjælp*) is the lowest level of income support, which is means-tested against family income and available to those who are neither working nor insured against unemployment. It was worth about 22 (24)% of APWE. Unemployment Insurance Benefit (*arbejdsløshedsforsikring*) is available to those who are not working, are actively seeking work and currently members of an unemployment insurance fund and have been insured for at least 6 of the previous 12 months. Benefit lasts for up to 30 months, is 90% of former wage up to a ceiling and was worth 60 (58)% of APWE. Provision for those not working due to disability or long-term sickness is through the social and disability pension (*fortidspension*) programme. It is available to those aged over 17 according to three levels of assessed capacity for work, based on medical and social criteria. The lowest level of entitlement was worth 46 (41)% of APWE.

The Public Sector Employees Pension (*tjænstemændspension*, hereafter PEP) is available to civil servants in selected occupations from age 60. Entitlement is a function of years of service and seniority (or pensionable wage).

The Post-Employment Wage (*efterlon*, hereafter PEW) is an early retirement programme where remuneration is the same as for Unemployment Insurance Benefit, but after 30 months, instead of support being withdrawn, it is reduced to 80% of its former level until age 66. Eligibility is restricted to those aged 60–66 who have contributed to an unemployment insurance fund.

Social and disability pension, social assistance and unemployment insurance benefit programmes experienced no major reforms relevant to the elderly population. Until 1978, PEP was available first from age 67 or 70, depending upon seniority. In 1979 an early retirement option was made available starting age 60. PEW was introduced in 1979 conditional on current UI fund membership and membership for 5 out of the previous 10 years. The eligibility requirement for the number of years of membership was increased in 1980 (10/15), 1985 (15/20), 1990 (20/25) and 1995 (25/30). Before 1979 there were no pension rights associated with UI Fund membership. In this sense PEW membership is pre-determined.

In summary, PEW and PEP are the most attractive early exit routes from work for those who are eligible. PEW offers high replacement rates for low wage workers.

2.2. Health Insurance And Occupational Pensions

Health insurance provision is universal, and financed through general taxation. Only prescription medicine purchases have co-payments below a ceiling, but these are still heavily subsidized. Health insurance is also independent of the employment relationship.

Employer-provided pensions are organized along occupational and industry lines into about 50 different pension funds. These groups closely correspond to labour unions and unemployment insurance funds, but membership is not bundled. Consequently, the fund follows the worker rather than the employer, and individual transition between funds is rare. Movement of workers between employers has no consequence for pension entitlements. Employer lock-in through occupational pensions is not an issue in Denmark.

Membership of these funds only began to expand in the late 1980's, contribution histories are not complete, the funds are not yet mature and pension receipt is still a low proportion of total pension income.

These institutional features have important implications for modeling of retirement behaviour in Denmark which contrast sharply with the US setting. In the US employer-provided health insurance is an important determinant of elderly labour supply, which has consequences for movement of workers between employers and out of the labour force. This ties together work decisions with individual expected future health and attitude to risk through health insurance. Furthermore, most plans cover spouses, and couples choose to contribute to the most generous plan that their respective employers offer. This ties spouses to their employers differentially according to plan generosity.

In Denmark, health insurance is irrelevant to the retirement decision, although health itself of course might be an important determinant. Employer-to-employer movements are neither relevant to health insurance nor occupational pensions. This greatly simplifies the problem of modeling elderly labour supply, since employer-to-employer movements need not be explicitly considered and neither does health insurance plan design and choice need to be taken into account.

The aim of any structural model of couples' retirement is essentially to estimate the elasticity of husband and wife retirement ages with respect to husband and wife replacement rates. This provides a common currency with which to compare evidence from different models estimated in different institutional settings on the basis of different datasets. While it is important to take distinctive local institutional features appropriately into account in modeling, and care needs to be taken when comparing elasticities between settings, it is precisely this different institutional detail which can inform us about the determinants of behaviour. In Denmark, the financial consequences of elderly labour supply decisions are relatively uncomplicated. This simplifies analysis because of a rather transparent incentive structure which helps direct interpretation of results.

Our observation period spans large reforms to public pension programmes which provide arguably exogenous variation in replacement rates that can help identify behavioural responses to financial incentives. The next section describes the dataset used in analysis and illustrates the raw variation in retirement behaviour and income in a descriptive way.

2.3. Data Description

Retirement is defined as a transition to long-term (at least 1 year) non-work for older workers. Non-work, for us, requires that two conditions are fulfilled for a calendar year: (1) zero mandatory pension contributions which are only made in-work; (2) primary source of income during the year is not from current employment.[7] Our register data does not allow us to time retirement within the year, and all we are able to say is that the transition from work to retirement occurred sometime during the calendar year before the first full year of non-work.

Real net income is computed from administrative tax records of individual gross incomes and taxes paid. Income taxation of couples is separate for labour income and joint for capital income. Contributions to pension funds are tax deductable, and tax is paid separately when the pension is received. Net incomes in- and out-of-work are calculated in the same way. However, in the year of retirement, income is classified as out-of-work income, despite the fact that this is most often a combination of income from work in the early part of the year and from non-work in the later part.

Real net wealth is obtained from administrative tax records. Wealth taxation existed until 1996 and was on a joint basis. Wealth continued to be registered on a similar basis after 1996. Important omissions from the wealth measure are value of pension funds and value of owner-occupied dwellings.

The sample is defined as married couples at any time during the years 1977-2001, where both are aged over 49 years, the husband is observed working until at least age 57 and the wife until at least 55. Should the couple

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[7] This definition is similar to that used in other retirement studies using Danish register data, for example Pedersen and Smith (1996).

separate or divorce, or either member die or emigrate, then both members of the couple are observed in the sample for the last time in the previous year. Men are assumed to be first at risk of retirement at age 58 and women at 56. Income flows are estimated on the basis of the entire population at risk of retirement fitting these criteria (1,673,376 observations on 153,818 couples). Retirement age is modeled for a 1% sub-sample of couples fitting these criteria where at least one partner is at risk of retirement (17,107 observations on 1,538 couples).

Changes in eligibility criteria to the PEW programme form the basis for identification of the effects of transfer programmes on individual income and retirement. Calculating individual eligibility requires knowledge of unemployment insurance fund membership back to 1970. We do not observe membership prior to 1977. However, we do know the employment history for each person from 1970, thanks to the history of mandatory social security contributions. Fund membership is imputed during these missing years by using employment history together with fund membership status in 1977. The assumption is that membership status in 1977 reflects membership during the period 1970–1976.[8]

Unemployment insurance fund contributions, UI Benefits and PEW entitlements are a function of hours worked. The unemployment insurance system and social security contributions measure hours of work in similar

[8] This can be justified by the fact that very few older workers (only 3% of those aged over 49) change membership status in the first 6 year period over which we observe membership 1977-1983.

ways. Hence, conditional on the assumption regarding the equivalence of mandatory social security contributions and continued insurance fund membership, we are able to impute to each worker an age at which he or she becomes eligible to the PEW. In our sample, 82% of men and 62% of women are ever potentially eligible.

Figure 1 presents the evolution over time of labour force participation of the population of married men and women for selected ages. The introduction of PEW in 1979 can clearly be seen to coincide with a sharp reduction in elderly male employment. For women the reduction was somewhat more modest, falling from a lower base employment rate, but still obviously within a few years of PEW. Similar reductions are not observed at younger ages, where secular and cyclical movements predominate.

3. Empirical Model

Assume that each household consumes each period a fixed proportion α of its disposable income whatever the labour force participation state of its members. At time t and in any state (i,j,R_m,R_w) (where i [respectively j] is equal to one if the man [respectively the woman] is active in the labour market and 0 otherwise; R_m [respectively R_w] is equal to 0 if the man has not retired by time t and is equal to the retirement date if the man [resp. woman] has retired before t) the equation of motion for the household disposable income, $Y_d\left(t,i,j,R_m,R_w\right)$, from the previous period's state $\left(i',j',R'_m,R'_w\right)$ is:

$$Y_d\left(t,i,j,R_m,R_w\right)=\left(1+r\right)\left(1-\alpha\right)Y_d\left(t-1,i',j',R_m',R_w'\right)+y\left(t,i,j,R_m,R_w\right), \quad (1.1)$$

where r stands for the interest rate on savings. Furthermore, since retirement is absorbing the state variables must obey the following dynamics:

$$\begin{aligned}
&0\le i\le i'\le 1,\\
&0\le j\le j'\le 1,\\
&R_m=R_m'\mathbf{1}\left[\left\{i'=0\right\}\cup\left\{R_m'>0\right\}\right]+\left(t-1\right)\mathbf{1}\left[\left\{i'=0\right\}\cup\left\{R_m'=0\right\}\right],\\
&R_w=R_w'\mathbf{1}\left[\left\{j'=0\right\}\cup\left\{R_w'>0\right\}\right]+\left(t-1\right)\mathbf{1}\left[\left\{j'=0\right\}\cup\left\{R_w'=0\right\}\right].
\end{aligned} \quad (1.2)$$

Furthermore $y\left(t,i,j,R_m,R_w\right)$ stands for the couples joint income at time t in state *(i,j,*R_m*,*R_w*)*, i.e. the sum of the spouses' income flows at time t (earnings or out of work income):

$$y\left(t,i,j,R_m,R_w\right)=y_m\left(t,i,R_m\right)+y_w\left(t,j,R_w\right). \quad (1.3)$$

At time t_0, we set the initial value of the disposable income as

$$Y_d\left(t_0,1,1,0,0\right)=Y_d\left(t_0\right).$$

Finally we assume further that by some given age T all household members have retired.

At time t , when at least one member of the household is active in the labour market, we assume that household *h*'s instantaneous utility flows are specified in the following way:

$$U\left(h,t,1,1,0,0\right)=\beta_{11}^{0}+\beta_{11}^{1}\frac{\left(\alpha Y_{d}\left(h,t,1,1,0,0\right)\right)^{1-\rho}}{1-\rho}+\varepsilon\left(h\right)+\eta\left(h,t,1,1,0,0\right),$$
$$U\left(h,t,1,0,0,R_{w}\right)=\beta_{10}^{0}+\beta_{10}^{1}\frac{\left(\alpha Y_{d}\left(h,t,1,0,0,R_{w}\right)\right)^{1-\rho}}{1-\rho}+\varepsilon\left(h\right)+\eta\left(h,t,1,0,0,R_{w}\right), \quad (1.4)$$
$$U\left(h,t,0,1,R_{m},0\right)=\beta_{01}^{0}+\beta_{01}^{1}\frac{\left(\alpha Y_{d}\left(h,t,0,1,R_{m},0\right)\right)^{1-\rho}}{1-\rho}+\varepsilon\left(h\right)+\eta\left(h,t,0,1,R_{m},0\right),$$

where the unobserved component $\eta\left(h,t,i,j,R_m,R_w\right)$ are household, time, and alternative specific, while $\varepsilon\left(h\right)$ is specific to the household and is time invariant. The parameters of interest are $\beta_{ij}^{k}, k\in\{0,1\},(i,j)\in\{(1,1),(1,0),(0,1)\}$, which could in principle be made household specific (i.e. dependent on some household specific observable characteristics and/or unobserved component), ρ which can be understood as the coefficient of relative risk aversion, and α the average propensity to consume.

To complete the model we specify the terminal value accruing to a household where both spouses are out of employment first at time *t*,

$$W\left(h,t,0,0,R_{m},R_{w}\right)=$$
$$\beta_{00}^{0}+\beta_{00}^{1}\frac{\left(\left(1+r\right)\left(1-\alpha\right)Y_{d}\left(h,t-1,i',j',R_{m},R_{w}\right)+\delta y\left(h,t,0,0,R_{m},R_{w}\right)\right)^{1-\rho_{00}}}{1-\rho_{00}} \quad (1.5)$$
$$+\varepsilon\left(h\right)+\eta\left(h,t,0,0,R_{m},R_{w}\right),$$

where at least one of the retirement dates R_m, R_w is equal to *t* (perhaps both) and where the parameter δ allows for a differential effect between the accumulated assets so far and the first income flow to the household when both of its members are out of work. Hence if $\delta=1$ accumulated assets and the flows of income have the same relative value, while if $\delta > 1$ (respectively $\delta < 1$) income flows are more (resp. less) "valuable" to the household than accumulated wealth.

The value at time *t* of a particular course of action of household *h* can then be evaluated recursively using the Bellman equation

$$W\left(h,t,i,j,R_m,R_w\right) = U\left(h,t,i,j,R_m,R_w\right) + \beta \mathrm{E}_t\left[\max_{\substack{m\in\{0,i\}\\ n\in\{0,j\}}}\left\{W\left(t+1,m,n,R_m,R_w\right)\right\}\right], t \geq 0, \tag{1.6}$$

and at time *t*, given the previous period labour force participation status $\left(i',j'\right)$, the household decision problem becomes

$$\max_{\substack{i\in\{0,i'\}\\ j\in\{0,j'\}}} W\left(h,t,i,j,R_m,R_w\right). \tag{1.7}$$

Hence at time *t*, given the state, both household members plan to be in employment if:

$$\begin{aligned} &W\left(t,1,1,0,0\right) \geq W\left(t,0,1,0,0\right),\\ &W\left(t,1,1,0,0\right) \geq W\left(t,1,0,0,0\right),\\ &W\left(t,1,1,0,0\right) \geq W\left(t,0,0,0,0\right), \end{aligned} \tag{1.8}$$

and the other possible transitions can be characterized in a similar fashion by a set of three inequalities .

Because leaving employment is absorbing for any member of the household, the problem simplifies whenever one of the two spouses has left employment by time *t*. For example assume that $R_m = t-1$ and $R_w = 0$, then the wife will remain in employment if

$$W\left(t,0,1,t-1,0\right) \geq W\left(t,0,0,t-1,0\right), \tag{1.9}$$

and retire otherwise. If instead it is the case that $R_m = 0$ and $R_w = t-1$, the husband will participate if

$$W(t,1,0,0,t-1) \geq W(t,0,0,0,t-1), \tag{1.10}$$

Assumptions about the exact distribution of unobservables are crucial here to compute of the quantities

$$E_t\left[\max_{\substack{i\in\{0,1\}\\ j\in\{0,1\}}} \left\{W(t+1,i,j,R_m,R_w)\right\}\right]. \tag{1.11}$$

Given the above and given a past history, all instances of the unobservables relevant at time *t* are jointly normally distributed and in particular we assume that

$$\begin{pmatrix} \eta(i,t,1,0,R_m,R_w)-\eta(i,t,0,0,R_m,R_w) \\ \eta(i,t,1,0,R_m,R_w)-\eta(i,t,0,1,R_m,R_w) \\ \eta(i,t,1,0,R_m,R_w)-\eta(i,t,1,1,R_m,R_w) \end{pmatrix} \overset{iid}{\sim} N(0,\Sigma), \tag{1.12}$$

with $\Sigma = \begin{bmatrix} 1 & & \\ \sigma_{12} & 1 & \\ \sigma_{13} & \sigma_{23} & 1 \end{bmatrix}$[9].

Expressions A.1 and A.2 in the appendix show how to calculate $E_t\left[\max_{i,j} W(t,i,j,R_m,R_w)\right]$ recursively in terms of $E_t\left[\max_{i,j} W(t+1,i,j,R_m,R_w)\right]$.

Furthermore, this recursive calculation gives the probability at each time *t* that a given household chooses a particular participation pattern, for example

$$\Pr_t\left[(1,0,0,0) = \arg\max\left\{W(t,1,1,0,0), W(t,1,0,0,0), W(t,0,1,0,0), W(t,0,0,0,0)\right\}\right],$$

[9] In principle the variance-covariance structure can be made to be dependent on the household age composition and on the particular decision time.

which is evaluated simply in terms of a trivariate normal joint distribution function and makes the evaluation of the likelihood straightforward.

Our specification potentially captures some of the features that have been deemed important in the literature to explain the timing of retirement decisions, i.e the pattern of complementarity/substitutability in leisure, and the consumption smoothing behaviour.

The complementarity/substitutability pattern that out model allows may be described along the lines presented in Train (2003, chapter 3 and 5). Consider first the myopic case where $\beta = 0$. In this case, to simplify, we can imagine first that each of the four options available (in general) to a couple at entry in our sample depend on an alternative specific attribute. In our context this could simply be the identity of the alternative, or the alternative specific income flow. In the case of a multinomial Logit specification (where the distribution of the alternative specific unobservables would be type I extreme value) varying the value of a single attribute affects all the choice probabilities. If it increases the probability of the given alternative it will however decrease all other probabilities by the same percentage. As emphasized by Train, this pattern of substitution is specific to the Logit specification and is a manifestation of the IIA property. This is a restrictive assumption to make, presumably the larger the number of alternatives. The multinomial probit specification (where the distribution of the alternative specific unobservables is jointly normal) does not impose such restrictions and in principle complex patterns of substitution can be obtained. Hence a variation in an attribute which makes the members of a household more likely to remain both in work, will have a differential effect on the likelihood that the spouse decides to chose one of the other patterns of labour market participation available to them.

When allowing the household to account for the option of future actions (i.e. whenever $\beta \neq 0$) the causes of substitution becomes more complex since not only variation in current attributes matter but variability in future flows of income or more generally utility in all alternatives available in the future [10]. In the penultimate section, we will consider separate permanent changes in each spouses flows of income to describe the pattern of complementarity/substitution.

Furthermore, our simplified treatment of the consumption/saving behaviour allows us to capture some aspects of consumption smoothing and how it interacts with retirement behaviour. In particular it can be easily shown that accounting for saving implies that today's labour market participation decision depends on distributed lags of last period's income flows. It is that dependence on past income flows which in principle allows us to identify the average propensity to consume out of income.

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[10] See Maestas (2001) for an alternative model of joint retirement decision where complementarity/substitutability at the individual level is studied.

4. Estimation and Results

Given the assumption of conditional independence formulated above the likelihood of the sample is straight forward. For example, consider a couple such that the man retires first at some age t_m and the woman retires a few years later at age t_w. The contribution to the likelihood for such an observation is then easily written as

$$
\begin{aligned}
L(t_m, t_w) = & \prod_{\tau=t_0}^{t_m-1} \Pr_\tau [\text{both employed}] \times \\
& \Pr_{t_m} [\text{husband alone retires}] \times \\
& \prod_{\tau=t_m+1}^{t_w-1} \Pr_\tau [\text{wife employed while husband retired}] \times \\
& \Pr_{t_w} [\text{wife retires}].
\end{aligned}
$$

Contributions to the likelihood for alternative retirement age patterns can be obtained in a similar fashion. Furthermore, the contribution of right-censored observations (i.e. such that one or both retirement ages are not yet observed) can be easily accommodated using conventional arguments (see for example Bingley & Lanot, 2004). The estimation results presented in Table 1 assume a value of the discount rate β of 0.95 and for an interest rate r of 5%. This value reflects a consensus in the literature that retirement behaviour is forward looking. Alongside these results and for illustration only we present the results which we obtain under complete myopia (i.e. such that $\beta = 0$).

Table 1 presents the estimates of the main parameters of the model. In addition to the model presented in the earlier section we add alternative specific variances that vary with the age of the spouses. Furthermore we make the alternative specific constants $\beta_{11}^{0}, \beta_{10}^{0}$ and β_{01}^{0} linearly dependent on the age of each spouse. This captures changes in tastes for each alternative where at least one of the spouses is still in employment relative to the alternative where both spouses retire. Finally the model presented earlier is further modified to account for the probability of death of one or both spouses. To that effect we calculate life tables based on the population of couples.

Because of the multinomial aspect of the model the parameters are difficult to comment upon in isolation. We can nonetheless note that the coefficients ρ and ρ_{00} take sensible values which in other context would imply reasonable values for the coefficient of risk aversion (depending on the particular circumstances). However, these parameters are imprecisely estimated.[11] The average propensity to consume takes a reasonable value around 0.7 which would obviously imply saving rates of around 30%. For this population of couples, who are fairly advanced in their life cycle, this appears believable. Furthermore this implies a non negligible smoothing of the consumption path over time (although because of the sizeable drop in income when both spouses retire relative to all other alternative, this is consistent with a sizeable drop in consumption after both spouses have retired).

[11] The variance covariance of the parameters we present here is obtained using the outer product of the gradients to estimate to information matrix

The parameters $\beta_{11}^{1}, \beta_{10}^{1}$ and β_{01}^{1} take similar values between 0.5 and 0.6 and are significant at the 10% significance level. At 5% level we could not reject the hypothesis that $\beta_{11}^{1}, \beta_{10}^{1}$ and β_{01}^{1} take the same value of 0.55.

[Table 1 about here…]

To illustrate the significance of our estimates we calculate (through simulations) the effect of a permanent change of 1% in either income flow (in or out of work) for each spouse. We concentrate on couples where the man is 57 and the woman 55 when the couple enters our sample. The results are presented in Figure 5. Age of either spouse runs along the horizontal axis, and the vertical axis measures the magnitude of the elasticities. The continuous line gives the elasticity of the probability of retirement of the (average) man at any given age, while the dashed line gives the corresponding elasticity for the (average) woman. The left hand column describes the effect in a change in the man's income (top pane: in work income flows, bottom pane: out of work income flows) while the right hand column describes the effect of a change in the woman's income. Clearly the model implies that the woman reacts more to a change in her own income (whatever the source) than the man does, i.e. the range of values of the elasticities is larger for women than for men. Since these represent "unconditional" retirement probabilities (i.e. probability of retiring at a given age) an increase in one probability has to be matched by a decrease of another probability to satisfy adding up. Hence a permanent increase in the man's earnings of 1% decreases the probability of retiring before 60 (by about

-0.8% for the probability of retiring at age 58) while it increases the probability of retiring after 60 (by about 0.4% for the probability of retiring at age 62). Noticeably the probability of retiring at age 60 for either spouse does not seem to be affected by the change in the man's in-work income. The effect of a permanent increase in men's earnings on the woman's probability of retiring satisfy a similar pattern although the elasticities are smaller (about half of the man's at age 58 and 62). A permanent increase in the man's out-of-work income (bottom left pane) has the opposite effect on the probabilities of retiring for the man and the woman with comparable relative magnitudes. The negative sign of the elasticity of the probability of the woman retiring before 60 would suggest that the woman's leisure is a complement to the man's leisure before age 60 and is a complement after age 60 (this must be the case by contruction, the probability to retire at some age have to sum to one, hence negative elasticities early on have to be matched by positive ones later on).

A permanent change of the woman's income flows causes a similar pattern. The change in income has little effect on the woman's probability of retiring at 60, while it has no discernable effect on the man's probability of retiring at 61. In this case we observe that the man's leisure is a complement to the woman's.

5. Conclusions

TO BE ADDED

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Appendix

Derivation of E[max{*W*}] in multinomial (trivariate) normal case

Note that the quantities (1.11) involve at most four elements which are in general correlated since in general we find:

$$\begin{aligned}
&\mathrm{E}_t\left[\max_{\substack{i\in\{0,1\}\\ j\in\{0,1\}}}\left\{W(t,i,j)\right\}\right]= \\
&\mathrm{E}_t\left[\max\left\{W(t,1,1),W(t,1,0),W(t,0,1),W(t,0,0)\right\}\right]= \\
&\mathrm{E}_t\left[W(t,0,0)\right]+ \\
&\mathrm{E}_t\left[\left\{W(t,1,0)-W(t,0,0)\right\}\mathbf{1}_{\left[(1,0)=\arg\max\left\{W(t,1,1),W(t,1,0),W(t,0,1),W(t,0,0)\right\}\right]}\right]+ \\
&\mathrm{E}_t\left[\left\{W(t,0,1)-W(t,0,0)\right\}\mathbf{1}_{\left[(0,1)=\arg\max\left\{W(t,1,1),W(t,1,0),W(t,0,1),W(t,0,0)\right\}\right]}\right]+ \\
&\mathrm{E}_t\left[\left\{W(t,1,1)-W(t,0,0)\right\}\mathbf{1}_{\left[(1,1)=\arg\max\left\{W(t,1,1),W(t,1,0),W(t,0,1),W(t,0,0)\right\}\right]}\right]
\end{aligned} \qquad \text{A.1}$$

In turn, given our earlier assumption, each element of the form

$$\mathrm{E}_t\left[\left\{W(t,1,0)-W(t,0,0)\right\}\mathbf{1}_{\left[(1,0)=\arg\max\left\{W(t,1,1),W(t,1,0),W(t,0,1),W(t,0,0)\right\}\right]}\right],$$

can be evaluated as

$$\begin{aligned}
&\mathrm{E}_t\left[\left\{W(t,1,0)-W(t,0,0)\right\}\mathbf{1}_{\left[(1,0)=\arg\max\left\{W(t,1,1),W(t,1,0),W(t,0,1),W(t,0,0)\right\}\right]}\right]= \\
&\Big\{\mathrm{E}_t\left[W(t,1,0)-W(t,0,0)\right]\;+ \\
&\beta\mathrm{E}_t\left[\max\left\{W(t+1,1,1),W(t+1,1,0),W(t+1,0,1),W(t+1,0,0)\right\}-W(t+1,0,0)\right]\Big\}\times \\
&\mathrm{Pr}_t\left[(1,0)=\arg\max\left\{W(t,1,1),W(t,1,0),W(t,0,1),W(t,0,0)\right\}\right]+ \\
&\mathrm{E}_t\left[\;\left\{\eta(t,1,0)-\eta(t,0,0)\;\right\}\mathbf{1}_{\left[(1,0)=\arg\max\left\{W(t,1,1),W(t,1,0),W(t,0,1),W(t,0,0)\right\}\right]}\right]
\end{aligned} \qquad \text{A.2}$$

where the first part of the right hand side above is straightforward to evaluate, while all quantities involving expectations on the RHS can be calculated analytically when the unobservables are jointly normally distributed, in terms of the univariate and bivariate standard normal distribution functions.
In particular, the following result is directly applicable here[12]:

---

[12] A full proof is available from the authors upon request.

$$\mathrm{E}\left[\xi_1 \mathbf{1}_{[\xi_1>a_1,\xi_2>a_2,\xi_3>a_3]}\right]=$$

$$\sum_{i=1}^{3}\rho_{1i}\phi\left[a_i\right]\left\{1-\Phi\left[\frac{a_{i+1}-\rho_{i,i+1}a_i}{\sqrt{1-\rho_{i,i+1}^{2}}}\right]-\Phi\left[\frac{a_{i+2}-\rho_{i,i+2}a_i}{\sqrt{1-\rho_{i,i+2}^{2}}}\right]\right.$$

$$\left.+\Phi_2\left[\frac{a_{i+1}-\rho_{i,i+1}a_i}{\sqrt{1-\rho_{i,i+1}^{2}}},\frac{a_{i+2}-\rho_{i,i+2}a_i}{\sqrt{1-\rho_{i,i+2}^{2}}},\frac{\rho_{i+1,i+2}-\rho_{i,i+1}\rho_{i,i+2}}{\sqrt{\left(1-\rho_{i,i+1}^{2}\right)\left(1-\rho_{i,i+2}^{2}\right)}}\right]\right\}$$

where any subscript i is read as $(i-1)\bmod(3)+1$, and where the ξ_i, $i=1..3$, are standard normal random variables, with correlations $\rho_{ij}=\frac{E\left[\xi_i\xi_j\right]}{\sqrt{E\left[\xi_j^{2}\right]E\left[\xi_i^{2}\right]}}$, and the a_i, $i=1..3$, are real numbers. Note that for any two distinct *j,k* such that $a_j=a_k=-\infty$, the formula above becomes the usual:

$$\mathrm{E}\left[\xi_1 \mathbf{1}_{[\xi_i>a_i]}\right]=\rho_{1i}\phi\left[a_i\right],$$

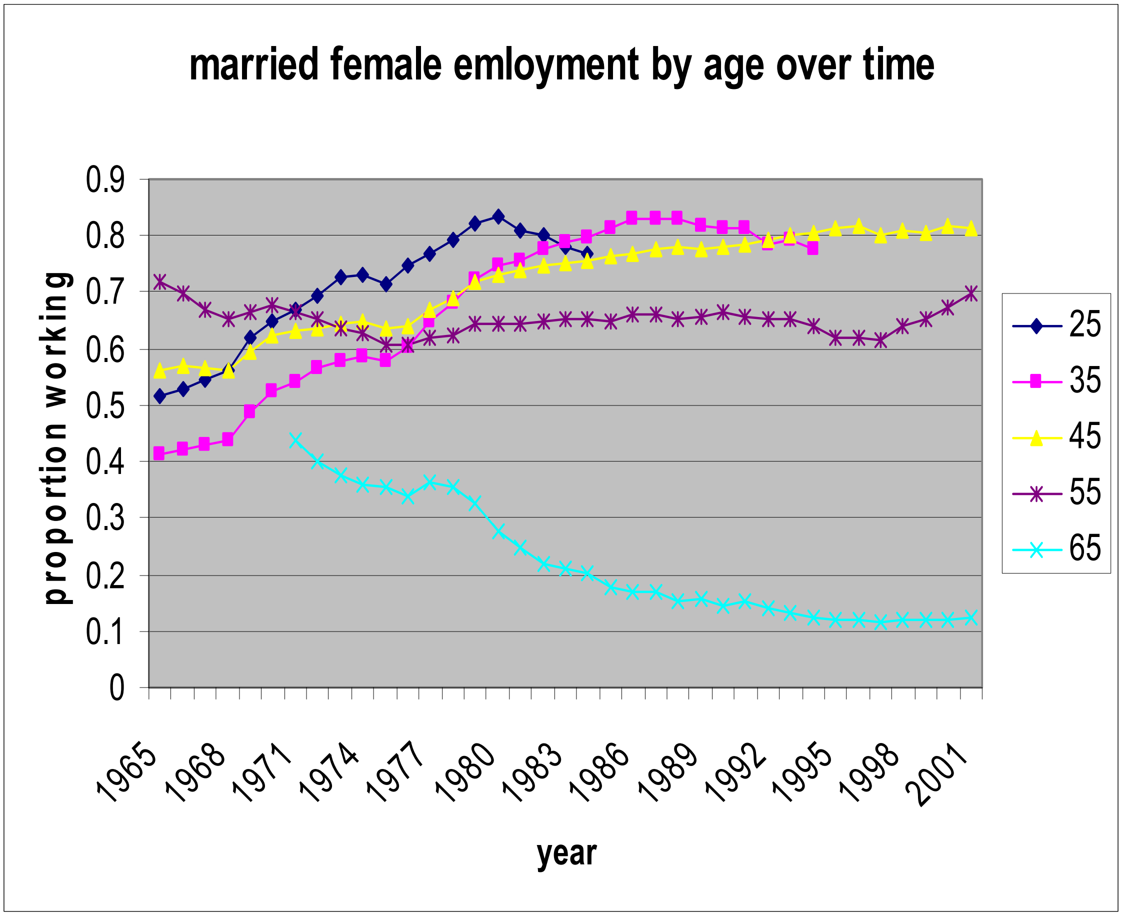
and if we have a single *j* such that $a_j=-\infty$, the formula above gives (as expected):

$$\mathrm{E}\left[\xi_1 \mathbf{1}_{[\xi_i>a_i,\xi_k>a_k]}\right]=\rho_{1i}\phi\left[a_i\right]\left\{1-\Phi\left[\frac{a_k-\rho_{i,k}a_i}{\sqrt{1-\rho_{i,k}^{2}}}\right]\right\}+\rho_{1k}\phi\left[a_k\right]\left\{1-\Phi\left[\frac{a_i-\rho_{i,k}a_k}{\sqrt{1-\rho_{i,k}^{2}}}\right]\right\}.$$

Table 1: Selected Maximum Likelihood Estimation Results
$\beta = 0.95$, r=0.05.

Parameters	Estimates	Std. err.
α	0.7165	0.2842
β_{11}^{0} constant	-0.3763	0.9220
β_{11}^{0} (age man -62)/10	-0.1320	0.0872
β_{11}^{0} (age woman -62)/10	-0.3254	0.0962
β_{11}^{1}	0.6032	0.3745
β_{10}^{0} constant	-0.1995	0.5265
β_{10}^{0} (age man -62)/10	-0.1301	0.0917
β_{10}^{0} (age woman -62)/10	-0.1144	0.0822
β_{10}^{1}	0.5192	0.3678
β_{01}^{0} constant	0.1011	0.9685
β_{01}^{0} (age man -62)/10	0.0909	0.0784
β_{01}^{0} (age woman -62)/10	-0.4299	0.1072
β_{01}^{1}	0.5839	0.4135
ρ	0.3609	0.5482
β_{00}^{1}	0.8785	0.2624
δ	4.4141	1.9857
ρ_{00}	0.5716	0.6877
$\sigma_1 = \exp\left(\theta_m^1 \left(age_m - 62\right)/10 + \theta_w^1 \left(age_w - 62\right)/10\right)$		
θ_m^1	1.6658	0.4685
θ_w^1	0.9199	0.4330
$\sigma_2 = \exp\left(\theta_m^2 \left(age_m - 62\right)/10 + \theta_w^2 \left(age_w - 62\right)/10\right)$		
θ_m^2	1.3339	0.4525
θ_w^2	0.9818	0.3869
$\sigma_3 = \exp\left(\theta_m^3 \left(age_m - 62\right)/10 + \theta_w^3 \left(age_w - 62\right)/10\right)$		
θ_m^1	0.8485	0.4808
θ_w^2	1.0853	0.4662
σ_{12}	0.7965	0.0935
σ_{13}	0.0577	0.0045
σ_{23}	0.0617	0.1512
Mean Log-likelihood	-3.550	
Number of observations	1511	
Number of couples x year observations	11199	

Figure 1.


married female emloyment by age over time
proportion working
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1965
1968
1971
1974
1977
1980
1983
1986
1989
1992
1995
1998
2001
year
25
35
45
55
65


married male emloyment by age over time
proportion working
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1965
1968
1971
1974
1977
1980
1983
1986
1989
1992
1995
1998
2001
year
25
35
45
55
65

Figure 2: Transition Probabilities

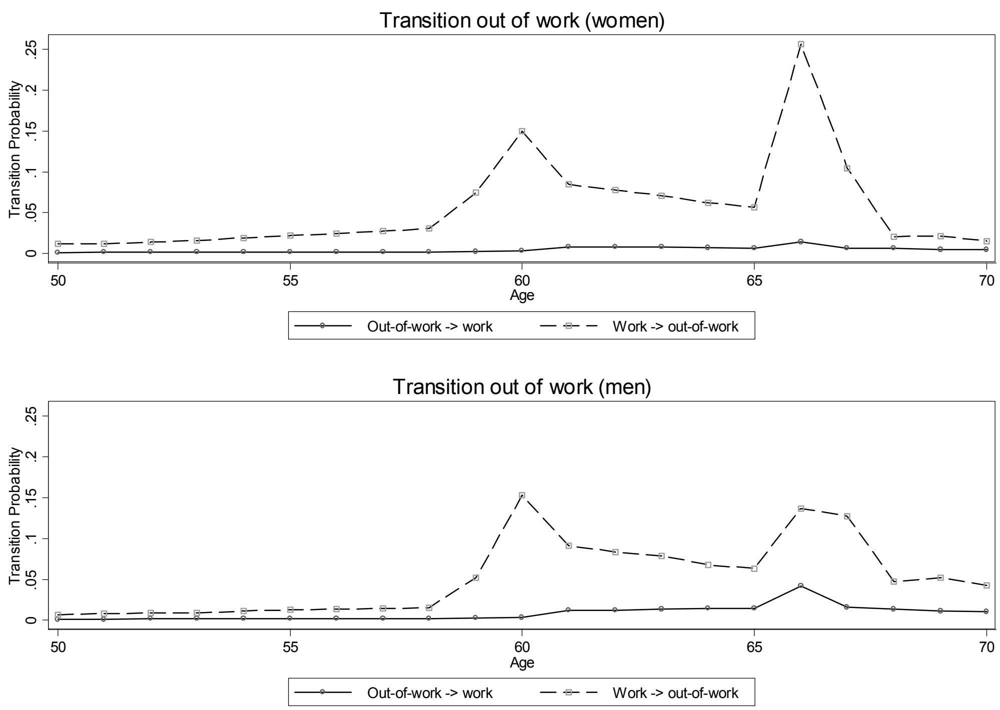


Figure 3: Flows of Income In and Out of Work

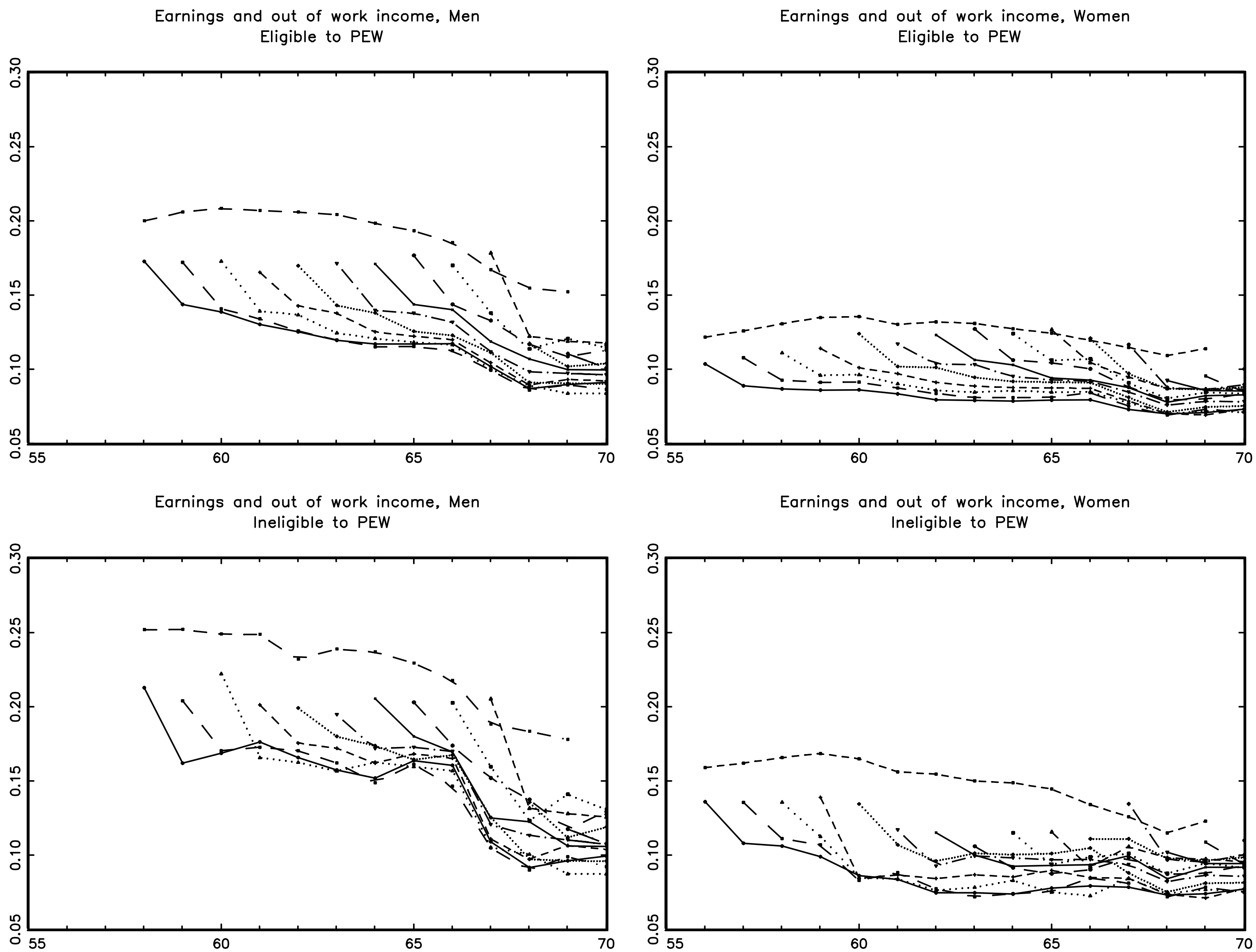


Figure 4: Couples Income Flows

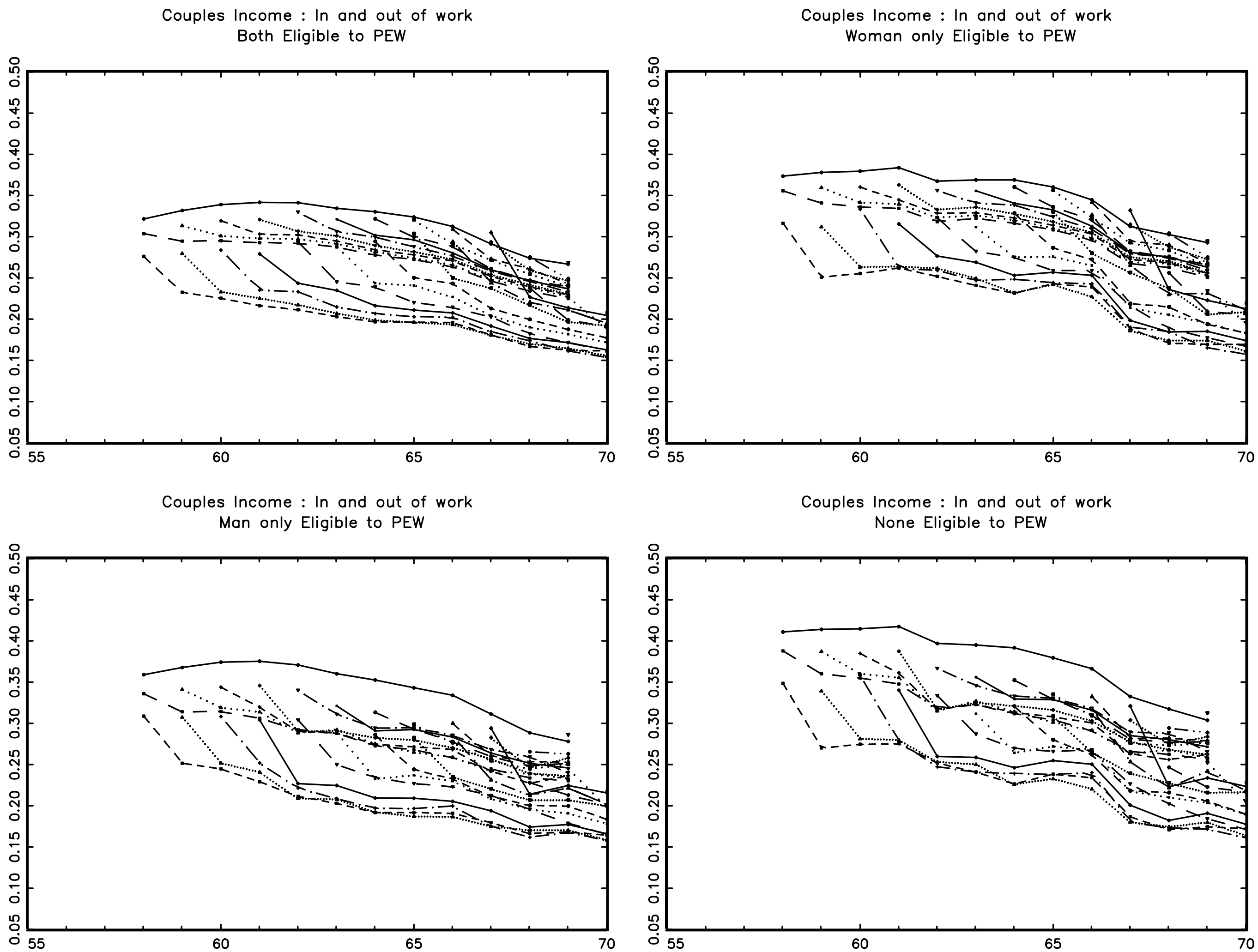


Figure 5: Elasticities Probability of Retirement