Essays on the Labour Supply of Older Workers

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DECLARATION OF AUTHORSHIP

I, *Maria Casanova*, confirm that the work presented in this thesis *"Essays on the Labour Supply of Older Workers"* is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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Abstract

The objective of this thesis is to contribute to a strand of the empirical labor supply literature by advancing our understanding of the labor supply of relatively older workers. This is a topic of particular interest in developed countries, where due to current population trends older individuals comprise an ever growing share of the population.

Chapter 1 provides a summary and overview of the thesis.

Chapter 2 shows that husbands and wives have an incentive to coordinate their retirements due to the existence of leisure complementarities, which arise when one or both spouses enjoy retirement more if it is shared with their partner.

Chapter 3 advances our understanding of older individuals' incentives to continued work by showing that, after accounting for selection into retirement and composition effects, there is no statistical evidence that wages of individuals who remain in their career job ever decrease with age. In other words, conditional on remaining on the career job, the individual wage profile does not have an inverted-U shape. Any wage decreases associated to the declining physical and cognitive abilities associated to the aging process would materialize only at the point where the individual transits from the career job into part-time work, usually referred to as semi-retirement. For individuals that transit directly from the career job into full retirement, no decrease in wages would be observed.

Chapter 4 builds on the results obtained in chapters 2 and 3 to estimate the role of leisure complementarities in determining joint retirements. If finds that they account for 8% of the joint retirements observed in the data (those where husband and wife retire within a year of each other). This result underlines the importance of jointly modeling the behavior of husbands and wives. Confining the analysis to the study of men while taking the behavior of their wives as exogenous -the approach traditionally followed in the literature-, ignores a source of simultaneity in spouses' decisions. This may lead to inaccurate predictions of the effect of policy changes on men's retirement behavior.

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Chapter 1

Overview of the Thesis

The objective of this thesis is to contribute to a strand of the empirical labor supply literature by advancing our understanding of the labor supply of relatively older workers. This is a topic of particular interest in developed countries, where due to current population trends older individuals comprise an ever growing share of the population.

As a consequence of population aging, an increasing number of individuals is drawing retirement benefits from the public sector; and they are doing so for increasingly longer periods of time. This has triggered concern over the future of most developed countries' social security systems, both in terms of their sustainability and their capacity to provide adequate coverage to a vulnerable part of the population. In order to restore financial balance to social security programs, governments are in the process of enacting a series of reforms, including increases in payroll contributions, delays in retirement ages, reductions of replacement rates and cost-of-living adjustments, and incentives to private savings.

While not all of these policies are targeted to older workers, and some of them will primarily affect the young, some others are exclusively aimed at those close to (or exactly at) retirement age. Individuals approaching retirement age, and their labor-supply sensitivity to policy changes, are the focus of this thesis. The reason I choose to focus on them, rather than their younger counterparts, is that the knowledge we have about their labor supply responses is relatively limited. We do know that they are different from workers in their prime years -the labor supply elasticity of men in their 60's, for instance, is several times higher than that of men in their 40's-, but there are many aspects affecting their labor supply choice that have not been sufficiently explored.

The policy changes aimed at older workers that are currently being introduced across OECD countries have one common objective: to give incentives for older individuals to remain employed for longer and thus delay retirement. This is done through a combination of policy instruments which include increases in the pension accrual rate for individuals who remain in employment beyond normal retirement age (e.g., the rate of benefit increase per year of work beyond normal retirement age has increased from 4.5% in 1995 to 8% today in the US. In the UK, since 2005 individuals are allowed to defer receipt of the Basic State Pension for as long as they wish, accruing a 10.5% increase in benefits per year of delay.); increases in the normal retirement age, which imply higher penalties for individuals who retire early (e.g., full retirement age in the US is gradually being increased from 65 years of age for individuals born in 1937 to 67 for those born after 1959. In the UK, state-pension retirement age for women will rise from 60 to 65 years of age between 2010 and 2020); and limits on access to routes into early retirement (several OECD countries have strengthened the requirements to qualify for a disability pension before normal retirement age and have (partially) eliminated early-retirement pensions).

In order to design this type of policies and predict their success in changing workers' behavior, we need measures of older workers' labor supply sensitivity to policy changes. These are usually obtained in the context of structural models that approximate the process whereby workers make their participation decision. These models must accurately measure not only the change in financial incentives associated to the policy reform, but also all other factors affecting the labor supply choice: how much individuals value leisure; the accrual rules of any private pension the worker may have; the wage individuals would receive were they to remain in the labor force; the ability of employers to oblige workers to retire, even if the individual would have found it optimal to remain employed; etc.

This thesis contributes to the literature that seeks to estimate the labor supply response of older individuals to policy changes in two respects. First, it shows the importance of jointly modeling the behavior of husbands and wives. Confining the analysis to the study of men, taking the behavior of their wives as exogenous -the approach traditionally followed in the literature- leads to biased estimates of preference parameters, and therefore incorrect predictions of the effect of policy changes. Second, it advances our understanding of the environment in which older individuals make decisions by showing that, after accounting for selection into retirement and composition effects, there is no statistical evidence that wages of individuals who remain in their career job ever decrease with age. In other words, conditional on remaining on the career job, the individual wage profile does not have an inverted-U shape. Any wage decreases associated to the declining physical and cognitive abilities associated to the aging process would materialize only at the point where the individual transits from the career job into part-time work, usually referred to as semi-retirement. For individuals that transit directly from the career job into full retirement, no decrease in wages would be observed.

The two contributions of the thesis just outlined, and how they are integrated in the structural model of labor supply and saving behavior of older couples estimated in the fourth and last chapter, are discussed in more detail below.

The second chapter of the thesis provides evidence of a tendency of spouses to retire together that cannot be explained by financial incentives or correlated unobservables alone. It shows that this tendency is consistent with the existence of interactions in the preferences of husbands and wives, stemming from one -or both- of the spouses deriving additional utility from their own retirement whenever their partner is retired too. Whether this type of interactions -often referred to as "complementarities in leisure"- exist is a crucial question, since through the link they create between one spouse's utility and their partner's work status they lead to simultaneity in the spouses' choice of their optimal retirement dates. In the presence of leisure complementarities, estimating a model of older men's retirement behavior which takes their wives' income and retirement decision as exogenous would lead to biased estimates of their preference parameters.

The chapter finds evidence consistent with leisure complementarities in a reduced-form framework, avoiding the functional-form assumptions implicit in structural models. This evidence is then used as a motivation for the fourth chapter, where a structural model of couples' labor supply which allows for complementarities in leisure is estimated.

The strategy to test for the existence of leisure complementarities is to assess whether men respond to the (exogenous) incentives to retirement that their wife gets from the Social Security system. In particular, the UK Social Security system gives incentives for women to retire exactly at the state retirement age of 60. Given that a pension cannot be claimed before that age, and that the incentives to continued work after 60 in terms of pension accrual were very limited for women in our sample, a majority of women in the UK actually retires at 60. The US Social Security system, on the other hand, does not give women any incentive to retire until age 62, and the data show that a majority of American women indeed retire at this age. Using American couples as a control group for those in the UK, we compare the likelihood that a man retires when his wife reaches age 60 across the two countries. We find that men in the UK over the age of 60 are considerably more likely to retire at this point than comparable American men.

Our identification strategy is arguably superior to the one previously considered in the literature, namely measuring whether men's retirement decisions were affected by their wives' financial incentives to retirement (proxied by measures of accrued pension wealth). The most obvious weakness of this strategy is that the wife's accrued pension is very unlikely to be exogenous to the husband's retirement decision: if men with a preference for early retirement are married to similar women, and both of them have tried to accumulate sufficient pension wealth to finance an early exit from the work force, we would expect to find a positive relation between men's probability of retirement and their wives' accumulated pension.

Through the use of an exogenous measure of the wife's incentives we avoid this potential endogeneity problem. In particular, we argue that the husband's sensitivity to his wife's age cannot be due to a correlation in unobservables -in the absence of an income effect, a husband whose aim is to retire as soon as possible has no reason to respond to his wife's reaching age 60.

Therefore, we conclude that among the possible explanations that have been proposed in the literature for the prevalence of observed joint retirements (i.e. those where the spouses retire within a year of each other, independently of the age difference between them), our findings are only consistent with the existence of complementarities in leisure.

The third chapter of the thesis estimates the (hourly) wage processes of older men, which is then used as an input for the structural model in chapter 4. Most studies of wage processes have focused on workers in the middle of their careers. Results from these studies cannot necessarily be extrapolated to workers approaching retirement, as there are several reasons why the wage processes of older workers may be different.

First, it is likely that the returns to experience or tenure will be smaller for workers approaching the end of their careers. Moreover, they are more likely to be affected by the physical and cognitive declines associated to the aging process. As a consequence, while the wages of young workers are generally presumed to increase with age, it is not clear what shape we should expect for the wage-age profile of older individuals.

The empirical question of whether wages of older workers increase or decrease with age is of crucial importance for predicting the effects of Social Security reforms. Intuitively, the effectiveness of policies intended to delay average retirement age will be lower the lower the slope of wages with respect to age -in other words, if older workers expect diminishing returns to employment, higher rewards for delayed retirement or penalties for early retirement will be needed to entice them to continue working.

The existing literature that has looked at this issue has found evidence of wage decreases when individuals reach the ages at which they can start drawing Social Security benefits. It is known, however, that individuals who continue working after these ages are much more likely to be semi-retired -usually working part-time- than younger ones. This suggests that part of the decrease in wages happens at the point where individuals leave their career job, but leaves open the question of whether the wage declines had started before, while individuals were employed full-time. In my analysis I address this question by focusing on the wage-age profile of individuals who remain in the career job.

From a methodological perspective, the analysis of the wage processes of older workers requires particular focus on the process of selection into retirement, which turns out to play a crucial role in explaining the downward-sloping wage-age profiles for older workers observed in cross-sections.

After controlling for selection and composition effects, I find no statistical evidence of a decrease in hourly wage rates for workers who remain in their career job, which implies that any wage decrease to accommodate the potentially decreasing productivity of older workers must be fully realized at the time of the switch into partial retirement.

The fourth chapter of the thesis presents a structural, dynamic model of couples' work and saving decisions that builds heavily on the results of chapters 2 and 3. The evidence of the existence of complementarities in leisure presented in chapter 2 informs the structure of this model, where the period utilities of both spouses are allowed to depend on the partner's participation status. While the reduced-form analysis in chapter 2 was adequate to test for the existence of leisure complementarities, the structural model allows to obtain a quantitative assessment of their role in explaining joint retirement.

In order to adequately measure the role of leisure complementarities in determining optimal retirement timing for spouses, it is necessary to control for the other main determinants of spouses choices. Previous structural models of retirement that have estimated the effects of leisure complementarities have made strong simplifying assumptions about the financial and stochastic environment in which agents make decisions. In particular, they have assumed perfect markets and ruled out uncertainty, effectively implying that it was possible to determine the optimal retirement choice of a couple by simply observing their state variables on the first period they appear in the sample. While this considerably simplified the solution of the model, it also meant that any deviation from such retirement age due to the realization of a shock or the effect of liquidity constraints would be attributed to the effect of complementarities.

So as to to minimize this issue, the model presented in chapter 4 is rich enough to account for the main financial incentives and sources of uncertainty for the couples in the estimation sample. It includes a detailed specification of the Social Security rules, allows for limited borrowing, and accounts for uncertainty in future wage income, out-of-pocket medical expenditures, health, and survival.

The model captures couples' heterogeneity in the main observable variables associated to the retirement decision, that is, household wealth and spouses' wages, pension claims, and health status. The source of unobserved heterogeneity considered is the persistent component of wage offers, which is estimated from the data. Each spouse's preferences are represented by their own utility function, and the substitutability between consumption and leisure is not constrained to being equal for husband and wife.

The model is estimated using a subsample of older individuals from the Health and Retirement Study (HRS) in two steps. The first step involves the estimation of the parameters of the laws of motion of the state variables which can be identified without explicit reference to the model. This includes the parameters of the wage, medical costs, health and survival processes. The estimation of the wage process is a crucial input to the second-stage estimation, since it not only determines part of the environment in which individuals make decisions -as mentioned above, it is important to distinguish whether individuals who remain in full-time employment should expect increasing or decreasing wages-; but it also yields the estimates of the unobserved heterogeneity component. The methodology followed to perform this estimation is that described in chapter 3.

The second step of the estimation process concerns the preference parameters and the parameters measuring the wage depreciation following the switch from full-time into part-time employment. These parameters are estimated within model, taking as given those estimates obtained in the first step.

The results show that leisure complementarities are positive and significant, and account for up to 8 percent of observed joint retirements. To put this result in perspective, the model is also used to predict the effect that the elimination of the spousal benefit -which allows wives (the majority of spousal benefit recipients are women) to claim a Social Security pension based on the contributions of their husband- would have on optimal retirements. The simulations imply that the spousal benefit accounts for 13 percent of the observed joint retirements.

Since neither the incentives for joint retirement provided by leisure complementarities nor those given by the spousal benefit can be captured in a model that takes one spouse's behavior as exogenous, the results suggest that individual models of retirement are not an appropriate approximation of the average household's behavior, given the increasing number of couples approaching retirement age where both husband and wife are working.

As a final remark, the reader must be warned that the different chapters of the thesis were written as separate papers, which may lead to certain amounts of overlap across chapters. It is hoped that this nuisance is offset by the resulting advantage that chapters can be read independently.

Chapter 2

The dynamics of retirement behaviour in couples: Reduced-form evidence from England and the US

Joint with James Banks and Richard Blundell

2.1 Introduction

Labor market participation of older individuals is nowadays a major policy issue. In the current context of an ageing population, most countries in the developed world are introducing policy changes to encourage the delay of retirement, such as increasing retirement ages or restricting access to non-standard routes out of the labor force. The large literature analyzing the effects of Social Security and pensions on individual behavior is now more relevant than ever.

Many studies in this literature have looked at individual retirement incentives[1], but only recently has the focus began to switch towards retirement behavior of couples[2]. However, given that the typical worker approaching retirement age is married, it is crucial to be aware of potential interactions between spouses.

Evidence of joint retirement, defined as the coincidence in time of spouses' retirement dates, has been found in data from very different sources, including the New Beneficiary Survey (Hurd (1990a)), The National Longitudinal Survey of Mature Women (Gustman and Steinmeier (2000)), the Retirement History Study (Blau (1998)), and the Health and Retirement Study (Michaud (2003)). Different mechanisms may be at play in driving joint retirement outcomes in couples: financial incentives, willingness to spend time together after retirement, common shocks, caring needs of one spouse, children or grandchildren, etc. These can be broadly classified in four categories: sorting of spouses according to their tastes for leisure; correlation in observable variables such as assets, wages, pension incentives, health status, etc.; correlation in time-varying shocks; and interactions in leisure, so that spouses enjoy their own retirement more if their partner is retired as well.

Understanding the reasons underlying joint retirements is important for policy analysis. In particular, the presence of spillovers in spouses' decisions would imply that policies aimed at the individual level can potentially impact the behavior of both partners. In the UK, the state retirement age for women, which is currently 60 years of age, is set to increase by six months per year from 2010 until it reaches 65 in 2020. This is expected to

[1] See Hurd(1990b), Stock and Wise (1990), Blau (1994), Diamond and Gruber (1999), Rust and Phelan (1997), French (2005).

[2] See Gustman and Steinmeier(2000), Blau and Gilleskie (2006), Coile (2004a, 2004b), Michaud (2003), Michaud and Vermeulen (2004).

affect women's retirement patterns. Given the incidence of joint retirement in the UK[3], which we document in the chapter, the question is whether this type of policy will change men's retirement patterns as well.

In this chapter we use the exogenous variation in institutional incentives to retirement between the US and the UK to analyze the effect on husbands' participation of their wife's retirement. Using working American couples as a control group for British ones, we are able to identify significant responses of British husbands to their wives' (exogenous) retirement incentives. Moreover, we show that the husband's retirement is directly linked to the actual realization of the wife's transition, using institutional incentives to instrument the latter.

Our results provide evidence of the existence of spillovers in spouses' retirement decisions. We attribute those to complementarities in leisure, whereby husbands value retirement more when their wife is retired as well. This raises the value of their leisure when their wife retires, creating a link between husbands' retirement transitions and wives' retirement incentives. We do not exclude the presence of further mechanisms leading to a correlation in spouses' outcomes, but none of those can explain our results in the absence of complementarities in leisure.

Our results imply have important implications for policy analysis. Since the wife's participation status enters the husband utility function, their participation decisions will be taken simultaneously. Analyses of men's retirement outcomes that ignore the wife's retirement decision will yield innacurate policy predictions.

The rest of the chapter is structured as follows: Section 2.2 reviews the literature on joint retirement and discusses our identification strategy. Section 2.3 describes the institutional settings in the US and the UK. Section 2.4 describes the data and observed retirement patterns for individuals and couples in the two countries. Section 2.5 outlines the empirical strategy. The results are presented in section 2.6, and section 2.7 concludes.

[3]The institutional setting we describe in the paper is common to all the UK. For simplicity we will refer to the UK when talking about the data too, even though ELSA only surveys English households.

2.2 Overview

There is a growing literature on couples' retirement choices that has analyzed the determinants of joint retirement. A strand of this literature has estimated the extent of leisure complementarities within structural models of family retirement (Maestas (2001), Gustman and Steinmeier (2004), Casanova (2010)). These papers find that leisure complementarities are a key source of spillovers in spouses' retirement decisions, although they differ in their conclusions regarding the relative magnitude of leisure interactions and financial incentives. Regarding the role of unobserved tastes for leisure, Gustman and Steinmeier (2004) find that they are an important determinant of *individual* retirement decisions, but not of joint retirements.

The advantages of estimating structural models are clear when the objective is to recover utility parameters. However, they also have drawbacks. Structural models require a full parameterizations of individual preferences and stochastic processes, including distributional assumptions about structural errors. Moreover, these models must be sufficiently rich to capture the different sources of incentives to retirement (from the institutional setting, private and public pensions, etc.). Failure to properly capture any of them may lead to over or underestimation of the role of leisure interactions -Casanova (2010) argues that simplifying assumptions regarding the financial and stochastic environment in which couples make decisions lead Maestas (2001) and Gustman and Steinmeier (2004) to overstate the role of leisure complementarities relative to the incentives for joint retirement provided by the Social Security system.

A complementary approach is the estimation of reduced-form models of the effect of one spouse's retirement incentives on their partner's participation. This approach does not require distributional assumptions, but relies on the exogeneity of the measure of retirement incentives. Early studies[4] in this literature regressed indicators of the wife's participation on the husband's retirement status. It is difficult to argue that this identifies a causal effect, as the husband's decision is unlikely to be exogenous -on the one hand, both spouses' participation decisions are linked through the shared budget constraint. Moreover, in the presence of leisure interactions, each spouses' utility depends on their

[4]See Coile (2004a) for a review.

partner's retirement status.

Coile (2004b) addresses these endogeneity concerns in her analysis of how husbands and wives respond to their partner's retirement incentives. She finds modest but significant responses of husbands to different measures of their wives' Social Security and private pension accrual. In particular, her results show that the stronger the financial incentive for a wife to delay retirement, the less likely her husband is to retire. She interprets this as evidence of complementarities in leisure: the value of leisure is diminished for a husband whose wife remains employed, which makes him more likely to remain employed himself.

The identifying assumption in Coile (2004b) is the exogeneity of pension accruals. In particular, these must be exogenous to individual tastes for retirement. Part of the heterogeneity in accruals is determined by Social Security parameters such as retirement ages, percentage benefit increases after early retirement age, the number of years of earnings used in the computation of benefits, etc. These are clearly exogenous from the individual's perspective. On the other hand, there is some scope for forward-looking individuals to time their accrual according to their taste for early retirement. A man who intends to retire early may choose an employer providing a defined-benefit pension which allows him to draw benefits at age 55. A woman who wants to accumulate 35 years of earnings[5] before, say, age 62, may go back to work sooner after taking time off to raise her kids than a woman who intends to work until age 65. To the extent that these mechanisms are important, and given the correlation in spouses' tastes for early retirement (Gustman and Steinmeier (2004)), they could explain part of husbands' responses to their wive's accruals.

2.2.1 Identification Strategy

In this paper we use an alternative measure of retirement incentives, namely the age of entitlement to a public pension, which we refer to as the retirement age. Since this is an institutional feature it is not correlated with couples' tastes for retirement. We first show that reaching retirement age is a strong predictor of wives' retirements. Then we exploit

[5] Social Security pension accruals tend to flatten out after 35 years of work, because only the 35 highest years of earnings are used in the computation of benefits. Additional years of work after that only increase AIME (the earnings measure used to determine monthly benefits) if they replace a an earlier lower earnings year. See description of Social Security benefits below for further details.

the different institutional environments in the UK and US, where women reach retirement age at 60 and 62, respectively, to test whether men respond to their wives' retirement incentives. We find that British men are significantly more likely to retire when their wife becomes 60 than their American counterparts.

We attribute the difference to complementarities in leisure: British wives are more likely to retire at age 60 than American wives. This raises the value of retirement for British husbands with respect to American husbands, and explains why the former are more likely to retire at this point. A threat to our identification strategy would be the presence of spurious incentives to retirement for British husbands that kick in when their wife becomes 60, even if she does not stop working. We explore this possibility by running IV regressions of husbands' transitions on those of their wives, using the retirement ages in each county as instruments, which confirm our previous results.

In order to illustrate how our identification strategy allows us to tease out the effect of complementarities, it is important to consider all potential sources of interactions in spouses retirement decisions, and how they affect couples' choices, not only upon reaching retirement age but during their whole working lives. This is key, since forward-looking individuals will be aware of the retirement age for public pensions from the start of their careers, and plan accordingly.

The first channel that may lead to a link in spouses' retirement dates is a correlation in their tastes for leisure and, in particular, their willingness to retire early. Our measure of retirement incentives, however, is common to all workers, and thus exogenous to couples' tastes within each country. A concern would be that tastes for work are different in the UK and the US. We control for this in the empirical analysis of men's retirement transitions by interacting age dummies with a country indicator, allowing for different propensities to retire at every age in the two countries.

The second channel linking spouses' choices is the shared budget constraint. If institutional incentives lead British wives to retire earlier, they will have to finance retirement for a longer period. British couples may respond by accumulating more wealth during their working years -they may do so by reducing consumption or working longer hours. This type of anticipatory responses would allow them to smooth out consumption, and therefore rule out an income effect at the time of retirement. Our analysis does not exclude this type of responses, but focuses only on the employment response of the husband when his wife turns 60. Our maintained assumption is that, in the absence of leisure complementarities, the need to provide for a longer retirement for British wives would not make their husbands more likely to retire at the exact point when they reach retirement age.

It is also possible that some couples reach retirement age with insufficient savings to smooth out the drop in income brought about by the wife's retirement. This cannot, though, explain our results. A negative income effect would give husbands incentives to increase, rather than decrease, their labor supply upon their wife's retirement.

The final channel leading to correlations in spouses retirements is complementarity in leisure, whereby the husband enjoys retirement more when his wife is also retired.[6] Leisure complementarities increase the value of leisure for husbands upon their wife's retirement, and in turn make them more likely to retire themselves.

We have argued so far that in the absence of leisure complementarities British men should not have stronger incentives to retire when their wife reaches retirement age at 60 than American men, after controlling for their own age-specific retirement incentives. Hence we propose the comparison of retirement propensities in the two countries at the point when wives turn 60 as a test for the presence of leisure complementarities.

2.3 Financial Incentives for Retirement in the US and UK

In this section, we describe the main financial incentives for retirement facing individuals in the US and the UK. Since the focus of our empirical analysis are husbands' labor supply responses when their wife becomes entitled to a public pension for the first time, we focus on the rules governing Social Security pension entitlement in the two countries. In particular, we illustrate how these may give UK women incentives to retire at a different age from US women. Then, we consider other sources of financial incentives to retirement, and how they may influence our results.

[6] Our analysis can only identify one-sided complementarities. Coile (2004b) and Gustman and Steinmeier (2004) find that the evidence that women's enjoyment of retirement increases when their husband is also retired is rather weak.

2.3.1 Social Security Benefits in the US

Old-Age, Survivors Insurance

The Old-Age, Survivors Insurance (OASI) programme provides benefits for qualified retired workers (those who have worked for a minimum of 40 quarter in covered employment) and their dependants.

The level of individual benefits is determined from a worker's lifetime earnings in several steps. First, the average indexed monthly earnings (AIME) is computed as a weighted average of the worker's earnings in covered employment. The weights are obtained from a national wage index. Only the highest 35 years of earnings are used in this computation. On a second step, a three-piece linear formula is used to convert AIME into the primary insurance amount (PIA). The formula is weighed in favor of relatively low earners, so that the replacement rate falls with as the level of earnings rises. The final step is to adjust the PIA based on the age at which benefits are first claimed.

Individuals receive their full PIA if they retire at full retirement age (FRA). The FRA for people born before January 1938 is 65. For people born between 1938 and 1943, the FRA increased at the rate of 2 months per year, and further increases are scheduled for people born after 1954. The earliest age at which a worker can claim Social Security benefits (early retirement age or ERA) has remained constant at 62 throughout. Workers who start receiving benefits between ERA and FRA have their benefits reduced in proportion to the number of months they retire early. For workers born after 1943, the rate of increase is equivalent to 6.7% per year between 63 and 65 and 5% per year from 62 to 63. On the other hand, workers who postpone their retirement beyond FRA obtain an increase in benefits for every month of nonpayment up to age 70. For workers born after 1943, the rate of increase is equivalent to 8% per year of delay.

While it is possible to claim social security benefits as early as age 62 independently of labor force status, beneficiaries below FRA are subject to the annual earnings test, whereby their benefits are withheld at a rate of $1 for every $2 of earnings above a threshold. Earnings lost through the earnings test translate into higher benefits in the future. For the workers born after 1943, the increase would be equivalent to 8% per year of benefits lost.

An important benefit provision affecting couples is the so-called dependent spouse benefit. Spouses of social security beneficiaries can receive benefits equal to up to half of their spouse's full retirement pension, provided that this is higher than their own entitlement. According to the Social Security Administration[7], the proportion of women aged 62 or older in 2004 who received benefits as dependants (that is, those who did not qualify for retirement benefits on their own record, and received benefits on the basis of their husband's earnings record only) was 32%. The proportion with dual entitlement (those who received benefits on the basis of both their own and their husbands' entitlement) was 28%. The remaining 40% was receiving benefits based on their own entitlement only.

Widows and widowers are entitled to survivors benefits, which are based on the deceased spouse's earnings record. They are eligible for full benefits at full retirement age, or reduced benefits from age 60.

Social security benefits are annually adjusted for increases in the consumer price index (CPI).

2.3.2 Public Pension Benefits in the UK

Basic State Pension

Unlike the US Social Security pension, the basic state pension (BSP) does not depend on a worker's past earnings, but only on the length of contribution to the system. In this sense, this portion of the UK public pension system should be viewed as a minimum pension, as the one provided in the US by the Supplemental Security Income (SSI) program. Unlike the SSI, however, the BSP is not means-tested, and is paid to all workers that fulfill the criteria described below.

In order to qualify for the full BSP, individuals need to have paid National Insurance contributions (NIC) for 90% of the period between age 16 and the year before pension age. Those with less years of contributions qualify for a proportion of the BSP, subject to this being higher than 25%. Individuals qualify to receive the BSP at the state pension age, which at present is 60 for women and 65 for men[8].

[7] *Fast Facts & Figures About Social Security, 2005.* Social Security Administration. SSA Publication No. 13-11785. September 2005.

[8] The retirement age for women is set to increase by six months per year from 2010 until it reaches 65 in 2020.

Until 2005, individuals could choose to defer receipt of the BSP for a maximum of five years. For each year of delay they received approximately 7.5% extra BSP. From 2005, individuals can defer their pension for as long as they like. If they put off claiming for at least one year, they can choose one of two options when they do finally claim: either to earn extra state pension at a rate equivalent to 10.5% per year of deferral; or to earn a one-off taxable lump-sum payment based on the amount of BSP they would have received during the deferral period, plus interest.

Recipients of BSP who are married to a partner over the state retirement age receive a dependant's addition to their BSP, unless their partner qualifies for a larger pension based on their own contribution record. Many married women do not qualify for a BSP on their own right, since those who were married before April 1977 could choose to opt out of the system and pay reduced-rate NICs in return for a BSP equal to 60% of their husband's entitlement.

Widows and widowers can inherit their deceased partner's pension entitlement in full if it is higher than their own.

The BSP is linked to inflation since 1981. In the year 2005, the value of the BSP was just under 15% of average earnings.

Earnings-Related State Pension

The second tier of the UK public pension system is an earnings-related pension. Even though the regimes legislating this tier of the system have changed over the years, the pension arrangement in place during most of the working lives of individuals in our sample was the State Earnings-Related Pension Scheme (SERPS). The SERPS was introduced to provide additional retirement income to around half of the workforce, whose employers did not provide an occupational pension scheme. In order to avoid crowding out of existing private pension schemes, from the time of its introduction individuals were allowed to opt out of SERPS into an employer-provided, defined benefit pension scheme. In return, both their and their employer's contributions were reduced. As from 1988, individuals could also opt out of SERPS into a defined contribution pension scheme, in return for which a proportion of their NICs were paid into the individual's pension fund.

Because of the opt-out provisions, the proportion of retirees covered by SERPS is much lower than that entitled to a Social Security pension in the US.

The benefit level under SERPS was based on a worker's NICs and level of earnings above a threshold. Workers qualified for SERPS at the same age age BSP. Once in payment, SERPS was indexed to inflation.

Initially, surviving partners could inherit the full amount of their spouse's SERPS entitlement. Since 2002, however, changes are being phased in that will make the maximum inheritable amount equal to 50% in 2012.

Since 2002 SERPS has been replaced for new contributors by the State Second Pension (S2P). This is a reformed version of SERPS which provides more generous additional state pension for low and moderate earnings.

2.3.3 Other Financial Incentives for Retirement

Means-Tested Public Benefits

In the US, the Supplemental Security Income (SSI) programme provides income support to individuals aged 65 or older, as well as the blind or disabled.

The level of SSI entitlement is unrelated to previous work earnings, and it is based on the individual or couple's income. The federal benefit rate in 2005 was $579 per month for individuals and $869 per month for couples. These quantities are offset against income above a certain threshold. Furthermore, individuals are generally not eligible for SSI if they have net worth exceeding $2,000 (or $3,000 for couples).

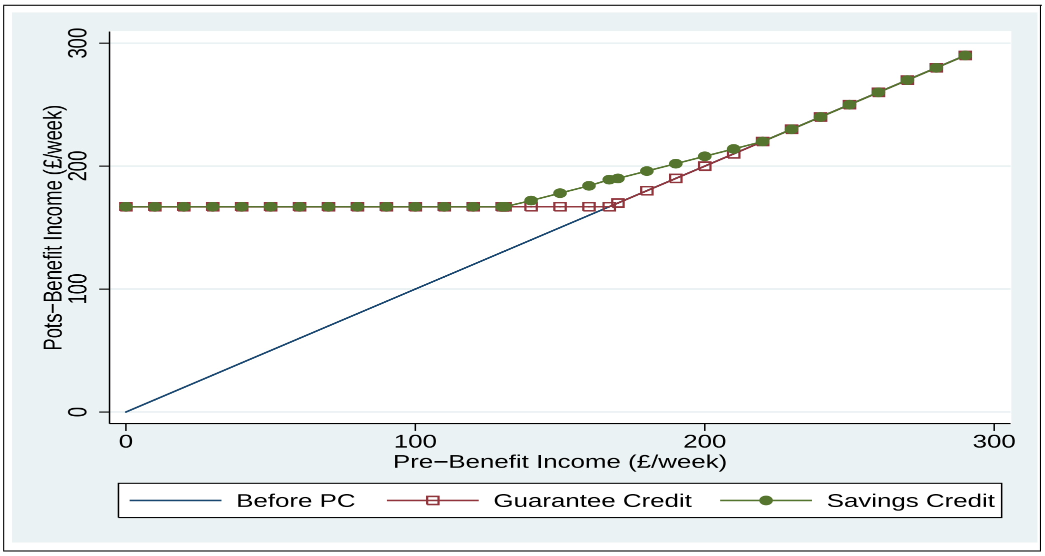
In 2004, just over a million individuals qualified for age-related SSI payments.

In the UK, the Pension Credit (PC) was introduced in 2003 to provide income support to those at or approaching retirement age. The pension credit has two components, the guarantee credit and the savings credit.

The guarantee credit aims to bridge the gap between individuals or couples' income and a specified minimum level called the 'appropriate amount' (£167.05 per week for couples in 2005). A single person must be 60 or over to qualify for guarantee credit. Couples qualify when the oldest spouse reaches 60.

As can be seen in figure 2.1, individuals qualifying for the guarantee credit face a 100% marginal withdrawal rate whenever their total income is lower than the minimum level. The savings credit, which becomes available when a single individual or the oldest spouse in a couple turns 65, attempts to reduce this disincentive to save by cutting the marginal withdrawal rate. Guarantee credit beneficiaries with income between a minimum threshold (£131.20 per week for couples in 2005) and the appropriate amount receive a saving credit equal to 60% of their income above the threshold. The third series of figure 2.1 shows the effect of the savings credit.

Figure 2.1: Effect of PC when oldest spouse is aged 65 or over



Private Pensions

It is well known that private pensions play an important role in determining retirement decisions[9]. In particular, defined benefit (DB) schemes offer strong incentives for retirement at certain ages through provisions such as the early and normal retirement ages.

On the surface, the expansions of private pensions in the US and the UK seem to follow some common trends. In particular, both countries have seen a switch from DB to defined contribution (DC) pensions in recent times. To our knowledge, however, there are no studies describing how private pension provisions -such as the distribution of normal retirement ages, relationship between early retirement ages and premium, etc.- may differ across the two countries. In the remaining of the chapter we implicitly assume that incen-

[9] Gustman and Steinmeier (1989), Gustman and Mitchell (1992), Stock and Wise (1990), French(2005)

tives from private pensions have no significantly different age-effects on the two countries, and that this is particularly true at the ages in which we focus our analysis, namely 60 and 62.

Health Insurance

In the US, the health insurance programme Medicare covers most people who are either 65 or meet a series of special criteria, such as being disabled. The programme has four different parts, which cover different aspects of health care costs. Some of these are only available to individuals who pay a monthly fee.

Spouses of Medicare recipients who are not disabled do not become entitled to Medicare benefits until they reach 65.

Medicaid is another US state-run programme that provides hospital and medical coverage for people with low income and little or no resources. The rules for Medicaid eligibility and coverage vary across states.

In the UK, health care is universal and free at all ages, and private provision is relatively rare. Therefore, there are no age-specific incentives to retire or stay in work related to health insurance.

Different studies have discussed how Medicare eligibility affects retirement decisions of individuals and their spouses in the US (Rust and Phelan (1997), Blau and Gilleskie (2006), French and Jones (2007)). Given that most health insurance before age 65 is provided by employers, these studies suggest that individuals whose employer-provided health insurance does not cover retirees may find strong incentives to remain in work until age 65. On the other hand, Lumsdaine, Stock, and Wise (1996) find that Medicare eligibility has little effect on retirement age. In the empirical analysis we do not specifically control for health insurance, but we think it is unlikely to have important effects in our results. Even in the presence of a health-insurance type of effect, the subsample of affected individuals would be relatively small. According to the HRS data, only around 9% of men and 8% of women from the initial cohort report having an insurance which they could not keep if they retired. It is conceivable that the fraction of these individuals in the sample of workers increases as they approach age 65, but our main interest is in retirement behavior at age 60, when the majority of both men and women are still in the labor force.

Disability Insurance

Disability benefits can provide important labor supply disincentives[10]. In particular, disability insurance is sometimes viewed as a path towards early retirement. Take-up of disability benefits has risen rapidly in recent years both in the US and the UK.

Given the difficulty in exactly quantifying the age structure of the disincentive to work these benefits provide, we opt once again for not including any specific controls in the empirical analysis.

2.3.4 Potential Interactions Among Incentives to Retirement

Table 2.1 summarizes the age-structure of incentives for retirement in the US and UK from public pensions, means-tested public benefits and state-provided health insurance. Private pensions and disability benefits are not included in table 2.1. For the latter, even though coverage increases with age -as does ill health-, we cannot identify jumps in entitlement at particular ages. The former do give strong incentives to retire at early retirement ages -particularly DB pensions-, but both these ages and the strength of the incentives vary wildly across plans in the two countries.

2.3.5 Sources of Elderly Couples' Income

Our identification strategy will exploit the difference in retirement ages in the US and the UK. British women reach state pension age at 60, whereas American women cannot claim a Social Security pension before age 62. The power of our instrument will depend on how strongly women respond to the incentives provided by the system, and in particular whether they tend to retire upon reaching retirement age. Since this will be partly determined by the importance of Social Security income as a proportion of household income in the two countries, we analyze these below.

Figures 2.2 and 2.3 show the relative importance of different sources of income for households in the US and the UK where the husband is past normal retirement age. Households are divided by country-specific income quintiles. The different sources of

[10] See Bound and Burkhauser (1999), Benitez-Silva et al. (1999), Benitez-Silva, Buchinsky and Rust (2004).

Table 2.1: Age structure of incentives to retirement. US and UK.

	US	UK
Husband's age		
60		Guarantee Credit (if husband is older)
62	**Early Retirement Social Security Benefit**	
65	**Normal Retirement Social Security Benefit*** Supplemental Security Income Medicare	**Basic and Earnings-Related State Pensions** Savings Credit (if husband is older)
Wife's age		
60		**Basic and Earnings-Related State Pensions** Guarantee Credit (if wife is older)
62	**Early Retirement Social Security Benefit***	
65	**Normal Retirement Social Security Benefit** Supplemental Security Income Medicare	Savings Credit (if wife is older)

* Normal retirement age will be higher than 65 years of age for individuals reaching age 62 later than the year 2000.

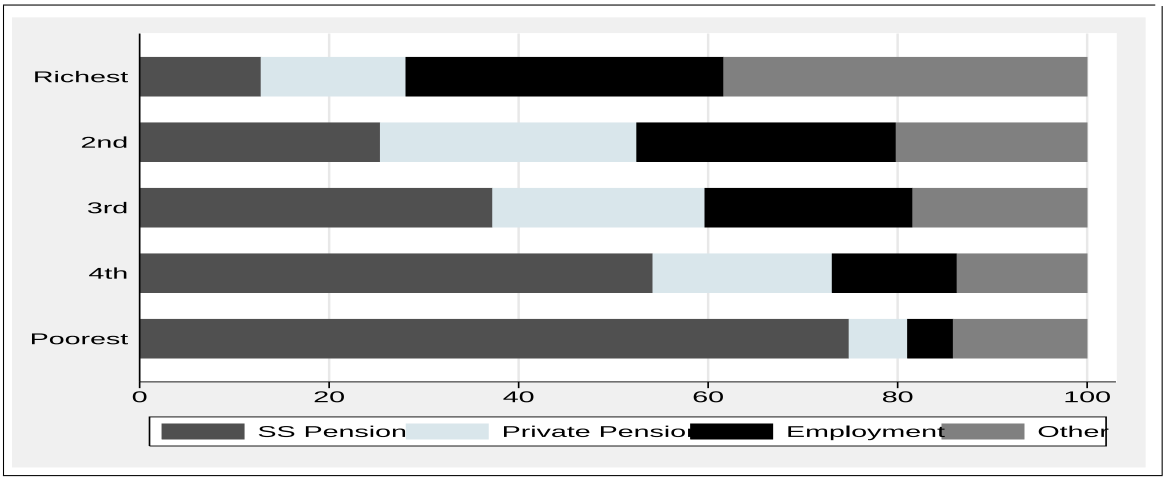
income considered are Social Security pensions, private pensions, income from work and income from all other sources, including disability pensions and health insurance payments.

The general trends are common for the two countries: The proportion of income from social security decreases as family income increases, whereas the proportion of income from private pensions, work and all other sources increases.

An important difference between the graphs is the proportion of income from employment, which is higher in the US for all income quintiles. The proportion of income from private pensions is generally higher in the UK. This is because 55% of workers in the UK[11] opt out of the earnings-related part of the public pension system, and instead contribute

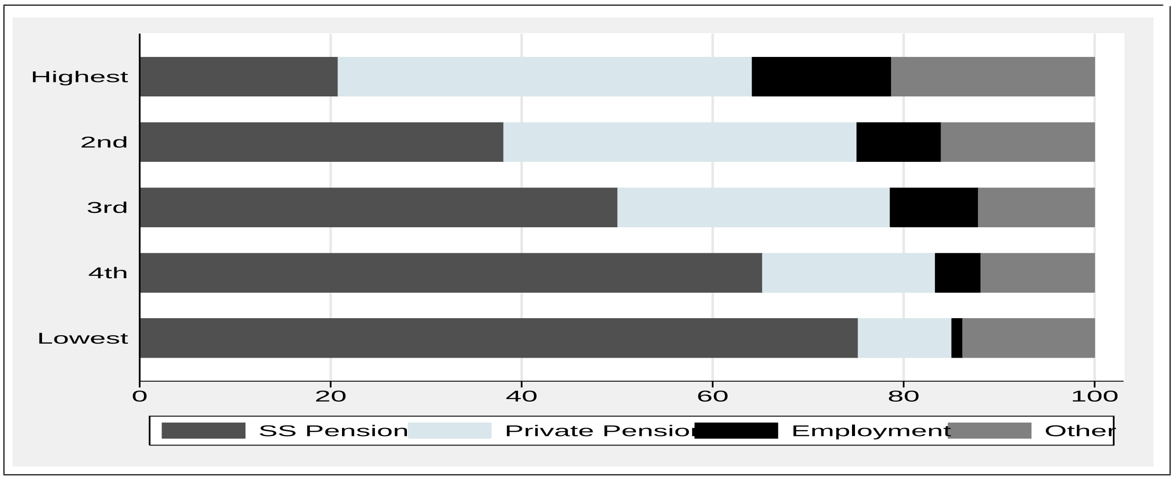
[11] Data for years 2001/02. Source: Department of Work and Pensions. "Second Tier Pension Provision 1978/79 to 2003/04". UK.

Figure 2.2: Sources of household income by income quintile. HRS. Year 2002.



NOTE. - Source: Authors' calculations using the 2002 HRS wave. Sample includes couples where the husband is 66 to 70.

Figure 2.3: Sources of household income by income quintile. ELSA. Year 2002.



NOTE. - Source: Authors' calculations using the 2002 ELSA wave. Sample includes couples where the husband is 66 to 70.

to their employer's occupational pension.

Regarding the relative weight of Social Security benefits in household income, we can see that this is higher in the UK for all income groups except the lowest one. This may seem puzzling, given that UK workers who opt out of the earnings-related public pension only get the basic pension from the public system, and this replaces a lower percentage of lifetime wages that the US Social Security pension for a majority of workers. However, other factors such as the larger proportion of workers delaying Social Security receipt beyond age 65 in the US, the larger proportion of US workers receiving income from employment after that age, and the higher replacement rates in the UK can explain the higher reliance on Social Security for British workers.

The higher share of public benefits in UK households' income should not affect the interpretation of our empirical results. The identifying power in our analysis comes only from the different age structure of public benefits in the US and UK, which gives rise to a discrete jump in benefit entitlement for women in the UK, but not in the US, at age 60.

2.4 Data Description

2.4.1 Data Sources

We use data from the Health and Retirement Study (HRS) for the US and from the English Longitudinal Study of Ageing (ELSA) for the UK[12].

The HRS is a longitudinal study of individuals over the age of 50 and their spouses. This US-representative survey is carried out every two years. Currently there are 7 waves available, the first of them corresponding to the year 1992, and the last one to 2004. The survey provides extensive information on individual sources of income, retirement plans, health and demographics. It also provides comprehensive measures of household wealth.

ELSA samples individuals aged 50 and over residing in the household sector in the UK at baseline, and their spouses. The study is conducted every two years. There are currently two waves available, corresponding to the years 2002 and 2004, plus baseline data from the Health Survey for England (HSE) from the years 1998 to 2001.

ELSA also provides comprehensive information on financial and health status of individuals, together with retirement expectations and demographics. ELSA has been developed in collaboration with the HRS, and the aim is for the income and wealth data and many of the health questions and experimental modules to be directly comparable across the two surveys.

The comparability of variables and their focus on individuals close to retirement age makes these two surveys optimal candidates to be used in our empirical study. We use data from the overlapping waves, corresponding to the years 2002 and 2004. Our core sample is made of working couples where the husband is aged between 55 and 66. After

[12]The institutional description in section 2.3 is relevant for the whole of the UK. For simplicity we refer to the UK too when describing the data, even though ELSA is only representative of the English population.

dropping those observations where any of the spouses is not present or did not respond to the survey in one of the two waves, we are left with 1338 such couples, 817 from HRS and 521 from ELSA.

We have tried to build a measure of participation that is as comparable as possible across surveys. We first compute the number of hours each individual works every week. For ELSA observations, these are obtained as the sum of the number of weekly hours worked in the main salary job or in self employment, plus the number of monthly hours worked in any other casual jobs divided by four. For HRS observations, weekly hours are the sum of hours worked per week in the main and secondary job, including self-employment.

Using this information, an individual is defined as active if they describe themselves as working for pay and work for more than 2 hours a week[13]. A person is defined as making a transition out of work between the two waves if they are active in the first wave and inactive in the second one.

Health is measured at baseline with three dummy variables constructed from the self-reported health question. The dummies indicate whether an individual is in very good, good or bad health (corresponding to excellent or very good; good; and fair or poor self-reported health, respectively). In all our regressions, the omitted category is being in good health.

Education is also measured at baseline with three dummies. The dummy “graduate” is equal to 1 for individuals in both countries who have at least some college education. The dummy “high school” indicates whether US individuals are high school graduates or equivalent and whether British individuals have at least an O level or equivalent. The omitted category corresponds to individuals who are not high school graduates in the US or do not have any O level or equivalent in the UK.

Throughout our analysis we allow for differential effects of the health and education dummies in the two countries.

[13] We have experimented with alternative definitions of participation, coding as participants those individuals working more than 8, 10 and 15 hours per week, and do not find any qualitative impact on the results.

2.4.2 Labor Force Transitions of Older Couples

Figures 2.7 and 2.8 in the appendix show employment rates for ELSA and HRS men and women, respectively, after age 55. We use the two available observations per individual, corresponding to the 2002 and 2004 waves, to build 1-year cohorts by age at baseline, and follow these across the two waves. The figures show that the employment and transition patterns in both countries are relatively similar until age 60. At this point, the first retirement incentives take effect in the UK, and the series for the two countries start to diverge.

The post-age 60 divergence is more evident for women, for whom the state pension age is 60 in the UK. For men, a clear divergence takes place after 65, the state pension age in the UK and normal retirement age in the US. Participation rates past age 65 are much lower for men in the UK than in the US.

These two figures suggest that, until retirement incentives kick in, labor market outcomes are similar in the two countries. This provides preliminary evidence that the US is a proper control group for the UK.

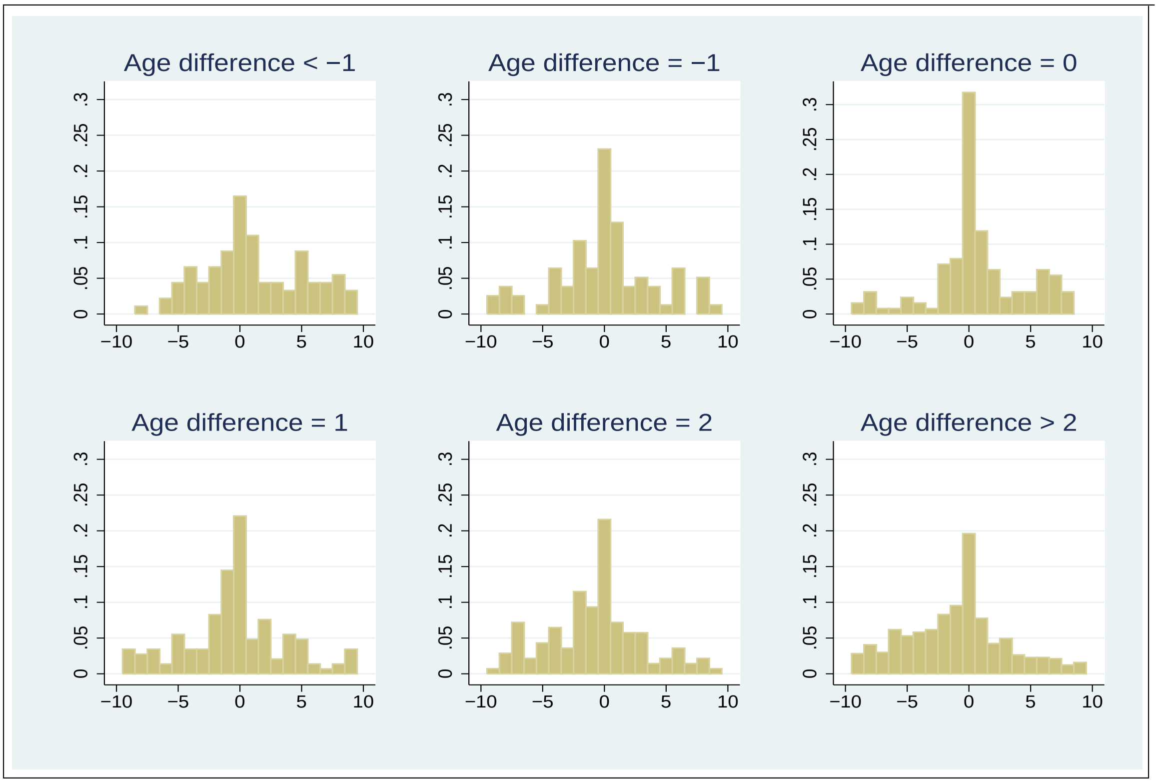
Figure 2.9 shows labor market exits for men and women in the US as a function of age. The series for men and women look relatively similar, which is consistent with retirement incentives in this country being the same for all individuals. The series for men shows the well-known spikes at 62 and 65, the early and normal retirement ages, respectively. The series for women also shows spikes at 62 and 65, even though they are less pronounced than for men.

Figure 2.10 shows the age pattern of labor market exits for men and women in the UK. The two series look remarkably different. Both men and women tend to concentrate their exits around their respective state pension ages of 65 and 60.

Figures 2.9 and 2.10 indicate that both men and women follow their individual incentives in planning retirement exits. There is, however, a further dimension to retirement behavior, which is that of within-couple interactions. Individuals may take into account their spouse's incentives, on top of their own, when making retirement decisions. We analyze this possibility below.

The phenomenon of joint retirement refers to the coincidence in time of spouses' retirement, independently of the age difference between them. Several studies have studied the prevalence of this type of joint behavior in the US. Here, we compare the evidence for the US and the UK.

Figure 2.4: Distribution of differences in spouses' retirement dates, by age difference between spouses. HRS.



Our data for the baseline wave of 2002 confirm the importance of joint retirement in both countries. Figure 2.4 analyzes the correlation in retirement dates[14] for HRS couples where both members are retired in 2002. Each graph in figure 2.4 shows the distribution of differences in retirement dates for couples with different age differences across spouses[15]. The first graph shows the distribution of retirement date differences for couples where the husband is more than a year younger than the wife; the second graph shows the distribution of retirement date differences for couples where the husband is exactly one year younger than the wife; and so on. In all of the 6 graphs, the highest frequency corresponds to a retirement date difference of zero, that is, to spouses retiring on the same calendar year.

[14]Retirement date difference is defined as the husband's retirement date minus the wife's retirement date. Hence positive values indicate that the husband retired at a later calendar date than the wife.

[15]Age difference is defined as age of the husband minus age of the wife.

Figure 2.5: Distribution of differences in spouses' retirement dates, by age difference between spouses. ELSA.

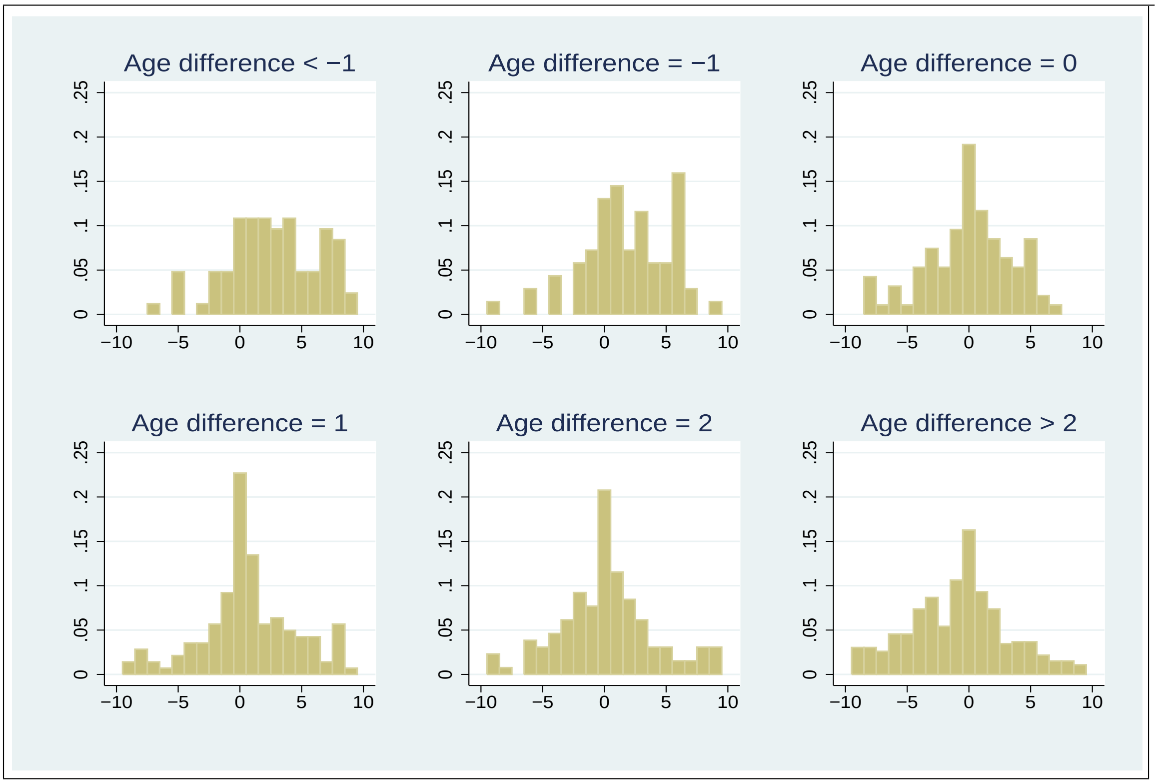
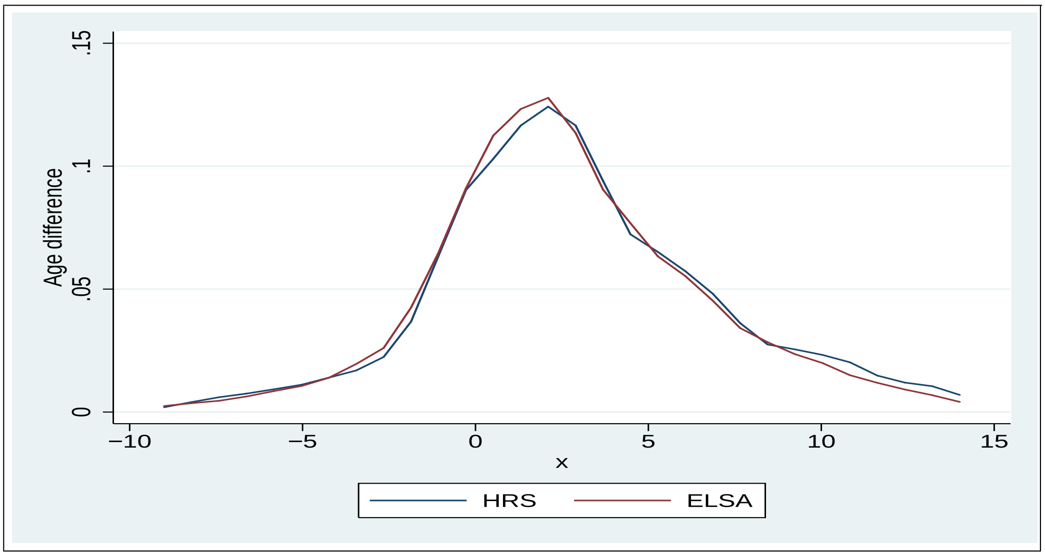


Figure 2.5 plots differences in retirement dates for ELSA couples. Once again, with the exception of the two first graphs -which correspond to couples where the husband is younger, and therefore a relatively small number of observations-, the highest frequency corresponds to spouses retiring the same year. Even in the first to graphs, the frequency of same-date exits is among the highest.

It is interesting to note that graphs 1 to 3 in figure 2.5 show a relatively large frequency of exits at the dates corresponding to both spouses retiring at state pension age (this would correspond to a difference in retirement dates greater than 7 years in graph 1, equal to 6 years in graph 2 , and 5 years in graph 3). For couples where the husband is older than the wife, which are one of the subsets that we analyze in the empirical part below, the only remarkable peaks corresponds to both spouses retiring at the same date, independently of their corresponding state pension ages.

These figures tell us that there is an important role to play for within-couple retirement incentives, beyond individual ones. In the empirical part of the analysis we study the effect of wives' incentives on men's retirement behavior, after controlling for men's individual incentives. We do this by using working US couples as a control for working British couples. When interpreting the results of the analysis we make the implicit assumption that any within-couple incentives coming from complementarities in leisure are similar across countries. This is a difficult hypothesis to test. In order to provide some support for it, we show in figure 2.6 that the distributions of age differences within spouses in the two countries are extremely close. This rules out differences in couples' preferences stemming from country-specific within-couple age patterns. We assume that any other country-specific differences in tastes for joint leisure can be accounted for through the individual age, health status and education controls that we include in the empirical analysis.

Figure 2.6: Within-couple age difference distribution. Husband aged 55 to 66.



2.5 Empirical strategy

The goal is to estimate the differential effect that having a wife who reaches age 60 has for British men with respect to American men. We estimate regression equations of the following form:

$$R_{ht} = \alpha + \beta_0 \Delta^a_{wt} + \beta_1 \Delta^a_{wt} \times ELSA + ELSA + X_{t-1}\theta'_0 + X_{t-1}\theta'_1 \times ELSA + \varepsilon_{ht}, \quad (2.5.1)$$

where h denotes the husband and w the wife; R_{ht} is a dummy variable indicating whether the husband makes a transition out of the labor force between periods $t-1$ and t; Δ^a_{wt} is a dummy variable indicating whether the wife reaches age a between $t-1$ and t; $ELSA$ is an indicator that observation comes from the ELSA sample; and X is a vector of observables which includes measures of the husband's age and education and both spouses' health status.

We also run IV regressions of the following form:

$$R_{ht} = \gamma + \delta R_{wt} + ELSA + X_{t-1}\phi'_0 + X_{t-1}\phi'_1 \times ELSA + u_{ht}, \quad (2.5.2)$$

where the wife's transition R_{wt} is instrumented with indicators of whether she has reached retirement age, i.e. Δ^a_{wt} and $\Delta^a_{wt} \times ELSA$ for different values of a.

All regressors in equations 2.5.1 and 2.5.2 are included both on their own and interacted with the ELSA dummy to allow for differential effects in the two countries. The regressions are estimated as probits.

The object of interest from our regressions is the interaction effect for the indicator that the wife crosses age 60 and the $ELSA$ dummy. As discusses in Ai and Norton (2003), this is not the same as the marginal effect of the interaction term. In particular, given a regression of the type:

$$E[R_{ht} \mid \Delta^{60}_{wt}, ELSA] = F(\alpha + \beta_0 \Delta^{60}_{wt} + \beta_1 \Delta^{60}_{wt} \times ELSA + \beta_2 ELSA), \quad (2.5.3)$$

the interaction effect is defined as the following discrete double difference:

$$\frac{\Delta^2 E[R_{ht} \mid \Delta^{60}_{wt}, ELSA]}{\Delta(\Delta^{60}_{wt})\Delta ELSA} = \quad (2.5.4)$$

$$
\begin{aligned}
&= E[R_{ht} \mid \Delta_{wt}^{60} = 1, ELSA = 1] - E[R_{ht} \mid \Delta_{wt}^{60} = 0, ELSA = 1] - \\
&- \big(E[R_{ht} \mid \Delta_{wt}^{60} = 1, ELSA = 0] - E[R_{ht} \mid \Delta_{wt}^{60} = 0, ELSA = 0\big)
\end{aligned}
$$

In nonlinear models, this is different from the marginal effect of the interaction, which would be defined as:

$$\frac{\Delta E[R_{ht} \mid \Delta_{wt}^{60}, ELSA]}{\Delta(\Delta_{wt}^{60} \times ELSA)} =$$

$$= E[R_{ht} \mid \Delta_{wt}^{60} = 1, ELSA = 1] - E[R_{ht} \mid \Delta_{wt}^{60} = 0, ELSA = 0]$$

Equation 2.5.4 shows that the interaction effect is the difference-in-differences estimator of the differential effect of the wife crossing 60 in the UK with respect to the US. This is the object of interest of this paper, and the effect we report in our results.

Given that the variables Δ_{wt}^{60} and $ELSA$ are dummies, 2.5.4 simplifies to:

$$\frac{\Delta^2 E[R_{ht} \mid \Delta_{wt}^{60}, ELSA]}{\Delta(\Delta_{wt}^{60})\Delta ELSA} =$$

$$= F(\alpha + \beta_0 + \beta_1 + \beta_2) - F(\alpha + \beta_2) - F(\alpha + \beta_0) + F(\alpha)$$

A further point of interest regarding marginal effects concerns the marginal effect of non-interacted variables. From equation 2.5.3, the marginal effect of the variable Δ_{wt}^{60} is defined as follows

$$\frac{\Delta E[R_{ht} \mid \Delta_{wt}^{60}, ELSA]}{\Delta(\Delta_{wt}^{60})} =$$

$$= E[R_{ht} \mid \Delta_{wt}^{60} = 1, ELSA] - E[R_{ht} \mid \Delta_{wt}^{60} = 0, ELSA] =$$

$$= F(\alpha + \beta_0 + \beta_1 ELSA + \beta_2 ELSA) - F(\alpha + \beta_2 ELSA)$$

.

Notice that this marginal effect cannot be interpreted as the effect on American husbands of their wife reaching age 60. This is because the effect of a change in the variable Δ^{60}_{wt} operates through the coefficient β_0 and, for observations from the ELSA sample, also through the coefficient β_1.

In some cases we will want to comment on the effect on American husbands of their wives reaching a particular age. In those cases, we compute this effect separately according to the following formula:

$$\frac{\Delta E[R_{ht} \mid \Delta^{62}_{wt}, ELSA = 0]}{\Delta(\Delta^{62}_{wt})} = \tag{2.5.5}$$

$$= E[R_{ht} \mid \Delta^{62}_{wt} = 1, ELSA = 0] - E[R_{ht} \mid \Delta^{62}_{wt} = 0, ELSA = 0] =$$

$$= F(\alpha + \beta_0) - F(\alpha)$$

2.6 Estimation Results

We start by estimating equation 2.5.1 using the sample of couples where both spouses work at baseline and the wife is younger than 60 at baseline. We exclude older wives because in the UK most of them will have retired at age 60, and therefore the group of working women aged 61 and older will likely oversample those with a strong taste for work. Results for the variables of interest are presented in table 2.2 below.

Table 2.2: Effect on husbands' transitions of wife reaching age 60.

Dependent Variable: R_{ht}				
	Full sample	Agediff >0	Agediff >1	Agediff >2
Δ^{60}_{wt}	-0.01928 (0.464)	0.01995 (0.606)	0.01699 (0.693)	-0.00360 (0.918)
Δ^{60}_{wt}×ELSA	0.03255 (0.566)	0.15438 (0.041)	0.13991 (0.102)	0.19918 (0.038)
N	1,027	899	782	671

NOTE.- Average individual marginal effects from probit regressions reported. Empirical p-values (in parentheses) obtained from 2,500 parametric bootstrap replications. Sample includes couples where both spouses are working and wife is younger than 60 at baseline. Full set of controls includes both spouses' health status and husband's age and education at baseline. See table 2.6 in appendix 1.B for full estimation results.

As can be seen from the second column of table 2.2, the marginal effect of having a wife who reaches age 60 is small and not significant. More importantly, the interaction effect for the indicator that the wife crosses age 60 and the $ELSA$ dummy is positive but small and not significantly different from zero. As pointed out in section 2.5, the interaction effect is the difference-in-differences estimator of the effect of having a wife reaching age 60 for a British husband, with respect to an American one. Hence British husbands do not appear more likely to retire when their wives reach retirement age than their American counterparts.

We hypothesize that the lack of a differential effect is driven by the behavior of very young husbands, who are many years away from becoming entitled to their own public pension -state pension age is 65 for British men. In the absence of a private pension with an early retirement clause, these husbands will have strong financial incentives to continue working. In order to check this hypothesis, we run the same regression restricting the sample to those couples where the husband is older than the wife (that is, where the variable "Agediff", which is equal to husband's age minus wife's age, is greater than zero). In this restricted sample, all husbands of women reaching age 60 between waves will have reached age 60 themselves. Results are shown on the third column of table 2.2.

We can see that for the restricted sample the baseline effect of having a wife crossing age 60 is not significant, but the differential effect for British men is positive and significant. In particular, the retirement propensity for British husbands whose wife reaches age 60 is 15 percentage points higher than for their American counterparts. Further restricting the sample to couples where the husband is more than a year older than the wife (column 4) yields a coefficient of similar magnitude, while in the sample of couples where the husband is more than two years older than the wife (column 5), British husbands are 19 percentage points more likely to retire when the wife becomes 60 than American husbands.

As argued in section 2.2, the increase in husbands' retirement propensity when their wife reaches retirement age cannot be explained by a correlation in tastes for retirement or income effects, so our results are suggestive of complementarities of leisure. There is a concern, though, that British men may have incentives to retire when their wife reaches age 60 that are independent of whether she retires or not. To confirm that we are not capturing a spurious effect, and British husbands are indeed responding to their wives' retirement, we next run IV regressions of the husband's retirement transition indicator on that of his wife. We instrument the wife's transition with indicators that she has reached age 60 or age 62, the retirement ages in the UK and the US, respectively. In order to sample women reaching retirement age in the two countries, we use observations for all working couples where the wife is younger than 62 at baseline. Results for the second stage are reported in table 2.3 below.

Table 2.3: Effect of wife's transition on husband's transition.

Dependent Variable: R_{ht}				
	Full sample	Agediff >0	Agediff >1	Agediff >2
R_{st}	0.11795 (0.565)	0.46392 (0.019)	0.54210 (0.008)	0.63521 (0.035)

NOTE.- Average individual marginal effects from probit regressions reported. Empirical p-values (in parentheses) obtained from 2,500 parametric bootstrap replications. Sample includes couples where both spouses are working and wife is younger than 62 at baseline. Full set of controls includes both spouses' health status and husband's age and education at baseline. See table 2.7 in appendix 1.B for full estimation results.

The effect of the wife's transition on that of her husband is positive but not significant for the full sample, as seen in column 2. As before, we next restrict the sample by dropping those couples where the husband is furthest from his own retirement age. Column 3 shows results for the sample of couples where the husband is older than the wife. The results indicate that a husband whose wife retires is 46% more likely to retire himself than one whose wife continues working. The coefficient is significant with a p-value of 0.02. For the samples of couples where the husband is more than a year and more than two years older than their wife, we find that the wife's transition increases the husband's retirement propensity by 54 and 63%, respectively.

These results confirm that the increases in British husbands' retirement propensities we found in table 2.2 were triggered by their wives' high retirement propensity upon reaching age 60. The retirement age for women in exogenous to husbands' taste for retirement. Most household should be prepared to smooth out the drop in income at the time of the wife's retirement. For household without savings, the negative income effect would give husbands incentives to decrease, rather than decrease their labor supply. On the other hand, if the husband values retirement more when this is shared with his wife, upon his wife's retirement the value of leisure increases for him, which would in turn increase his retirement propensity. Thus we interpret the positive differential responses of British husbands to their wives reaching retirement age as evidence of leisure complementarities.

2.6.1 Retirement transitions of American men

By the time women reach age 60 either in the US or the UK, most of those who were working in their 50's remain in the labor force. Most of their husbands are working, too. However, by the time they reach age 62 the majority of British women will have retired. For this reason, those British couples where both spouses are working by the time the wife becomes 62 are likely to have a strong taste for work. Hence they may not be as good a control group for their American counterparts at this age as American couples where for British couples at the time when wives become 60. Keeping this caveat in mind, we turn now to the analysis of American men's retirement transitions when their wives reach early retirement age at 62.

We estimate equation 2.5.1 using the sample of working couples where women are up to 61 years at baseline, and adding as a regressor an indicator for whether the wife reaches age 62 between waves. Results are reported in table 2.4.

Table 2.4: Effect on husbands' transitions of wife reaching age 60 or age 62.

Dependent Variable: R_{ht}				
	Full sample	Agediff >0	Agediff >1	Agediff >2
Δ_{wt}^{60}	-0.01424	0.03032	0.02972	0.00435
	(0.616)	(0.452)	(0.528)	(0.944)
$\Delta_{wt}^{60}\times$ELSA	0.04994	0.17656	0.15564	0.21871
	(0.392)	(0.024)	(0.088)	(0.040)
Δ_{wt}^{62}	0.06408	0.06957	0.06816	0.09415
	(0.056)	(0.092)	(0.124)	(0.116)
$\Delta_{wt}^{62}\times$ELSA	-0.08776	-0.13591	-0.13296	-0.11330
	(0.296)	(0.188)	(0.236)	(0.444)
N	1169	996	861	717

NOTE.- Average individual marginal effects from probit regressions reported. Empirical p-values (in parentheses) obtained from 2,500 parametric bootstrap replications. Sample includes couples where both spouses are working and wife is younger than 62 at baseline. Full set of controls includes both spouses' health status and husband's age education at baseline. See table 2.8 in appendix 1.B for full estimation results.

As before, we find that the differential effect of having a wife who reaches age 60 for British with respect to American husbands is small and not significant for the whole sample, but is positive for the subsamples of couples where the husbands are at least one, two, or three years older than their wives. The magnitude of the effects is similar to those reported in table 2.2, and they are significant at 5 percent for the third and fifth columns and at 10 percent for the fourth one.

We turn now to the effect of having a wife who reaches age 62. The differential effect for British husbands is negative for all samples, indicating that they are less likely to retire when their wife becomes 62 than their American counterparts. This is what we would have expected in the presence of leisure complementarities, since American women reach retirement age at 62, while British women do not have specific incentives coming from the public pension system to retire at that age. The coefficients, however, are not statistically significant for any of the samples. This is likely due to the small number of observations: since the majority of British women retire at 60, we end up with few working British couples where the wife crosses age 62 between waves.

Beyond the interaction effect, we are also interested in the marginal effect of having a wife crossing age 62 for American men, which we would expect to be negative if American men are responsive to their wives' retirement incentives. As explained in section 2.5, the marginal effect for the indicator that the wife crosses 62, reported in table 2.4 above, compounds the responses of American and British husbands. The marginal effect of having a wife who reaches age 62 for American husbands, computed according to the formula described in 2.5.5, is reported in table 2.5 for the different samples. It is always significant, and it increases from 10 to 13 percent as we restrict the sample to exclude young husbands who are further from their own retirement age.

Table 2.5: Marginal effect on American husbands' transitions of wife reaching age 62.

Dependent Variable: R_{ht}				
	Full sample	Agediff >0	Agediff >1	Agediff >2
$\Delta^{62}_{wt} \mid_{ELSA=0}$	0.10129 (0.028)	0.12370 (0.028)	0.11867 (0.076)	0.13731 (0.112)
N	1169	996	861	717

NOTE.- Average individual marginal effects from probit regressions reported. Empirical p-values (in parentheses) obtained from 2,500 parametric bootstrap replications.

2.7 Conclusion

In this chapter we use the institutional variation across the US and the UK, and in particular the different ages of entitlement to a public pension in the two countries (60 in the UK, 62 in the US), to analyze husbands' responses to their wives' retirement incentives.

We show in section 2.4 that labor market outcomes in the two countries are comparable until the first retirement incentives for women kick in in the UK. Based on this, we use working American couples as a control group for British ones at the point when British women reach retirement age.

We find that, in the sample of couples where the husband is older than the wife, British men are from 14 to 20 percentage points more likely to retire when their wife reaches state pension age at 60 than their American counterparts.

We then use the exogenous institutional retirement ages to instrument women's transitions in a regression of husbands' transitions onto those of their wives. For the sample of couples where the husband is older than the wife, we find a strong effect of the wife's retirement onto that of the husband.

We interpret our results as evidence of complementarity in leisure, whereby the husband enjoys retirement more when his wife is retired as well. Alternative explanations for the correlation in spouses' retirement outcomes are not consistent with our results.

Our findings have important implications for policy analysis. They imply that the wife's participation status enters the husband's utility function, and hence that the spouses' participation choices are made simultaneously. Analyses of men's retirement outcomes that ignore the wife's retirement decision will yield biased policy predictions.

2.8 Appendix 1.A. Figures

Figure 2.7: Percentage employed by age cohort, men.

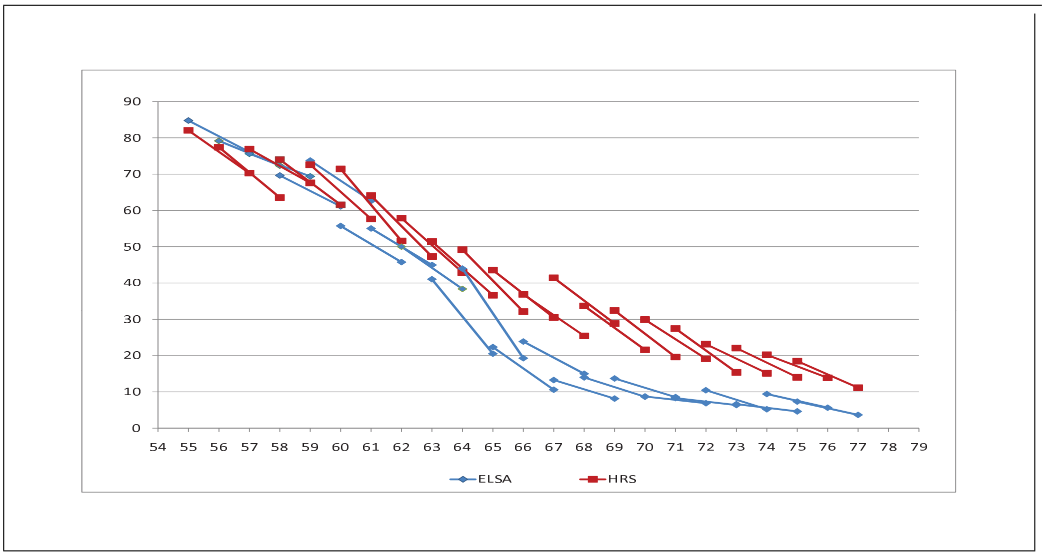


Figure 2.8: Percentage employed by age cohort, women.

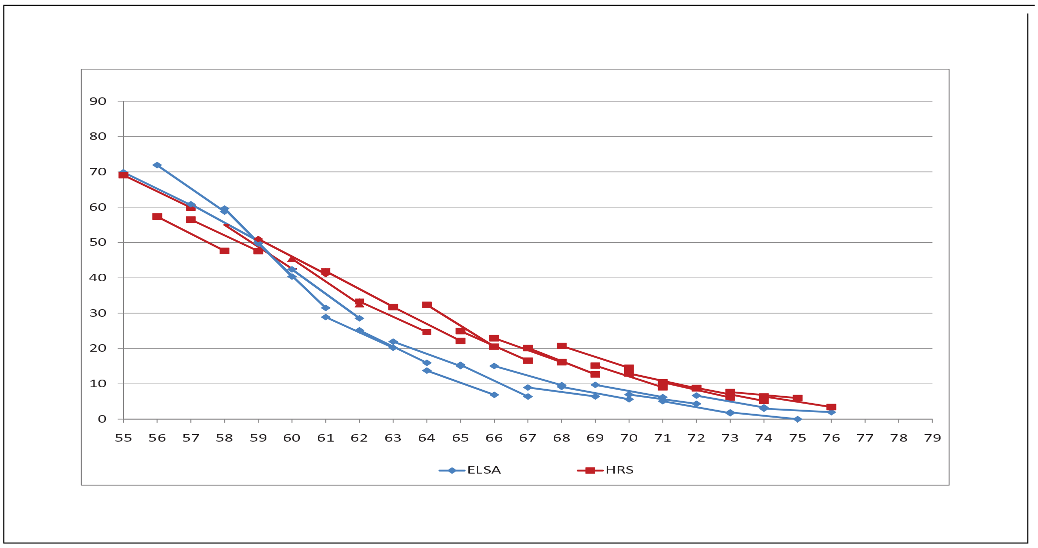


Figure 2.9: Change in proportion working by age crossed between waves, men and women, US.

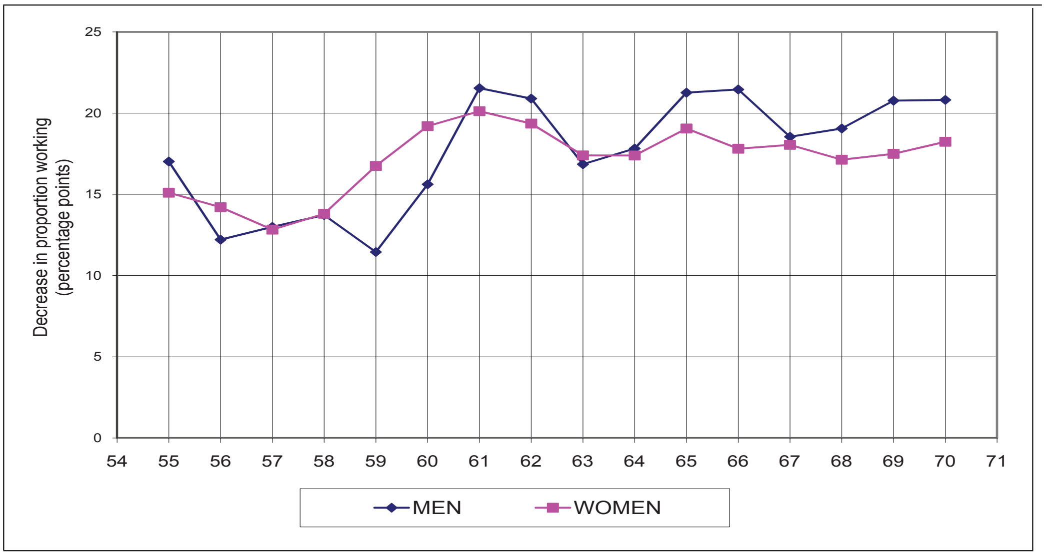
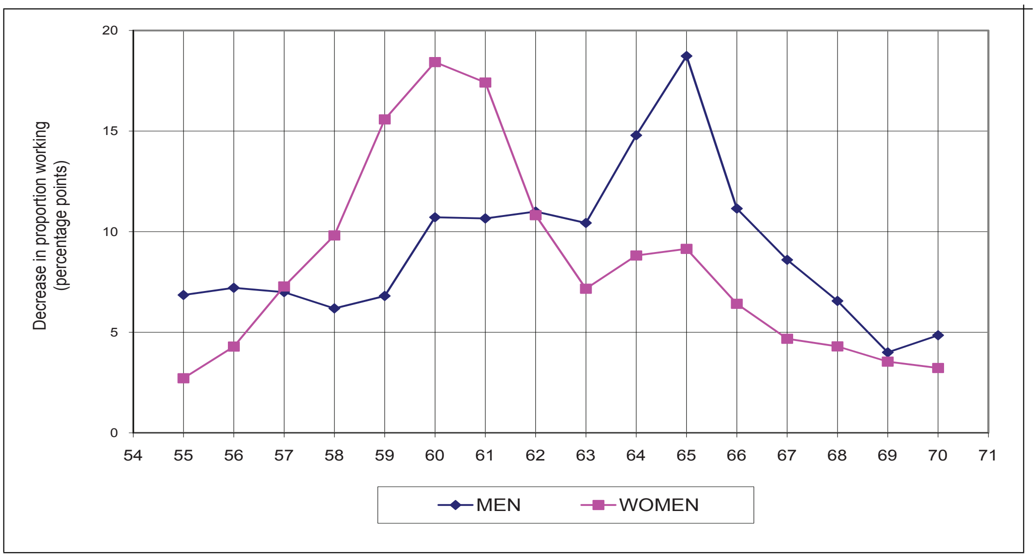


Figure 2.10: Change in proportion working by age crossed between waves, men and women, UK.



2.9 Appendix 1.B. Tables

Table 2.6: Probit regression of husbands' transitions on dummies indicating whether their wives reach age 60. Marginal effects reported. (Continued in next page).

	Full sample	Agediff >0	Agediff >1	Agediff >2
Δ^{60}_{st}	-0.01928	0.01995	0.01699	-0.00360
	(-0.068, 0.035)	(-0.044, 0.092)	(-0.052, 0.095)	(-0.080, 0.086)
$\Delta^{60}_{st}\times$ELSA	0.03255	0.15438*	0.13991	0.19918*
	(-0.071, 0.138)	(0.013, 0.305)	(-0.011, 0.299)	(0.024, 0.387)
ELSA	0.07375*	0.08555**	0.08369**	0.10003**
	(0.025, 0.122)	(0.032, 0.139)	(0.025, 0.141)	(0.038, 0.160)
Graduate	0.01335	0.01552	0.00290	-0.00832
	(-0.047, 0.073)	(-0.049, 0.080)	(-0.066, 0.071)	(-0.082, 0.063)
High School	-0.00853	-0.00746	-0.03143	-0.03454
	(-0.071, 0.059)	(-0.074, 0.065)	(-0.103, 0.047)	(-0.109, 0.049)
Graduate × ELSA	0.03958	0.06598	0.04914	0.06059
	(-0.076, 0.167)	(-0.060, 0.205)	(-0.085, 0.199)	(-0.083, 0.217)
High School × ELSA	0.00052	0.01383	-0.04662	-0.07765
	(-0.120, 0.132)	(-0.115, 0.156)	(-0.180, 0.101)	(-0.218, 0.080)
Health = v good	-0.07539**	-0.09979**	-0.09615**	-0.09099*
	(-0.128, -0.026)	(-0.156, -0.047)	(-0.156, -0.040)	(-0.155, -0.031)
Health = v good × ELSA	0.03839	0.02047	0.01713	0.00928
	(-0.029, 0.116)	(-0.049, 0.098)	(-0.057, 0.101)	(-0.069, 0.100)
Health = bad	-0.02686	-0.03381	-0.09008	-0.13716*
	(-0.130, 0.080)	(-0.145, 0.082)	(-0.209, 0.035)	(-0.265, -0.004)
Health = bad × ELSA	0.07464	0.08811	0.05184	-0.01507
	(-0.076, 0.235)	(-0.065, 0.255)	(-0.108, 0.230)	(-0.185, 0.179)
Sp heal = v good	0.00969	0.02083	0.01119	0.01327
	(-0.039, 0.059)	(-0.031, 0.073)	(-0.045, 0.066)	(-0.047, 0.072)
Sp heal = v good × ELSA	0.02885	0.04833	0.04277	0.02639
	(-0.044, 0.113)	(-0.035, 0.143)	(-0.047, 0.148)	(-0.068, 0.139)
Sp heal = bad	0.07198	0.11287	0.12144	0.09407
	(-0.035, 0.176)	(-0.003, 0.224)	(-0.002, 0.242)	(-0.038, 0.221)
Sp heal = bad × ELSA	-0.01966	0.00510	-0.07950	-0.08815
	(-0.178, 0.140)	(-0.175, 0.188)	(-0.275, 0.117)	(-0.293, 0.114)
Age = 56	0.03350	0.03496	0.08870	0.12656
	(-0.049, 0.125)	(-0.062, 0.145)	(-0.038, 0.235)	(-0.035, 0.302)
Age = 57	-0.02025	-0.00323	0.04496	0.07091
	(-0.100, 0.081)	(-0.096, 0.113)	(-0.074, 0.195)	(-0.074, 0.254)
Age = 58	0.04001	0.04255	0.06684	0.10690
	(-0.046, 0.143)	(-0.053, 0.159)	(-0.059, 0.213)	(-0.048, 0.285)
Age = 59	0.05764	0.04683	0.10727	0.16462*
	(-0.036, 0.164)	(-0.052, 0.162)	(-0.018, 0.248)	(0.008, 0.336)
Age = 60	0.08098	0.06535	0.09392	0.12468
	(-0.017, 0.188)	(-0.041, 0.185)	(-0.037, 0.233)	(-0.027, 0.288)

NOTE.- Average individual marginal effects reported. Empirical confidence intervals (in parentheses) obtained from 2,500 parametric bootstrap replications. * indicates significance at 5%. ** indicates significance at 1%. Agediff is age difference between spouses, defined as age of the husband minus age of the wife. Sample: couples where both spouses work at baseline, husband's age is between 55 and 66 at baseline, and wife's age is less than 60 at baseline.

Table 2.6: Continued from previous page.

	Full sample	Agediff >0	Agediff >1	Agediff >2
Age = 61	0.07443	0.05104	0.08944	0.08395
	(-0.026, 0.193)	(-0.055, 0.176)	(-0.035, 0.233)	(-0.058, 0.252)
Age = 62	0.15326*	0.12719	0.17160*	0.21428*
	(0.023, 0.298)	(-0.008, 0.279)	(0.015, 0.340)	(0.036, 0.398)
Age = 63	0.27529**	0.24343**	0.28872**	0.33057**
	(0.134, 0.421)	(0.095, 0.400)	(0.124, 0.458)	(0.138, 0.517)
Age = 64	0.22358**	0.19892**	0.23937**	0.27227**
	(0.083, 0.366)	(0.052, 0.352)	(0.079, 0.407)	(0.088, 0.464)
Age = 65	0.34829**	0.31016*	0.34615**	0.40626*
	(0.132, 0.532)	(0.096, 0.505)	(0.141, 0.539)	(0.179, 0.613)
Age = 66	0.19855*	0.13796	0.17930*	0.19946
	(0.010, 0.421)	(-0.047, 0.379)	(-0.021, 0.430)	(-0.026, 0.467)
Age = 56 × ELSA	-0.00953	-0.07042	-0.01961	-0.16035
	(-0.188, 0.161)	(-0.285, 0.129)	(-0.299, 0.235)	(-0.486, 0.143)
Age = 57 × ELSA	-0.00089	0.00314	0.03811	-0.00841
	(-0.180, 0.186)	(-0.212, 0.217)	(-0.237, 0.319)	(-0.344, 0.307)
Age = 58 × ELSA	0.14590	0.18135	0.12182	0.00701
	(-0.047, 0.341)	(-0.042, 0.400)	(-0.161, 0.399)	(-0.324, 0.328)
Age = 59 × ELSA	0.06885	0.08605	0.11608	-0.01867
	(-0.144, 0.274)	(-0.150, 0.308)	(-0.169, 0.385)	(-0.352, 0.298)
Age = 60 × ELSA	0.03276	-0.01451	0.01032	-0.02594
	(-0.179, 0.252)	(-0.237, 0.220)	(-0.261, 0.282)	(-0.340, 0.278)
Age = 61 × ELSA	0.13604	0.08074	0.11707	-0.03075
	(-0.078, 0.373)	(-0.142, 0.330)	(-0.150, 0.401)	(-0.332, 0.296)
Age = 62 × ELSA	0.18359	0.12815	0.16345	0.00252
	(-0.111, 0.476)	(-0.179, 0.431)	(-0.178, 0.485)	(-0.358, 0.353)
Age = 63 × ELSA	0.34634*	0.27769	0.30185	0.14440
	(0.026, 0.615)	(-0.065, 0.566)	(-0.070, 0.611)	(-0.257, 0.493)
Age = 64 × ELSA	0.41565*	0.37602*	0.41384*	0.27913
	(0.106, 0.693)	(0.057, 0.673)	(0.067, 0.710)	(-0.096, 0.619)
Age = 65 × ELSA	0.50674*	0.42994	0.46272*	0.30557
	(0.057, 0.821)	(-0.026, 0.778)	(0.020, 0.801)	(-0.165, 0.700)
Age = 66 × ELSA	0.43941	0.30455	0.34520	0.20747
	(-0.022, 0.798)	(-0.160, 0.698)	(-0.134, 0.746)	(-0.300, 0.660)
obs	1027	899	782	671

NOTE.- Average individual marginal effects reported. Empirical confidence intervals (in parentheses) obtained from 2,500 parametric bootstrap replications. * indicates significance at 5%. ** indicates significance at 1%. Agediff is age difference between spouses, defined as age of the husband minus age of the wife. Sample: couples where both spouses work at baseline, husband's age is between 55 and 66 at baseline, and wife's age is less than 60 at baseline.

Table 2.7: IV regression of husbands' transitions on wives' transitions. Marginal effects reported. (Continued in next page).

	Full sample	Agediff >0	Agediff >1	Agediff >2
R_{st}	0.11795	0.46392*	0.54210**	0.63521*
	(-0.302,0.527)	(0.073,0.959)	(0.119,1.077)	(0.044,1.440)
ELSA	0.02576	0.00440	-0.02715	-0.00734
	(-0.059,0.122)	(-0.095,0.107)	(-0.138,0.088)	(-0.141,0.125)
Graduate	-0.02602	-0.02578	-0.06677	-0.07441
	(-0.141,0.082)	(-0.151,0.095)	(-0.197,0.063)	(-0.214,0.072)
Graduate × ELSA	0.05814	0.06557	0.11868	0.12703
	(-0.094,0.246)	(-0.101,0.261)	(-0.074,0.333)	(-0.080,0.358)
High School	-0.04447	-0.04469	-0.05122	-0.03975
	(-0.114,0.047)	(-0.118,0.053)	(-0.116,0.034)	(-0.114,0.058)
High School × ELSA	0.02924	0.02990	-0.00330	-0.02113
	(-0.090,0.151)	(-0.096,0.165)	(-0.127,0.147)	(-0.162,0.162)
Health=v good	-0.07574**	-0.10820**	-0.09470**	-0.07893*
	(-0.124,-0.026)	(-0.161,-0.053)	(-0.155,-0.034)	(-0.145,-0.012)
Health=bad	0.02929	0.01256	0.02130	0.03067
	(-0.040,0.107)	(-0.063,0.096)	(-0.063,0.114)	(-0.065,0.132)
Health=v good × ELSA	0.00105	0.01852	-0.03448	-0.12350
	(-0.100,0.105)	(-0.095,0.142)	(-0.159,0.109)	(-0.256,0.039)
Health=bad × ELSA	0.06527	0.07733	0.07106	0.02032
	(-0.085,0.224)	(-0.082,0.244)	(-0.106,0.271)	(-0.175,0.260)
Sp heal=v good	0.02022	0.02004	0.01424	0.03441
	(-0.029,0.068)	(-0.036,0.074)	(-0.047,0.074)	(-0.032,0.102)
Sp heal=bad	0.02221	0.03491	0.05156	0.13253*
	(-0.054,0.114)	(-0.054,0.131)	(-0.045,0.157)	(0.016,0.261)
Sp heal=v good ×ELSA	0.07495	0.09122	0.10413	0.06165
	(-0.025,0.175)	(-0.034,0.203)	(-0.033,0.227)	(-0.096,0.192)
Sp heal=bad × ELSA	-0.02385	-0.01446	-0.08351	-0.22231
	(-0.200,0.152)	(-0.205,0.170)	(-0.289,0.115)	(-0.467,0.011)
Age = 56	0.02521	0.03943	0.09875	0.17091*
	(-0.063,0.134)	(-0.069,0.168)	(-0.039,0.251)	(0.007,0.336)
Age = 57	-0.02884	-0.00099	0.04453	0.08161
	(-0.119,0.081)	(-0.108,0.131)	(-0.092,0.198)	(-0.088,0.267)
Age = 58	0.01525	0.00750	0.04218	0.10378
	(-0.074,0.131)	(-0.100,0.135)	(-0.091,0.191)	(-0.062,0.277)
Age = 59	0.02228	-0.00014	0.05101	0.09840
	(-0.067,0.134)	(-0.113,0.119)	(-0.100,0.203)	(-0.108,0.288)
Age = 60	0.08858	0.02948	0.05721	0.09336
	(-0.019,0.209)	(-0.090,0.154)	(-0.084,0.202)	(-0.083,0.263)
Age = 61	0.05600	-0.03565	-0.00736	-0.01567
	(-0.064,0.195)	(-0.167,0.092)	(-0.162,0.141)	(-0.206,0.155)

NOTE.- Average individual marginal effects reported. Empirical confidence intervals (in parentheses) obtained from 2,500 parametric bootstrap replications. * indicates significance at 5%. ** indicates significance at 1%. Agediff is age difference between spouses, defined as age of the husband minus age of the wife. Sample: couples where both spouses work at baseline, husband's age is between 55 and 66 at baseline, and wife's age is less than 62 at baseline.

Table 2.7: Continued from previous page.

	Full sample	Agediff >0	Agediff >1	Agediff >2
Age = 62	0.10979	0.05533	0.08922	0.18903
	(-0.006,0.244)	(-0.078,0.194)	(-0.075,0.251)	(-0.004,0.371)
Age = 63	0.24726**	0.15796	0.17988	0.22275
	(0.103,0.406)	(-0.025,0.340)	(-0.033,0.381)	(-0.088,0.493)
Age = 64	0.29799**	0.23252*	0.25065*	0.27772*
	(0.145,0.450)	(0.058,0.415)	(0.050,0.452)	(0.003,0.532)
Age = 65	0.25316**	0.17427	0.20111	0.21006
	(0.065,0.431)	(-0.026,0.377)	(-0.021,0.411)	(-0.060,0.460)
Age = 66	0.14411	0.09289	0.12970	0.15991
	(-0.022,0.344)	(-0.085,0.295)	(-0.073,0.344)	(-0.080,0.398)
Age = 56 × ELSA	-0.03562	-0.11113	-0.08580	-0.23924
	(-0.220,0.140)	(-0.330,0.099)	(-0.351,0.175)	(-0.528,0.062)
Age = 57 × ELSA	-0.01516	0.01183	-0.00432	-0.04823
	(-0.214,0.174)	(-0.225,0.245)	(-0.291,0.274)	(-0.373,0.269)
Age = 58 × ELSA	0.11204	0.13479	0.09012	0.00606
	(-0.090,0.302)	(-0.102,0.347)	(-0.181,0.348)	(-0.298,0.300)
Age = 59 × ELSA	0.06610	0.11668	0.09951	-0.02341
	(-0.139,0.261)	(-0.106,0.324)	(-0.178,0.353)	(-0.328,0.264)
Age = 60 × ELSA	0.02178	0.00143	-0.01860	-0.09685
	(-0.186,0.242)	(-0.218,0.229)	(-0.276,0.249)	(-0.388,0.196)
Age = 61 × ELSA	0.05907	0.05545	0.12151	0.06196
	(-0.143,0.276)	(-0.143,0.261)	(-0.120,0.367)	(-0.209,0.333)
Age = 62 × ELSA	0.10503	0.06017	0.12393	0.11250
	(-0.142,0.357)	(-0.195,0.306)	(-0.162,0.402)	(-0.218,0.436)
Age = 63 × ELSA	0.20703	0.17050	0.17789	0.12562
	(-0.071,0.490)	(-0.106,0.465)	(-0.124,0.496)	(-0.203,0.479)
Age = 64 × ELSA	0.29151	0.29073	0.29183	0.18592
	(-0.046,0.596)	(-0.054,0.602)	(-0.064,0.622)	(-0.177,0.528)
Age = 65 × ELSA	0.35704	0.18871	0.19290	0.05583
	(-0.093,0.742)	(-0.269,0.623)	(-0.291,0.632)	(-0.430,0.533)
Age = 66 × ELSA	0.12821	0.00675	0.00667	-0.14465
	(-0.245,0.508)	(-0.357,0.379)	(-0.370,0.391)	(-0.533,0.259)
obs	1169	996	861	717

NOTE.- Average individual marginal effects reported. Empirical confidence intervals (in parentheses) obtained from 2,500 parametric bootstrap replications. * indicates significance at 5%. ** indicates significance at 1%. Agediff is age difference between spouses, defined as age of the husband minus age of the wife. Sample: couples where both spouses work at baseline, husband's age is between 55 and 66 at baseline, and wife's age is less than 62 at baseline.

Table 2.8: Probit regression of husbands' transitions on dummies indicating whether their wives reach ages 60 and 62. Marginal effects reported. (Continued in next page).

	Full sample	Agediff >0	Agediff >1	Agediff >2
Δ_{st}^{60}	-0.01424	0.03032	0.02972	0.00435
	(-0.066,0.045)	(-0.036,0.105)	(-0.044,0.115)	(-0.077,0.099)
Δ_{st}^{60}×ELSA	0.04994	0.17656*	0.15564	0.21871*
	(-0.069,0.175)	(0.025,0.339)	(-0.015,0.336)	(0.022,0.426)
Δ_{st}^{62}	0.06408	0.06957	0.06816	0.09415
	(-0.006,0.143)	(-0.016,0.168)	(-0.027,0.178)	(-0.034,0.245)
Δ_{st}^{62}×ELSA	-0.08776	-0.13591	-0.13296	-0.11330
	(-0.240,0.058)	(-0.321,0.044)	(-0.337,0.064)	(-0.391,0.171)
ELSA	0.06297**	0.06354*	0.07309*	0.11534**
	(0.013,0.116)	(0.010,0.120)	(0.013,0.138)	(0.040,0.193)
Graduate	0.00969	0.00777	-0.01235	-0.01512
	(-0.051,0.069)	(-0.057,0.071)	(-0.084,0.057)	(-0.095,0.062)
High School	-0.02525	-0.02854	-0.05586	-0.05198
	(-0.081,0.036)	(-0.089,0.037)	(-0.121,0.014)	(-0.125,0.028)
Graduate × ELSA	0.04591	0.05633	0.05791	0.06878
	(-0.069,0.166)	(-0.066,0.186)	(-0.076,0.200)	(-0.079,0.228)
High School × ELSA	0.01299	0.00046	-0.05212	-0.08837
	(-0.105,0.135)	(-0.126,0.130)	(-0.187,0.086)	(-0.239,0.072)
Health = v good	-0.06797**	-0.09529**	-0.08440**	-0.07846*
	(-0.116,-0.020)	(-0.147,-0.044)	(-0.142,-0.028)	(-0.142,-0.016)
Health = v good × ELSA	0.02660	0.01290	0.01134	0.01999
	(-0.038,0.100)	(-0.054,0.089)	(-0.063,0.097)	(-0.065,0.118)
Health = bad	-0.01566	-0.03057	-0.10513	-0.16170*
	(-0.113,0.084)	(-0.136,0.080)	(-0.221,0.018)	(-0.291,-0.025)
Health = bad × ELSA	0.06707	0.07408	0.01422	-0.03158
	(-0.084,0.221)	(-0.082,0.234)	(-0.154,0.188)	(-0.222,0.166)
Sp heal = v good	0.02228	0.02415	0.01951	0.02307
	(-0.025,0.068)	(-0.027,0.073)	(-0.036,0.073)	(-0.038,0.082)
Sp heal = v good × ELSA	0.02549	0.04405	0.04112	0.04984
	(-0.048,0.115)	(-0.038,0.143)	(-0.050,0.153)	(-0.058,0.183)
Sp heal = bad	0.07849	0.11728*	0.13349*	0.10112
	(-0.014,0.174)	(0.015,0.221)	(0.022,0.249)	(-0.022,0.230)
Sp heal = bad × ELSA	-0.00129	0.01736	-0.05780	-0.11268
	(-0.159,0.164)	(-0.161,0.205)	(-0.259,0.152)	(-0.351,0.125)
Age = 56	0.02565	0.03628	0.08887	0.12820
	(-0.058,0.130)	(-0.064,0.164)	(-0.041,0.247)	(-0.035,0.318)
Age = 57	-0.02761	-0.00123	0.04933	0.07783
	(-0.105,0.071)	(-0.095,0.117)	(-0.074,0.201)	(-0.078,0.266)
Age = 58	-0.01339	-0.02636	0.04787	0.19048
	(-0.141,0.182)	(-0.159,0.187)	(-0.141,0.315)	(-0.089,0.494)

NOTE.- Average individual marginal effects reported. Empirical confidence intervals (in parentheses) obtained from 2,500 parametric bootstrap replications. * indicates significance at 5%. ** indicates significance at 1%. Agediff is age difference between spouses, defined as age of the husband minus age of the wife. Sample: couples where both spouses work at baseline, husband's age is between 55 and 66 at baseline, and wife's age is less than 62 at baseline.

Table 2.8: Continued from previous page.

	Full sample	Agediff >0	Agediff >1	Agediff >2
Age = 59	0.03288	0.04378	0.11006	0.17188*
	(-0.054,0.145)	(-0.056,0.175)	(-0.018,0.267)	(0.008,0.356)
Age = 60	0.09342	0.06073	0.09273	0.12710
	(-0.006,0.210)	(-0.048,0.190)	(-0.039,0.244)	(-0.033,0.304)
Age = 61	0.07088	0.03471	0.07830	0.08071
	(-0.034,0.182)	(-0.073,0.153)	(-0.051,0.221)	(-0.069,0.251)
Age = 62	0.10929	0.09592	0.14622*	0.21118*
	(-0.005,0.238)	(-0.024,0.234)	(0.002,0.301)	(0.031,0.394)
Age = 63	0.23254**	0.20966**	0.25701**	0.33015**
	(0.100,0.376)	(0.070,0.364)	(0.104,0.421)	(0.147,0.514)
Age = 64	0.27949**	0.25849**	0.30321**	0.33860**
	(0.121,0.438)	(0.098,0.427)	(0.133,0.477)	(0.149,0.531)
Age = 65	0.23852*	0.20385*	0.24720*	0.27515*
	(0.047,0.412)	(0.011,0.383)	(0.055,0.432)	(0.066,0.481)
Age = 66	0.11640	0.07871	0.12745	0.14637
	(-0.045,0.310)	(-0.078,0.278)	(-0.051,0.348)	(-0.055,0.391)
Age = 56 × ELSA	-0.02094	-0.06748	-0.01304	-0.15152
	(-0.217,0.151)	(-0.305,0.137)	(-0.309,0.242)	(-0.498,0.163)
Age = 57 × ELSA	-0.02017	0.01396	0.05442	0.00381
	(-0.214,0.166)	(-0.214,0.231)	(-0.237,0.327)	(-0.346,0.318)
Age = 58 × ELSA	0.00792	0.01073	0.07327	0.20972
	(-0.101,0.187)	(-0.106,0.209)	(-0.082,0.295)	(-0.017,0.418)
Age = 59 × ELSA	0.06179	0.07993	0.11591	-0.01353
	(-0.140,0.250)	(-0.152,0.291)	(-0.164,0.366)	(-0.344,0.286)
Age = 60 × ELSA	0.04153	-0.02341	0.01512	-0.01885
	(-0.172,0.249)	(-0.254,0.202)	(-0.262,0.281)	(-0.338,0.287)
Age = 61 × ELSA	0.09203	0.03675	0.11347	-0.02762
	(-0.127,0.325)	(-0.199,0.289)	(-0.174,0.401)	(-0.358,0.302)
Age = 62 × ELSA	0.14888	0.15432	0.18798	0.00199
	(-0.106,0.392)	(-0.111,0.414)	(-0.129,0.480)	(-0.370,0.355)
Age = 63 × ELSA	0.27645*	0.26023	0.29872	0.19217
	(0.001,0.516)	(-0.039,0.522)	(-0.025,0.573)	(-0.175,0.517)
Age = 64 × ELSA	0.33246*	0.31773	0.35361	0.21854
	(0.012,0.605)	(-0.020,0.603)	(-0.004,0.639)	(-0.176,0.555)
Age = 65 × ELSA	0.44452*	0.40715	0.46705*	0.34042
	(0.044,0.776)	(-0.005,0.765)	(0.048,0.801)	(-0.116,0.727)
Age = 66 × ELSA	0.22300	0.15986	0.21232	0.08008
	(-0.147,0.568)	(-0.214,0.525)	(-0.209,0.589)	(-0.375,0.507)
obs	1169	996	861	717

NOTE.- Average individual marginal effects reported. Empirical confidence intervals (in parentheses) obtained from 2,500 parametric bootstrap replications. * indicates significance at 5%. ** indicates significance at 1%. Agediff is age difference between spouses, defined as age of the husband minus age of the wife. Sample: couples where both spouses work at baseline, husband's age is between 55 and 66 at baseline, and wife's age is less than 62 at baseline.

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Chapter 3

The Wage Process of Older Workers

3.1 Introduction

This chapter estimates the shape of the age-wage profile of older career workers. Whether wages decline with age for workers who remain in their career job is a crucial question for both economic analysis and policy. Expected earnings play a key role in the retirement choice, and as such are an essential input to option value models and other structural models of savings and labor supply of older workers. Measures of expected earnings are used to compute the present value of Social Security's expected revenue stream. And, since they shape the incentives for workers to remain employed, they are needed to evaluate the effectiveness of policies aimed at delaying retirement.

Different theories of wage determination have different predictions on the shape of the age-wage profile at older ages. While the human-capital theory (Mincer (1974), Becker (1975)) predicts wage declines before retirement, both Lazear's (1979) model of deferred compensation and the forced savings hypothesis (Frank and Hutchens (1993), Neumark (1995)) are consistent with monotonically increasing wage profiles.

When testing the predictions of these theories, it is important to understand the nature of the retirement process. In particular, we know that for a majority of workers retirement is not a dichotomous switch from full employment into inactivity. Rather, most workers partially retire before completely withdrawing from the labor force. During the semi-retirement years, workers usually take on part-time jobs, often outside the industry and occupation of the career job. Repeated exits and re-entries into the labor force are also common.

In this chapter we argue that the theoretical models of wage determination mentioned above characterize the wage path of career workers. Both Lazear's model and the forced-saving hypothesis describe long-term contracts that can only arise under the prospect of an enduring relationship between firm and employee. This excludes the type of short-term contracts that partially-retired workers usually engage in. The human capital model focuses on the role of human-capital depreciation in leading to wage declines at older ages. It abstracts from other motives for wage declines that arise when a worker enters partial retirement, such as a part-time wage penalty, the lower quality of jobs taken by semi-retired workers, etc. As such, its predictions only apply to the age-wage profile of workers who remain in the career job.

The empirical literature that has tested for wage declines has not distinguished between career and partially retired workers. Since semi-retired workers have lower wages than career ones, the wage drops at older ages that have been documented in previous studies are likely partly capturing late-career switches into partial retirement. This leaves open the question of whether any wage declines set in while workers are in the career job. The answer to this question will allow to evaluate the predictions of the different theoretical models. Moreover, it will provide an estimate of the return to work for non-retired older workers, a crucial parameter both for economic analysis and policy evaluation.

In this chapter, we test for wage declines for career workers, controlling for selection out of the career job. We find no statistical evidence of such declines for any education or pension-type group. We conclude that any wage decline to accommodate drops in productivity with age, if present, occurs only when the individual goes into semi-retirement or full retirement, either switching to part-time work or completely withdrawing from the labor force.

The rest of the chapter proceeds as follows. Section 3.2 reviews the theoretical and empirical results on the relationship between age and wages. Section 3.3 describes the data. Section 3.4 analyzes cross-sectional wage-age profiles in the Census and Health and Retirement Study. Section 3.5 introduces the statistical model for wages. The results are presented in section 3.6, and section 3.7 concludes.

3.2 The Relationship Between Age and Wages

The human capital model (Becker (1964), Mincer (1974)) predicts that individual investment in (general) human capital will diminish over time due to both declining marginal benefits and increasing marginal costs. In the absence of depreciation, this implies that wages will reach a peak and remain on a plateau thereafter. Adding depreciation of education capital and skills leads to negative net investment in human capital at older ages, and hence earnings profiles with an inverted-U shape.

The aging process itself may lead to declines in productivity beyond those caused by human capital depreciation. The incidence of illness increases at older ages. And the decline in cognitive capabilities, which starts at some point during early adulthood, becomes particularly noticeable after the age of 50 (Skirbekk (2004), Verhaegen and Salthouse (1997)). Both factors may translate into further reductions in wages.

Alternative theories of wage growth over the life cycle do not necessarily predict declines in wages with age. Lazear's model (1979) of deferred compensation, for instance, is compatible with monotonically increasing wages up to the point where the worker is compelled to retire.[1]

The forced-savings hypothesis (Frank and Hutchens (1993), Loewenstein and Sicherman (1991), Neumark (1995)) states that individuals have a preference for rising consumption profiles. In the presence of self-control problems, increasing wage profiles are a substitute for personal savings that allows workers to finance an upward-sloping consumption profile. In this scenario, firms can always find a profitable way of providing workers with rising wage profiles by decreasing compensation in the earlier career years.

These theoretical analyses characterize the wage path of career workers. They would be a good description of observed wage paths if retirement implied a clean switch from the career job into inactivity. The reality is, however, that a majority of workers partially retire before completely withdrawing from the labor force.[2] During the partial retirement period, which can span several years, workers take on bridge jobs (so called because they *bridge* the gap between full employment and full retirement), usually on a part-time basis and outside the industry and occupation of the career job. This phase at the end of a worker's career is often characterized by intermittent attachment to the labor force, with workers going through spells of inactivity before returning to part-time or even full-time work.[3]

The dynamics of the retirement process are key to the analysis of potential declines in wages. It is important not only to establish whether wages decline with age, but if so, at which point in the career of an individual these declines set in. Evidence of declining wages while individuals remain in their career job would provide support to the

[1] In the absence of mandatory retirement, pension incentives can be designed so as to strongly encourage retirement at specific ages.

[2] Cahill et al. (2005) find that one-half to two-thirds of workers in full-time career jobs take on bridge jobs before exiting the labor force.

[3] See Cahill et al. (2005), Gustman and Steinmeier (1985), Honig and Hanoch (1985), Quinn (1996), and Ruhm (1990) for a detailed description of the retirement process and its evolution over time.

human capital model, and reject the forced-savings hypothesis. While Lazear's model does not necessarily rule out declining wage profiles, the most prevalent version of the model predicts monotonically rising wage profiles, and would also be rejected by evidence of declining wages for workers who remain in the career job.

Wage declines that only set in after (partial) retirement are consistent with both the deferred-compensation model and the forced-savings hypothesis. They are more difficult to reconcile with the human capital model, because they could be explained by reasons other than the depreciation of general human capital. First, workers who move into a bridge job give up all the firm-specific human capital they had accumulated on the career job. Second, partially retired workers may choose bridge jobs that require less effort in exchange of a lower wage rate.[4] Finally, most bridge jobs are part-time jobs. In the presence of a part-time wage penalty, even individuals who move to observationally equivalent part-time jobs would earn less once they leave their career job.

Nevertheless, evidence that wages do not decline before retirement may not be interpreted as a conclusive rejection of the human capital model. If employers face restrictions in their ability to reduce real wages of career workers (e.g. for contractual reasons), they may instead choose to give those whose productivity falls below some threshold incentives to retire. In this case, declines in productivity would only translate into wage drops at the time of separation from the career job.

Beyond its consistency with the different theoretical models, the timing of wage declines also has important policy implications. In view of looming shortfalls in public pension systems, most OECD countries are introducing policies to encourage individuals to remain employed for longer. The US Social Security Administration has recently introduced reforms aimed at increasing the return to work at older ages, including a gradual increase of the full retirement age from 65 to 67; the elimination of penalties associated to delaying benefit claiming beyond full retirement age; and the elimination of the earnings test after full retirement age (Maestas and Zissimopoulos (2010)). In order to predict the effects of this type of policy changes, it is crucial to know the shape of the wage profile for workers who remain fully employed. If wages decrease before partial retirement, much stronger

[4]Partially retired individuals have often started drawing Social Security of private pensions. Johnson and Neumark (1995) argue that this increase in wealth could lead them to reduce either hours or effort.

incentives will be needed to keep workers in their career jobs - limiting the effectiveness of such policies.

The empirical literature examining the relationship between wages and age provides cross-sectional evidence of wage and earnings declines at older ages.[5] These cannot, of course, be interpreted as unequivocal evidence of longitudinal wage declines, as the presence of cohort effects or selection may lead to spurious wage declines in a cross-section even if longitudinal profiles are flat.

We turn therefore to longitudinal analyses. Ruggles and Ruggles (1974) study Social Security earnings records for different cohorts over the years 1957 to 1969 and find no evidence of wage declines at any point during the life cycle. Honig and Hanoch (1985), using Social Security records from 1951 to 1974, conclude instead that earnings profiles for working males decline after age 58, with sharp drops after the Social Security retirement ages. Johnson and Neumark (1995) use individual hourly wage data from 1966 to 1983 and find evidence of wage declines for workers in their 60's. They attribute a sizeable part of these declines to interactions with the Social Security early and full retirement ages.

The aforementioned longitudinal analyses do not explicitly separate wage data from individuals who are in the career job from those who are partially retired. Given the nature of the jobs held by semi-retired workers, there is a question of how much of these declines can be attributed to the switch into partial retirement. Honig and Hanoch and Johnson and Neumark's findings of strong wage declines at Social Security ages are particularly significant, as there is evidence that the incidence of partial retirement increases at those particular ages (Aaronson and French (2004)). This leaves open the question of whether wage declines set in while workers are in the career job.

Gustman and Steinmeier (1985) underscore the importance of separating non-retired from semi-retired workers. Their paper stresses that mixing up the two "may be adequate for describing the wage path currently traveled by older workers, but it is not adequate for describing the opportunity set they face". They find that estimating a wage equation on a sample of individuals who have not (partially) retired decreases the wage drop associated to moving from 40 to 52 years of experience from 22 percent to 8 percent. They do not

[5] Mincer (1974) and Ruggles and Ruggles (1977) analyze earning profiles, Hurd (1971) and Johnson and Neumark (1995) present evidence from wage profiles.

control for selection out of the career job, so it is possible that even this figure overstates the true decline in wages before retirement.

This paper extends previous work by testing for declines in wage rates for individuals who remain in the career job. We estimate separate wage equations for different pension and education categories. Also, acknowledging that the decision to go into partial retirement may not be random, we control for selection out of the career job within pension and education categories, and find strong evidence of negative selection.

We find no statistical evidence of wage declines for individuals who remain in the career job. Our results are consistent Lazear's model of deferred compensation and the forced-savings hypothesis. They are not inconsistent with the human capital model, but imply that any wage adjustments due to declining productivity would happen only once the individual has entered the retirement phase.

3.3 Data

We use data from two different sources, the 1990 US Census 5% Public Use Micro Sample (PUMS)[6] and the Health and Retirement Study (HRS).

The 1990 Census PUMS is a 1-in-20 cross-sectional sample of the US population. It provides information on standard economic and demographic characteristics of respondents, including age, gender, employment status, hours worked, and wage income. We use the 1990 Census data in the descriptive analysis of the cross-sectional age-wage profile.

For our primary analysis we use data from the HRS, a nationally representative sample of adults over 50 years of age. We focus on the HRS baseline cohort, which consists of individuals born between the years 1931 and 1941, inclusive[7]. They were interviewed for the first time in 1992, and subsequently every two years. We use the 9 waves that are currently available, spanning from 1992 to 2008. The advantages of the HRS with respect to the Census are its panel structure, with individuals being followed for up to 16 years, and the detailed information it provides on demographics, health status, job-related

[6] The data were obtained from the IPUMS-USA database (http://usa.ipums.org/usa/). See Ruggles et al. (2010).

[7] The HRS cohort also includes spouses of individuals born between the years 1931 and 1941. We restrict our sample to individuals born within those years.

variables and pension types. Its main drawbacks are the smaller sample size and the lack of information for individuals below the age of 50. This is adequate for our purposes, however, since the paper focuses on older individuals.

We choose to focus on the the 1990 Census to have a sample that is most directly comparable to the HRS one. In the year 1990, individuals in the HRS baseline cohort where 49 to 59 years-old, and thus exactly at the age when cross-sectional hourly wages begin to decline. We have repeated the analysis using data from the 1980 and 2000 Census, and the results are qualitatively unchanged.

From the Census data we build the variable measuring hours worked per year as the product of usual hours worked per week and weeks worked last year. Hourly wages are calculated dividing wage and salary income in the previous year by hours worked that year. Participation categories are defined based on usual hours worked per week. Full-time workers are those working more than 30 hours per week. Part-time workers are those working between 6 and 30 hours per week. Individuals working 5 or less hours per week are considered inactive[8].

The HRS data come from the RAND-HRS Data File (see RAND HRS Data (2010) for a description). The wage variable that we use for the analysis is the (hourly) *Wage Rate*. Participation categories are defined according to the variable *Hours of work per week at current job*. As before, full-time workers are those working more than 30 hours per week, part-time workers are those working between 6 and 30 hours per week, and those working 5 or less hours per week are considered inactive. We define two education categories. The highest one includes individuals who have at least some college, and the lowest one pools high-school graduates and those who have not finished high-school. An individual is considered to be in bad health if he describes his health status as “fair” or “poor”, and is considered to be in good health if he says his health is “excellent”, “very good”, or “good”. The wealth variable that we use is *Total Wealth (Excluding Secondary Residence)*, which includes the value of the primary residence and all financial assets net of mortgages or debt.

Pension type is a crucial variable in our analysis, as separate wage processes are esti-

[8]We have experimented with different participation thresholds (5, 2, and 0 hours per week) and the participation profiles are barely affected.

mated for individuals with different pension types. It is defined defined according to the variable *Type of pension from current job.* An individual is assigned the type of pension he has in the period he enters the sample. The value of this variable does not change even if the individual leaves the job. This is intended to capture the pension type that individuals had in the career job.

3.4 Analysis of Cross-Sectional Age-Wage Profiles

The median- and average-hourly wage profiles for men in the 1990 Census, shown in figure 3.1, confirm previous evidence that cross-sectional male wages peak in the late 40's and later decrease with age.

Figure 3.1: Cross-Sectional Wage Profile. Men. 1990.

NOTE. - Source: Author's calculations using 1990 Census-PUMS. Average wage computed using observations between 5th and 95th percentile for each age.

From a peak value of \$15.67 per hour at age 47 to \$11.41 per hour at age 73, average wages decline by 27% (p-value = 0.00). The decline is initially slow, and it accelerates after the Social Security early retirement age of 62. Median wages decline more quickly than average wages, and the two series diverge noticeably from the mid 50's. From peak (\$14.68 at age 47) to trough (\$8.11 at age 77), mean wages drop by 45% (p-value for nonparametric test of equality of medians is 0.00).

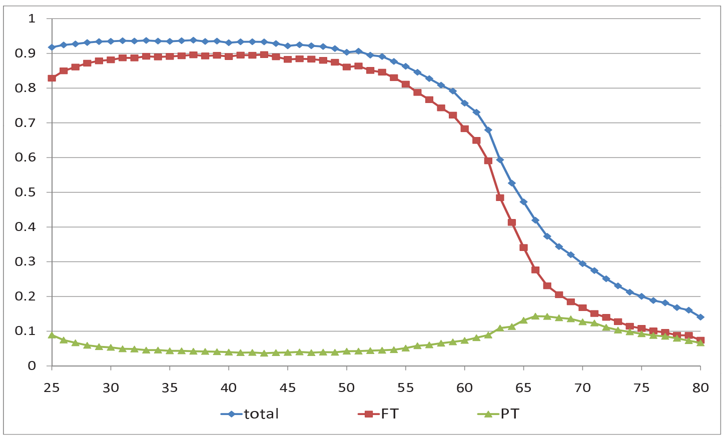
There are many possible explanations for a declining cross-sectional wage profile for older workers, only some of which are related to the effects of age and experience. These explanations include changes in the proportion of part-time workers, cohort effects, and selection. Below we examine each one in turn.

3.4.1 Full-Time vs. Part-Time Work

This paper is concerned with the age-wage profile of career workers. Different criteria can be used to distinguish between career workers and those partially retired, but most of them include a measure of the number of hours worked because, as explained in section 3.2, the majority of bridge jobs taken during retirement are part-time jobs. In the absence of information on tenure or past spells of part-time work to further refine our measure, we can classify Census observations according to the number of weekly hours worked, under the assumption that full-time workers are the most likely to remain in the career job, while part-time workers are the most likely to have entered partial retirement.

An analysis of the proportion of part-time workers in the labor force during the retirement years can illustrate how combining observations of full- and part-time workers may exacerbate cross-sectional wage declines. Figure 3.2 shows total, full-time, and part-time participation rates for men in 1990. Full-time participation stabilizes at around 90% once men complete their education, and remains virtually constant until the late 40's. Then, at around the same time as wages start declining, full-time employment begins to drop. The decline is initially slow (21 percentage points between ages 50 and 61 (p-value of the difference is 0.00), equivalent to 2 percentage points per year), accelerating as workers reach the early and full Social Security retirement ages of 62 and 65, respectively: full time participation drops by 37 percentage points between ages 61 and 66 (p-value = 0.00), equivalent to 7.4 percentage points per year.

Figure 3.2: Total, Full- and Part-Time Participation. Men. 1990.



NOTE. - Source: Author's calculations using 1990 Census-PUMS.

Part-time participation, on the other hand, rises by 4 percentage points between ages 50 and 61 (p-value = 0.00), and by 6 further percentage points between ages 61 and 66 (p-value = 0.00), before declining thereafter. As a result of the diverging trends in full-time and part-time participation, the proportion of part-time workers increases steadily from the late 40's until the late 70's. By age 78, 47% of workers are part-time employees.

This change in the composition of the labor force may explain part of the wage drop observed in figure 3.1. Previous studies that found evidence of wage declines in samples mixing full-time and part-time workers may have been picking up the shift from full-time to part-time if part-time wage rates are lower than full-time ones.

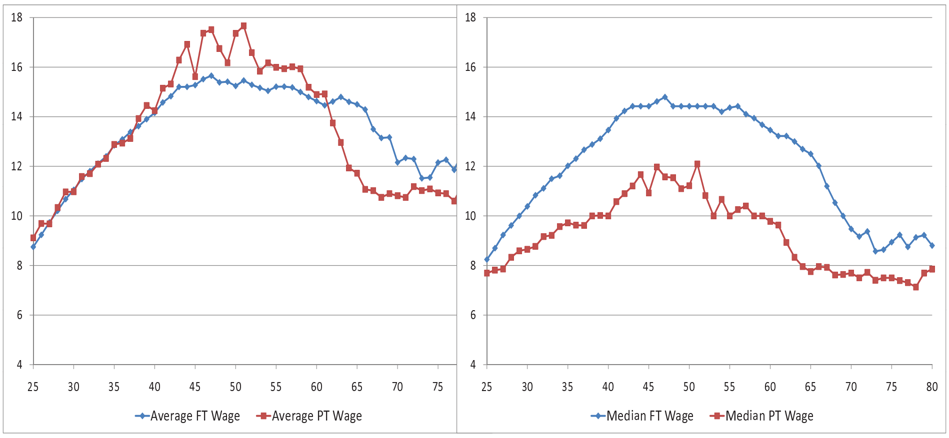
There are several reasons why we would expect to see a gap between full-time and part-time wages. First, there may be a part-time wage penalty, whereby part-time workers earn less per hour than full-time ones with similar skills and in similar jobs[9]. Second, the average part-time job may be different from the average full-time job. It is likely that semi-retired workers will take on jobs with different characteristics from their career job, e.g. jobs that carry less responsibility and require less effort. Third, workers in their career jobs tend to have longer tenures than those in bridge-jobs, and will have accumulated more specific human capital. Finally, if workers leave their career job when their productivity begins to decline, there may be unobservable differences between those in full- and part-time employment.

Figure 3.3 confirms that part-time wages are lower at older ages. Median part-time wages, shown in the right panel, are below median full-time wages at all ages (equality can be rejected with a p-value of 0.00 at every age between 25 and 79), while average part-time wages, shown on the left panel, are lower than full-time ones for workers older than 60 (equality can be rejected at all ages between 61 and 72 with p-value = 0.00).

Interestingly, excluding part-time employees from the sample does not eliminate the late-career drop in wages. Figure 3.4 compares the age-wage profile for all employees with that of full-time employees. Restricting the sample to full-time workers delays the onset of the decline in wages, but the drop is still noticeable, particularly after workers become eligible for early Social Security retirement benefits at age 62.

[9] Hirsch (2005) finds evidence of a wage gap between full-time and part-time workers that persist after controlling for standard measures of worker and job attributes.

Figure 3.3: Average (left) and Median (right) Full-Time and Part-Time Wage. Men. 1990.



NOTE. - Source: Author's calculations using 1990 Census-IPUMS. Average wage computed using observations between 5th and 95th percentile for each age.

Figure 3.4: Average (left) and Median (right) Wage for All Employed vs. FT Employed. Men. 1990.

NOTE. - Source: Author's calculations using 1990 Census-IPUMS. Average wage computed using observations between 5th and 95th percentile for each age.

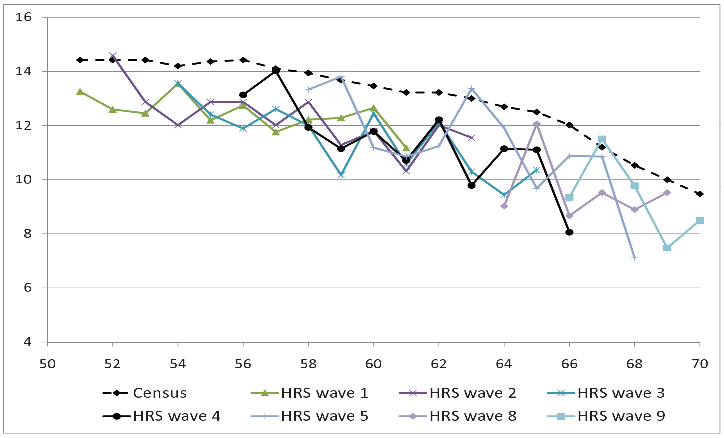
There are several reasons why the decline in full-time wages in figure 3.4 cannot be interpreted as evidence of productivity declines without further analysis. On top of cohort effects, it may be the result of selection, as the decision to leave the career job is likely not random, and the marginal full-time worker may be changing with age. Previous studies of age-wage profiles at older ages, from Hurd (1971) to Johnson and Neumark (1996) and Myck (2007), have suggested an important role for selection but none has formally quantified its effects. In order to control for selection out of the career job, we need a panel of individuals approaching the end of their working lives.

3.4.2 Cross-Sectional Age-Wage Profiles in the HRS

In the next sections, we will use data from the HRS to estimate individual age-wage profiles. As mentioned in section 3.3, the HRS is a panel dataset that follows the cohort of individuals born between the years 1931 and 1941 for a maximum of 16 years, starting in 1992. While the main appeal of these data is their panel structure, it is useful to start by analyzing the cross-sectional wage profiles in the HRS, which we can compare to the ones obtained from the Census.

Making use of the panel structure of the HRS, figure 3.5 plots the 1990 Census median full-time age-wage profile against repeated cross-sections from selected HRS waves. The first noticeable aspect is that the wage series from the HRS lie somewhat below the one from the Census[10]. More importantly, the HRS series confirm the decline in cross-sectional wages observed in the 1990 Census. Also, the different cross-sections overlap, from which we conclude that there is no evidence of cohort effects within the birth-year range used to select the sample.

Figure 3.5: Median Cross-Sectional Full-Time Age-Wage Profile. Men. Selected Years.



NOTE. - Source: Author's calculations using 1990 Census-PUMS and HRS. HRS wages deflated to 1989 dollars using CPI. Results reported for wave-age cells containing at least 30 observations.

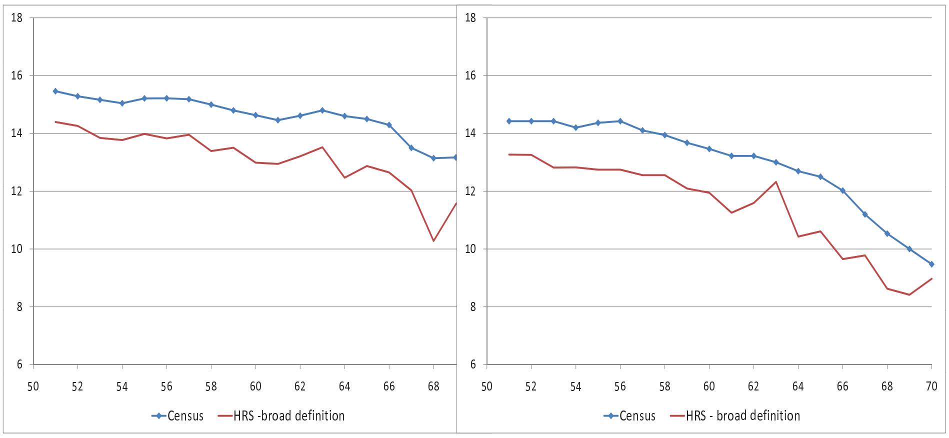
Finally, the right panel of figure 3.6 shows once more the median Census age-wage profile against the equivalent one in the HRS, this time pooling all observations available

[10]The main reason why the two series are not totally comparable is the definition of wage income, which is narrower in the HRS (where individuals are asked to report the wage rate for "regular work time" only) and broader in the Census, where as well as regular wages it includes "commissions, cash bonuses, tips, and any other income received from an employer". On the other hand, the differences cannot be attributed to cohort effects, as the average individual in the 1990 Census series was born in 1932, while the average individual in the HRS-wave 1 series was born in 1936.

for every age. The HRS series closely tracks the wage declines observed in the Census. Between age 51 and age 59, median full-time wages drop by 22% in the Census (p-value of the difference $=0.00$) and by 26% in the HRS (p-value$=0.00$). The left panel of figure 3.6 tells a similar story for average wages, which fall by 13% in the Census and by 16% in the HRS between those ages (p-values of both differences below 0.01).

It is the HRS profile of average wages, shown on the left panel of figure 3.6, that will be the focus of the econometric analysis of the following sections.

Figure 3.6: Average (left) and Median (right) Full-Time Age-Wage Profiles in the 1990 Census and HRS. Men.



NOTE. - Source: 1990 Census-IPUMS and HRS. Average wage computed using observations between 5th and 95th 1990-Census percentiles for each age. HRS wages deflated to 1989 dollars using CPI.

3.5 The Statistical Model for Wages

Denote by w_{it} the hourly log-wage of individual i in period t, with $i = 1, ..., I$ and $t = 1, ..., T$. We assume a standard Mincerian specification for log-wages, but we include age, rather than experience, as our main regressor:

$$w_{it} = \sum_{k=j}^{J} \delta^k I\{age = k\} + X_{it}\beta + u_{it}^*, \tag{3.5.1}$$

where the coefficients on the age dummies, δ^j, identify the age-profile of log-hourly wages, X_{it} is a vector of other observables and u_{it}^* is the stochastic component of log wages. u_{it}^* is the sum of an unobserved time-constant individual specific factor, and an idiosyncratic error term:

$$u_{it}^{*} = \upsilon_i + u_{it}, \qquad (3.5.2)$$

where the distributional assumptions on υ_i and u_{it} will be made explicit below.

The main aim of the paper is to obtain consistent estimates of δ^k for $k = j, ..., J$ and β. We will use a sample of older workers to estimate equation 3.5.1. Given that a significant fraction of these workers enters (semi-)retirement every year, with their decision to leave the career job driven by a myriad of factors, both observable and unobservable by the econometrician, we do not want to assume that our sample has been randomly selected from the population. Below we describe the procedure -based on Wooldridge (1995)- used to correct for selection.

We begin by specifying the selection process. The wage associated to the career job is only observed before a worker starts working part-time or retires. We assume the following form for the structural selection equation, where the binary indicator P_{it} is equal to 1 whenever career-work wages are observed:

$$P_{it} = I\{X_{it}\theta + \nu_i + \xi_{it}\} \qquad (3.5.3)$$

ν_i and ξ_{it} are assumed jointly normally distributed with $E(\xi_{it}) = 0$ and ξ_{it} independent of X_{it} for all t.[11] So as to allow the time-persistent individual effect to be correlated with observables, we adopt a correlated random effects specifications, as in Chamberlain (1980):

$$\text{ASS1} : \nu_i = X_i\delta + \epsilon_i,$$

where ϵ_i is independent of X_i with a zero-mean normal distribution, and $X_i = \{X_{it}\}_{t=1}^{T}$. Defining $\mu_{it} \equiv \epsilon_i + \xi_{it}$, we obtain the following reduced-form expression for the selection equation:

$$P_{it} = I\{X_{it}\theta + X_i\delta + \mu_{it}\} \qquad (3.5.4)$$

The main assumptions needed to identify the coefficients of the wage equation are the

[11]The vector X_{it} in equation 3.5.3 includes exclusion restrictions that are not part of the set of regressors in the wage equation.

following:

$$\text{ASS2} : E(u_{it} \mid X_i, \mu_{it}) = E(u_{it} \mid \mu_{it}) = \rho_t \mu_{it}$$
$$\text{ASS3} : E(\upsilon_i \mid X_i, \mu_{it}) = L(\upsilon_i | X_i, \mu_{it})$$

The conditional mean independence assumption stated in the first equality of ASS2 always holds if (u_{it}, μ_{it}) are independent of X_i, something that is usually maintained in the selection context. The second equality in ASS2, which states that the conditional mean of u_{it} is linear in μ_{it}, is not crucial for identification and could be relaxed. It is, however, implied by the standard assumption in selection-correction models of joint normality of (u_{it}, μ_{it}).

ASS3 is certainly stronger. Notice that, without μ_{it} inside the conditioning set, it would be similar to the one used in Chamberlain (1980). What the addition of μ_{it} buys us is the ability to correct for sample selection bias in the presence of an individual time-constant component, while allowing this to be correlated with the X's -something crucial in the context of the wage equation.

Under ASS3, we can write:

$$L(\upsilon_i | X_i, \mu_{it}) = \Pi_0 + X_{i1}\Pi_1 + ... + X_{iT}\Pi_T + \phi_t \mu_{it}$$

Making use of ASS1, ASS2 and ASS3, the wage equation can be written as:

$$E(w_{it} | X_i, \mu_{it}) = X_{it}\beta + X_i\Pi + \gamma_t \mu_{it},$$

where $\gamma_t = \rho_t + \phi_t$. Conditioning on $P_{it} = 1$ and assuming, without loss of generality, that $E((\mu_{it})^2) = 1$, yields

$$E(w_{it} | X_i, P_{it} = 1) = X_{it}\beta + X_i\Pi + \gamma_t \lambda(X_i \mu_t),$$

where λ is the inverse Mills ratio.

In the empirical section we will make the simplifying assumption that $\gamma_t = \gamma$ for all

t. We will also assume, as in Mundlak (1978), that the time-constant unobserved effects depend on the vector X_i only through the time-average of X_{it} for each individual, denoted $\bar{X}_i$. Finally, for variables that do not vary in time it is not possible to separately identity their contemporaneous effect from their effect through the fixed effect. We will assume that they only have an effect through the fixed effect, and interpret their coefficients accordingly.

Consistent estimates of the age profile and β are obtained by first estimating equation 3.5.4 by pooled probit across i and t, generating the estimated inverse Mills ratios $\widehat{\lambda}_{it}$, and then running a pooled OLS regression of $\ln w_{it}$ on $I\{age = k\}$ for $k = j, ..., J$, X_{it}, $\bar{X}_i$, and $\widehat{\lambda}_{it}$ for the selected sample.

3.6 Results

3.6.1 Exclusion Restrictions

We use a series of exclusion restrictions to achieve nonparametric identification of the model. The first variables from the vector X_{it} that are excluded from the wage equation are indicators that the individual is above the Social Security early retirement age (ERA) and full retirement age (FRA). These indicators were proposed as instruments for the number of hours worked by Aaronson and French (2004). Past the Social Security ages, individuals face several incentives to reduce their work hours. First, workers who claim benefits and continue to work face the Social Security earnings test, which leads to a reduction of \$1 of benefits for every \$2 of earnings above a threshold.[12] Second, liquidity-constrained workers may not be able to reduce their work hours until they become eligible for Social Security benefits. Finally, by age 65 all workers who are eligible for Social Security become eligible for Medicare. Individuals younger than 65 who have employer-provided health insurance have an incentive to remain in the job until that age, as temporary bridge jobs are less likely to provide health insurance.

[12]Benefits lost through the earnings test are replaced in the form of higher benefits in the future at a rate that is roughly actuarially fair, so rather than a tax the earnings test acts as an intertemporal transfer. Nevertheless, if individuals are present-biased, they may prefer to enjoy leisure today rather than to work today for a reduced net wage in exchange for higher benefits in the future. Second, there is some evidence that individuals misunderstand the complicated rules of the earnings test, and they may perceive the adjustment as less than actuarially fair (Michaud and Van Soest (2007)).

The next exclusion restriction is a measure of wealth in the current period. Notice that our regressions control for lifetime wealth through the linearization of the time-constant individual component. Lifetime wealth is not exogenous to the retirement decision, as individuals may save in order to finance early retirement, and it would not be a valid exclusion restriction if individuals with higher lifetime wages end up accumulating more wealth. However, after controlling for lifetime wealth, current wealth measures the effect of deviations from the long-run value. Under our maintained assumption that these are exogenous to other individual characteristics, current wealth is a valid exclusion restriction.

We also use as an exclusion restriction an indicator that there is an outstanding mortgage in the household. Controlling for lifetime wealth, the existence of this fixed monthly expense should reduce the individual's willingness to cut his work hours or stop working, as this would reduce the income available to pay the mortgage in any future period.

An indicator of whether the worker's employment-provided health insurance policy covers his wife should capture an extra incentive for him to remain employed until his partner reaches age 65 and becomes eligible for Medicare coverage.

Finally, for low-education individuals, we include as an exclusion restriction an indicator that the wife is over age 62. This should increase the likelihood that she is retired, as there is a large spike in women's retirements at age 62. Given the correlation in spouses' retirement dates (Casanova (2010)), the indicator should, in turn, capture an extra incentive for the husband to retire. We find that this indicator is never significant in predicting the full-time participation propensity for the highly educated, and therefore we opt for removing it from those regressions. This suggests either that the correlation in spouses' retirement dates is not as strong for highly-educated individuals, or that highly educated individuals' partners are less likely to retire at 62.

3.6.2 Selection equation

For the estimation of the age-wage profiles, we separate individuals according to their education level and pension type. Table 3.3 shows the results from the estimation of the selection equation. The dependent variable in this equation is an indicator that equals 1 if the individual is a career worker. It is equal to 0 if the individuals has (semi)retired, both if he continues to work part-time and if he has completely withdrawn from the labor force. The coefficients reported in the table are divided into three groups. The first one, shown on the top panel of the table, shows the coefficients of explanatory variables that enter both the selection and the wage equations. The middle panel shows the coefficients of the exclusion restrictions. The third panel shows the coefficients of the variables that enter the selection and wage equations through the linearization of the unobserved individual effect.

The first and the fourth columns show results for the samples of men who have some college education and those who at most graduated from high school, respectively. The results indicate that the probability of being a career worker decreases with age, and it is significantly lower for individuals in bad health. Regarding the exclusion restrictions, they are all significant and with the expected signs. Individuals are significantly less likely to be in the career job after crossing the Social Security ages. Those whose wealth in the current period is above lifetime wealth are more likely to be (semi-)retired, while those who have an outstanding mortgage are more likely to remain in the career job. Having an employer-provided insurance plan that covers their wife increases men's incentives to remain in the career job. Finally, low-education men whose wife is above age 62 are less likely to remain in the career job. Regarding the variables proxying the time-constant unobserved component, we can see that the lower the level of health across the sample period, the less likely an individual is to remain in the career work. Higher lifetime wealth is associated with a higher probability of being (semi-)retired for those with high education only. Within the low education category, having graduated from high-school rises the likelihood of (semi-)retirement with respect to high-school dropouts, while those with more educated mothers are more likely to remain in the career job.

Columns 2 and 3 of table 3.3 show results for highly-educated men who had a defined benefit (DB) pension and a defined contribution (DC) pension in the career job, respectively.[13] It is clear that the declining age trend in the participation of career work-

[13] Due to the low number of men in jobs with no pensions who work at older ages, the coefficients of the wage equation are estimated very imprecisely for this subsample of workers. Moreover, this category combines two heterogeneous groups of workers, those who had low-attachment to the labor force during their working careers and the self-employed, which makes the results difficult to interpret. For these reasons, results for the no-pension category are not reported here, although they are shown in the appendix.

Table 3.1: Estimates of selection equation by education and pension type.

	High Education			Low Education		
	All	DB	DC	All	DB	DC
age52	-0.217	-0.756*	-0.438	-0.184	-0.398	0.334
	(0.149)	(0.351)	(0.345)	(0.121)	(0.297)	(0.354)
age53	-0.080	-0.422	-0.331	-0.074	-0.343	0.092
	(0.142)	(0.346)	(0.346)	(0.112)	(0.283)	(0.286)
age54	-0.288*	-0.872**	-0.448	-0.117	-0.228	0.431
	(0.138)	(0.334)	(0.339)	(0.113)	(0.286)	(0.320)
age55	-0.362**	-0.735*	-0.533	-0.180	-0.265	-0.039
	(0.136)	(0.330)	(0.342)	(0.110)	(0.279)	(0.281)
age56	-0.507**	-0.987**	-0.339	-0.156	-0.321	0.245
	(0.134)	(0.328)	(0.333)	(0.110)	(0.275)	(0.312)
age57	-0.438**	-0.914**	-0.327	-0.252*	-0.562*	0.208
	(0.136)	(0.330)	(0.338)	(0.111)	(0.274)	(0.290)
age58	-0.548**	-1.051**	-0.497	-0.211	-0.431	0.422
	(0.141)	(0.335)	(0.344)	(0.117)	(0.283)	(0.317)
age59	-0.681**	-1.198**	-0.772*	-0.371**	-0.662*	0.152
	(0.143)	(0.336)	(0.349)	(0.118)	(0.283)	(0.308)
age60	-0.712**	-1.255**	-0.609	-0.325**	-0.577*	0.071
	(0.147)	(0.341)	(0.354)	(0.121)	(0.287)	(0.316)
age61	-0.835**	-1.379**	-0.826*	-0.539**	-0.857**	-0.176
	(0.148)	(0.341)	(0.355)	(0.124)	(0.291)	(0.318)
age62	0.086	0.041				0.416*
	(0.096)	(0.148)				(0.172)
age63	0.029	-0.027	-0.072	-0.074	-0.003	0.121
	(0.094)	(0.145)	(0.163)	(0.083)	(0.136)	(0.163)
age64			-0.156	-0.229**	-0.182	
			(0.175)	(0.089)	(0.143)	
age65	0.072	0.022	0.118	0.243*	0.354*	0.199
	(0.111)	(0.191)	(0.205)	(0.114)	(0.177)	(0.235)
age66		-0.107	0.072	-0.010		0.271
		(0.208)	(0.212)	(0.121)		(0.227)
age67	0.007				0.147	
	(0.124)				(0.202)	
bad he	-0.231**	-0.269*	-0.206	-0.277**	-0.261**	-0.210
	(0.073)	(0.130)	(0.145)	(0.047)	(0.092)	(0.110)
overERA	-1.165**	-1.786**	-1.058**	-0.849**	-1.344**	-0.942**
	(0.160)	(0.355)	(0.360)	(0.129)	(0.296)	(0.339)
overFRA	-0.350**	-0.397*	-0.583**	-0.543**	-0.525**	-0.540*
	(0.110)	(0.192)	(0.221)	(0.123)	(0.188)	(0.231)
wealth	-0.001*	-0.002	-0.001	-0.003**	-0.007**	-0.005*
	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
mortg	0.284**	0.228**	0.363**	0.214**	0.126*	0.169*
	(0.033)	(0.054)	(0.066)	(0.030)	(0.052)	(0.070)
wife62				-0.253**	-0.248**	-0.137
				(0.049)	(0.084)	(0.103)
ins	0.447**	0.404**	0.403**	0.482**	0.370**	0.505**
	(0.035)	(0.054)	(0.068)	(0.032)	(0.052)	(0.072)
hsch grad				-0.168**	-0.242**	-0.077
				(0.032)	(0.062)	(0.073)
ever self	0.091*	-0.317**	0.003	-0.006	-0.165*	0.352**
	(0.037)	(0.069)	(0.070)	(0.037)	(0.076)	(0.102)
bad he (av)	-0.746**	0.014	-0.718**	-0.954**	-0.560**	-0.293
	(0.098)	(0.177)	(0.236)	(0.066)	(0.139)	(0.159)
wealth_0	-0.002**	-0.000	-0.002**	0.001	0.004**	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)
mother's ed	-0.030	0.054	-0.125**	0.027*	0.053*	-0.001
	(0.021)	(0.035)	(0.044)	(0.014)	(0.025)	(0.032)
constant	0.869**	1.690**	1.614**	0.818**	1.698**	0.967**
	(0.128)	(0.312)	(0.320)	(0.099)	(0.255)	(0.240)
Sample size	7,072	2,998	1,922	9,845	3,318	1,947

NOTE. - Robust standard errors in parentheses. * indicates significance at 5%; ** indicates significance at 1%. All regressions include time dummies.

ers, which was apparent for the whole sample from the early 50's, was mostly driven by workers with a DB pension. For workers with a DC pension participation declines at a slower rate, and the coefficients of the age variables are not significant until age 59. These results are consistent with the different pension incentives provided by DB and DC plans. DB plans usually establish an early and a normal retirement age, after which pension accrual decreases considerably and in some cases becomes negative. While 62 the median normal retirement age in DB plans (French (2005)), it is common for them to have early retirement ages as early as 50 or 55. In DC plans, on the other hand, pension accrual is determined by the amount that worker and employer contribute to the account each year, and is independent on the individual's age. The only age-related restriction in DC plans that is relevant for this analysis is that the balance in these accounts cannot be accessed without penalty before age 59 and a half. This explains why DC-pension holders do not significantly increase their entrance into semi-retirement until after this age.

The coefficients on the exclusion restrictions are comparable across the two pension plans. There are some differences regarding the proxies for the unobserved individual effects. Having been self-employed lowers the likelihood of being in the career job for DB but not DC-plan holders, while a low value of average health during the period increases the likelihood of (semi-)retirement for those with a DC pension, but not for those with a DB plan.

Finally, columns 5 and 6 of table 3.3 show results for low education men disaggregated by pension type. The main difference with respect to their highly-educated counterparts is that evidence of a decline in participation in the career job with age is less conclusive and generally insignificant. Having a wife above ERA increases (semi-)retirement of DB-pension holders but not for those with a DC plan. And the increased likelihood of being (semi-)retired for those who have completed high-school vs. high-school dropouts is only significant for individuals with a DB pension.

3.6.3 Wage equation

We use the coefficients from the selection equations to construct category-specific inverse Mills ratios, and then estimate equation 3.5. The results are reported in table 3.2. The coefficients on the age dummies, which identify the age profile of log-hourly wages and those of the inverse Mills ratios are described separately in the following section. Here we summarize the results for the vectors of coefficients β and Π.

Table 3.2: Estimates of wage equation by education and pension type.

	High Education			Low Education		
	All	DB	DC	All	DB	DC
age52	-0.031	0.080	-0.222	0.151**	0.111	0.092
	(0.065)	(0.062)	(0.116)	(0.059)	(0.058)	(0.089)
age53	-0.041	-0.009	-0.014	0.060	0.038	0.093
	(0.048)	(0.045)	(0.110)	(0.044)	(0.046)	(0.067)
age54	-0.025	0.045	-0.195	0.106	0.100	0.095
	(0.063)	(0.064)	(0.120)	(0.055)	(0.059)	(0.090)
age55	0.021	-0.002	-0.063	0.065	0.013	0.075
	(0.061)	(0.058)	(0.122)	(0.052)	(0.054)	(0.079)
age56	0.071	0.120	-0.235	0.064	0.028	0.111
	(0.071)	(0.074)	(0.125)	(0.057)	(0.059)	(0.096)
age57	0.023	0.064	-0.178	0.109	0.058	0.049
	(0.070)	(0.073)	(0.131)	(0.060)	(0.067)	(0.088)
age58	-0.000	0.039	-0.210	0.097	0.081	0.052
	(0.081)	(0.089)	(0.146)	(0.067)	(0.072)	(0.109)
age59	0.061	0.075	-0.027	0.080	0.013	0.032
	(0.091)	(0.101)	(0.173)	(0.074)	(0.085)	(0.103)
age60	0.062	0.118	-0.197	0.102	0.088	0.060
	(0.100)	(0.119)	(0.175)	(0.080)	(0.088)	(0.125)
age61	0.114	0.131	-0.115	0.107	0.025	0.050
	(0.112)	(0.123)	(0.198)	(0.093)	(0.111)	(0.126)
age62	0.160	0.297	-0.197	0.287**	0.156	0.228
	(0.136)	(0.163)	(0.226)	(0.108)	(0.161)	(0.146)
age63	0.250	0.286	-0.051	0.315*	0.171	0.370*
	(0.145)	(0.181)	(0.250)	(0.123)	(0.172)	(0.170)
age64	0.191	0.237	-0.212	0.426**	0.204	0.398*
	(0.159)	(0.194)	(0.272)	(0.139)	(0.202)	(0.191)
age65	0.359	0.432	-0.127	0.535**	0.217	0.558*
	(0.196)	(0.248)	(0.335)	(0.157)	(0.231)	(0.222)
age66	0.358	0.436	-0.112	0.617**	0.332	0.431*
	(0.218)	(0.309)	(0.352)	(0.173)	(0.283)	(0.217)
age67	0.403	0.252	-0.083	0.760**	0.379	0.470
	(0.229)	(0.295)	(0.407)	(0.192)	(0.298)	(0.266)
bad he	0.128**	0.084	0.082	0.134**	0.072	0.024
	(0.046)	(0.060)	(0.083)	(0.033)	(0.042)	(0.041)
hsch grad				0.227**	0.193**	0.160**
				(0.033)	(0.041)	(0.048)
ever self	-0.075	0.066	0.086	-0.051	-0.087	-0.096
	(0.047)	(0.072)	(0.083)	0.043)	(0.051)	(0.062)
bad he (av)	-0.126	-0.244*	-0.334	0.185*	-0.084	0.053
	(0.105)	(0.106)	(0.219)	(0.079)	(0.086)	(0.091)
wealth_0	0.004**	0.004**	0.006**	0.001	0.000	0.004**
	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)	(0.001)
mother's ed	0.070**	0.085**	0.063	0.043**	0.026	0.020
	(0.026)	(0.032)	(0.049)	(0.015)	(0.018)	(0.022)
Inverse Mills	-0.694**	-0.445**	-0.621**	-0.664**	-0.219	-0.534**
	(0.120)	(0.156)	(0.215)	(0.092)	(0.181)	(0.145)
constant	2.845**	2.699**	2.795**	2.331**	2.389**	2.278**
	(0.086)	(0.096)	(0.162)	(0.059)	(0.070)	(0.091)
Sample size	3,371	1,625	1,110	4,135	1,784	1,196
R^2	0.1577	0.1308	0.2418	0.1724	0.1089	0.1404

NOTE. - Standard errors (in parentheses) obtained from 2,500 bootstrap replications, accounting for estimation of inverse Mills ratios in first stage. * indicates significance at 5%; ** indicates significance at 1%. All regressions include time dummies.

The vector X_{it} minus the exclusion restrictions includes an indicator of whether the individual is in bad health in the current period. For the whole samples of men with college education and those who have graduated from high-school or are high-school dropouts (columns 1 and 4, respectively), the coefficient is positive and significant. This results is puzzling, as it would imply that being in bad health somehow increases a worker's productivity. Once we disaggregate by pension type, however, the coefficient on this variable becomes small and insignificant, suggesting that the positive sign was a spurious result of the combination of the different subsamples. Regarding the variables from the linearization of the unobserved individual-specific effects, higher lifetime wealth is associated with higher wages for those with high education, but is insignificant for the low-education group. Having a more educated mother, which is intended to proxy the individual's ability, is associated to higher wages for both education groups. Within the low education category, not surprisingly, we find that high-school graduates have higher wages than high-school dropouts.

3.6.4 The age-wage profile

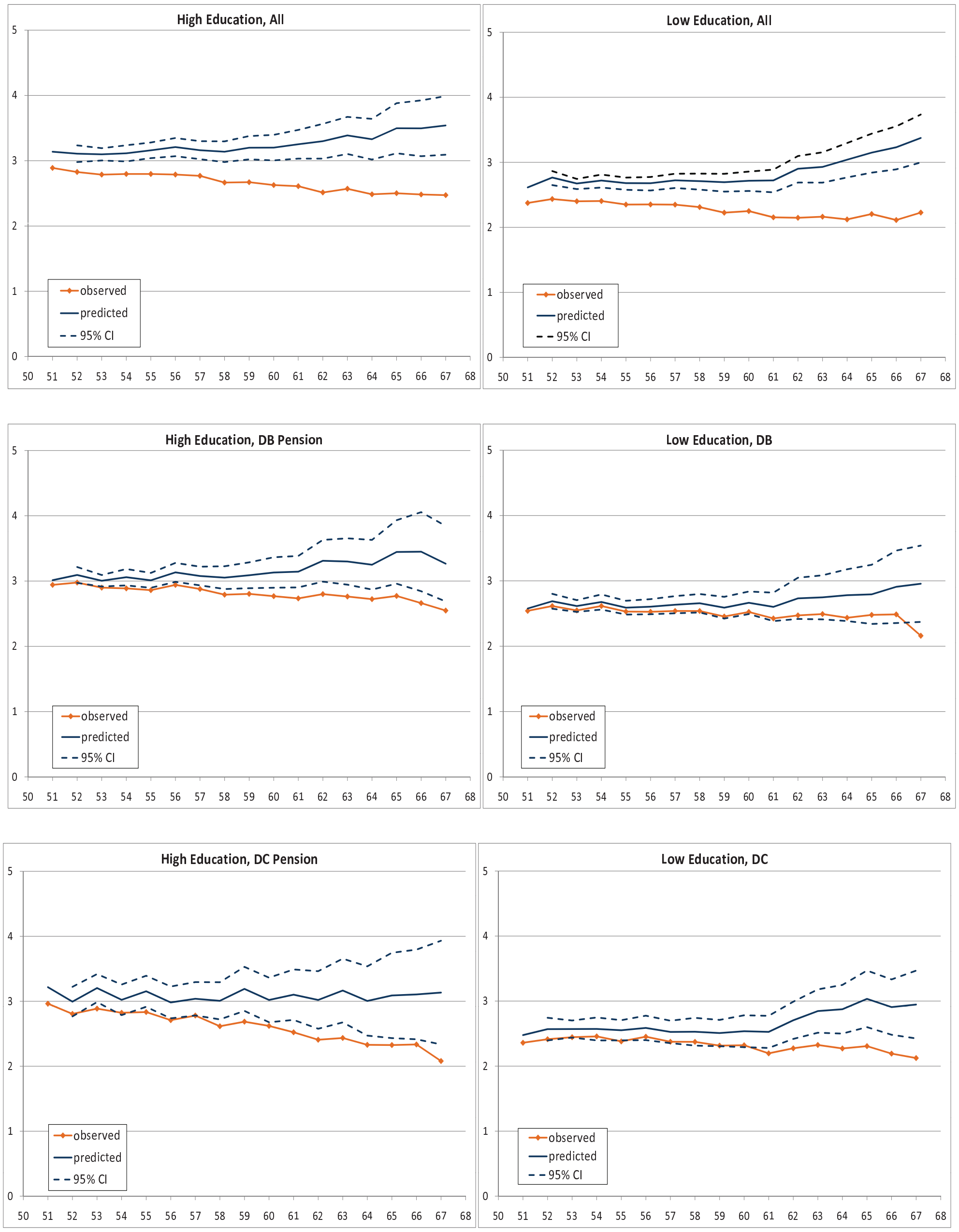
This section describes the estimated age profiles, identified by the coefficients on the age dummies in the wage equation. We show that after controlling for selection there is no evidence of a declining wage profile for any of the categories considered. The results are illustrated in figure 3.7, which shows the series of mean observed wages at every age (the *observed* age-profile), against the series of predicted wages at every age, after controlling for selection (the *true* age profile), and the associated 95% confidence interval. The graphs on the left of the figure show result for men with high education, and those on the right for men with low education. The first row corresponds to the regressions for the whole sample within each education category, while the other two show results for the subsamples of individuals who have a DB and a DC pension, respectively.

We can see that for all groups represented in figure 3.7 the *true* wage profile lies above the *observed* one, and the difference between the two increases with age. This is suggestive of negative selection, whereby those workers with low values for the unobserved determinants of the decision to remain in the career job (e.g. those with a strong taste for (semi-)retirement) tend to have a higher unobserved component of wages. The results in table 3.2 confirm that the sample of career workers is indeed negatively selected. The coefficient on the inverse Mills ratio is negative for all groups, and it is significant at 1% in all subsamples except for low-education workers with a DB pension.

After controlling for selection, there is no statistical evidence of a decreasing age-wage profile for any of the education-and-pension categories. Most age-wage profiles actually appear to increase with age, even though the age dummies are only significant for individuals with low education when we pool all pension categories together. When low educated individuals with DB and DC pensions are considered separately, the coefficients on the age dummies are never statistically significant.

To summarize, we can reject declines in log hourly wages at every age before 67 for all the subsamples analyzed. Our results indicate that the negative trend observed in cross-sectional data is partly due to negative selection that stems from individuals with higher potential wages (after controlling for observables) tending to retire earlier; and partly due to composition effects that arise when pooling all the pension categories together.

Figure 3.7: Observed vs. Predicted Wage Profiles by Education and Pension Type



3.7 Conclusions

This chapter addresses the question of whether the declines in wages at older ages that have been described in previous papers set in while individuals are in the career job or only after they enter (semi-)retirement. We estimate separate wage regressions for different subsamples of career workers, defined according to their educational level and type of employer-provided pension. In each case, we control for self-selection out of the career job. For none of the categories considered do we find statistical evidence of a declining age-wage profile. We conclude that wage declines at older ages observed in cross-sectional data are explained partly by selection on unobservables (as workers with higher potential wages tend to retire earlier than those with lower ones), and partly by compositional effects resulting from workers with different pension types, and hence different average wages, retiring at different ages.

Our results are consistent with Lazear's model of deferred compensation and the forced-savings hypothesis. They are not inconsistent with the human capital model, but imply that any wage adjustments to accommodate declines in productivity, if present, happen only when worker enters the the retirement phase.

With regards to policy analysis, our results are key to the evaluation of policies aimed at raising the return to work at older ages. Several policy changes with this stated objective were introduced by the Social Security Administration in the last decade. Their aim is to keep individuals employed for longer, which would reduce the overall amount of benefits they draw from the system during their lifetimes, and hence contribute to its fiscal balance in the upcoming decades. The effectiveness of such policies depends on the incentives for individuals to remain on the job. Clearly, if they expect a declining wage profile, much stronger incentives from the Social Security will be needed to persuade them to remain on the job. Our findings are good news for the Social Security system, as they imply that wages will not decline for workers who choose to remain on the career job.

3.8 Appendix 2.A.Tables

Table 3.3: Summary Statistics

Men: High Education								
	All		None		DB		DC	
	GH	BH	GH	BH	GH	BH	GH	BH
Working full-time	0.51	0.25	0.31	0.13	0.55	0.38	0.59	0.35
		(0.000)		(0.000)		(0.000)		(0.000)
Full-time wage	2.88	2.61	2.45	2.25	2.96	2.78	2.93	2.63
		(0.000)		(0.162)		(0.021)		(0.059)
Age	59.31	60.40	59.59	59.93	59.12	60.71	59.32	60.89
		(0.000)		(0.213)		(0.000)		(0.000)
Married	0.86	0.79	0.79	0.73	0.86	0.85	0.89	0.84
		(0.010)		(0.181)		(0.673)		(0.429)
Ever self-employed	0.35	0.29	0.55	0.36	0.22	0.17	0.40	0.35
		(0.174)		(0.002)		(0.435)		(0.669)
Average bad health	0.06	0.60	0.11	0.69	0.05	0.55	0.05	0.45
		(0.000)		(0.000)		(0.000)		(0.000)
Initial Wealth	30.89	20.65	38.74	14.39	22.42	22.29	38.11	34.62
		(0.028)		(0.000)		(0.981)		(0.823)
Mother's education	2.57	2.28	2.50	2.32	2.58	2.22	2.62	2.32
		(0.000)		(0.112)		(0.002)		(0.048)
N	6,104	968	1,456	480	2,697	301	1,749	173
Men: Low Education								
	All		None		DB		DC	
	GH	BH	GH	BH	GH	BH	GH	BH
Working full-time	0.51	0.22	0.34	0.11	0.58	0.36	0.65	0.47
		(0.000)		(0.000)		(0.000)		(0.000)
Full-time wage	2.41	2.27	2.12	1.93	2.56	2.49	2.41	2.35
		(0.000)		(0.004)		(0.185)		(0.249)
Age	59.26	59.91	59.36	59.61	59.16	60.37	59.28	60.51
		(0.000)		(0.112)		(0.000)		(0.000)
Married	0.83	0.76	0.79	0.72	0.86	0.84	0.84	0.79
		(0.000)		(0.006)		(0.546)		(0.284)
Finished high-school	0.67	0.46	0.58	0.41	0.74	0.54	0.66	0.52
		(0.000)		(0.000)		(0.000)		(0.027)
Ever self-employed	0.25	0.16	0.42	0.19	0.15	0.10	0.17	0.11
		(0.000)		(0.000)		(0.246)		(0.244)
Average bad health	0.14	0.71	0.18	0.77	0.10	0.58	0.12	0.60
		(0.000)		(0.000)		(0.000)		(0.000)
Initial Wealth	14.90	7.75	16.91	7.03	14.81	8.91	12.43	9.27
		(0.000)		(0.000)		(0.134)		(0.246)
Mother's education	1.98	1.62	1.84	1.49	2.15	1.85	1.91	1.84
		(0.000)		(0.000)		(0.007)		(0.620)
N	6,685	3,160	2,391	2,011	2,644	674	1,506	441

NOTE. - p-values (in parentheses) for null hypothesis that means are the same across health status.

Table 3.4: Estimates of selection equation for no-pension category

	High Education	Low Education
age52	0.576*	-0.186
	(0.279)	(0.177)
age53	0.369	0.008
	(0.284)	(0.166)
age54	0.580*	-0.037
	(0.261)	(0.165)
age55	0.323	-0.104
	(0.253)	(0.164)
age56	0.239	0.039
	(0.251)	(0.163)
age57	0.436	-0.027
	(0.253)	(0.166)
age58	0.593*	-0.070
	(0.267)	(0.177)
age59	0.622*	-0.157
	(0.272)	(0.180)
age60	0.652*	0.005
	(0.282)	(0.186)
age61	0.495	-0.135
	(0.291)	(0.190)
age62	-0.016	0.067
	(0.199)	(0.147)
age63	0.061	0.003
	(0.200)	(0.142)
age64		
age65	0.095	0.373*
	(0.248)	(0.178)
age66	-0.100	
	(0.270)	
age67		0.136
		(0.202)
bad he	-0.249	-0.282*
	(0.132)	(0.072)
overERA	0.629*	-0.303
	(0.318)	(0.215)
overFRA	-0.127	-0.363
	(0.242)	(0.186)
wealth	-0.000	0.000
	(0.001)	(0.000)
mortg	0.052	0.176**
	(0.067)	(0.048)
wife62		-0.213**
		(0.075)
ins	0.110	-0.080
	(0.093)	(0.074)
hsch grad		-0.233**
		(0.049)
ever self	1.066**	0.285**
	(0.076)	(0.051)
bad he (av)	-0.551**	-0.937**
	(0.169)	(0.099)
wealth_0	-0.004**	-0.002*
	(0.001)	(0.001)
mother's ed	-0.048	-0.028
	(0.038)	(0.021)
constant	-0.680**	0.371*
	(0.245)	(0.149)
Sample size	1,936	4,402

NOTE. - Robust standard errors in parentheses. * indicates significance at 5%; ** indicates significance at 1%. All regressions include time dummies.

Table 3.5: Estimates of wage equation for no-pension category

	High Education	Low Education
age52	-0.472	0.061
	(0.366)	(0.144)
age53	-0.450	0.093
	(0.274)	(0.112)
age54	-0.454	0.093
	(0.358)	(0.120)
age55	-0.263	-0.046
	(0.269)	(0.118)
age56	-0.088	0.081
	(0.257)	(0.131)
age57	-0.394	0.114
	(0.315)	(0.132)
age58	-0.484	0.037
	(0.389)	(0.153)
age59	-0.568	-0.071
	(0.413)	(0.165)
age60	-0.750	0.029
	(0.454)	(0.176)
age61	-0.401	-0.054
	(0.402)	(0.183)
age62	-0.741	-0.121
	(0.503)	(0.236)
age63	-0.594	-0.201
	(0.518)	(0.244)
age64	-0.789	-0.163
	(0.542)	(0.291)
age65	-0.583	-0.130
	(0.539)	(0.305)
age66	-0.421	-0.345
	(0.536)	(0.445)
age67	-0.060	-0.005
	(0.671)	(0.440)
bad he	0.234	-0.131
	(0.186)	(0.136)
hsch grad		-0.070
		(0.125)
ever self	-0.878	0.250
	(0.598)	(0.145)
bad he (av)	0.248	-0.516
	(0.348)	(0.395)
wealth_0	0.006*	0.001
	(0.003)	(0.002)
mother's ed	0.080	0.101**
	(0.065)	(0.032)
Inverse Mills	-1.408	0.472
	(0.769)	(0.571)
constant	4.011**	1.571**
	(1.027)	(0.341)
Sample size	522	1,062
R^2	0.1273	0.1510

NOTE. - Standard errors (in parentheses) obtained from 2,500 bootstrap replications, accounting for estimation of inverse Mills ratio in first stage. * indicates significance at 5%; ** indicates significance at 1%. All regressions include time dummies.

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Chapter 4

Happy Together: A Structural Model of Couples' Joint Retirement Choices

4.1 Introduction

With the first baby-boomers reaching retirement age in 2010, a massive increase in US old-age population will be taking place during the next decade. Even under the most optimistic assumptions regarding future birth rates and immigration, a sharp rise is projected in the share of GDP devoted to Social Security and Medicare.[1] Different policies have been suggested in order to alleviate the budgetary burden, some of which, such as the progressive increase of normal retirement age up to 67 years of age, are already taking place. In this context, it is crucial that we understand how savings and employment decisions respond to changes in incentives during the years around retirement age. This will allow understanding and predicting the effects of policy changes and, more importantly, measuring the effects on old age well-being.

Most existing retirement models study the behavior of individuals -usually men. Many of these studies[2] analyze retirement within the framework of a structural model. A structural approach is particularly suited to the analysis of retirement decisions, given the complex financial incentives facing workers at the end of their careers. It is hard to summarize the high nonlinearity of pension accrual with age, for instance, in a measure that can be used in a reduced-form framework. Moreover, a structural approach captures the sequential nature of work and saving decisions, which are adjusted over time following the realizations of uncertain events. Uncertainty plays an increasing role at older ages, when the incidence of negative shocks to health, out of pocket medical expenditures, and survival is much larger than when individuals are young. Finally, the estimation of structural parameters allows to carry out counterfactual policy experiments, such as forecasting the impact of changes in social security rules on the retirement choices and wellbeing of workers affected by those changes.

A crucial fact about individuals approaching retirement is that the majority of them are married. According to the Health and Retirement Study (HRS) data, 78% of men aged 55 to 64 in 1992 were married or living with a partner. Structural models of men's

[1] Congressional Budget Office (CBO) "The Long-Term Budget Outlook 2009" http://www.cbo.gov/ftpdocs/ 102xx/doc10297/06-25-LTBO.pdf

[2] Gustmand and Steinmeier (1986), Blau (1994 and 2008), Rust and Phelan (1997), French (2005) and French and Jones (2007).

retirement have traditionally taken their wives' income as exogenous, and have ignored the wives' participation decision. While this may have been an appropriate approximation of reality in a time when the majority of women did not work, those strong restrictions are no longer valid. The typical household approaching retirement today is one where both husband and wife are employed. In the HRS, 70% of married men aged 55 to 64 in 1992 and 58% of their wives were working.

In the last 10 years we have seen the first structural models of couples' retirement decisions. These models acknowledge the role of both husband and wife as separate decision-making agents within the household, and represent each spouse's preferences with a separate utility function. The models of couples' retirement can be broadly divided in two groups. In the first group, models such as Blau and Gilleskie (2006) and Van der Klaauw and Wolpin (2008) concentrate on carefully modeling the environment in which couples make decisions and its effect on husbands and wives' choices through the shared budget constraint. Both these papers include a detailed specification of the social security rules, the rules associated to different types of health insurance coverage, and the stochastic processes for wages, health, and survival. Van der Klaauw and Wolpin also incorporate savings with limited borrowing and unobserved heterogeneity. Accounting for the presence of both husband and wife in the household improves in several respects on previous papers that also modeled carefully the environment in which men make decisions but abstracted from their wives' role (such as Rust and Phelan (1997), French (2005) and French and Jones (2007)). On the one hand, these papers have something to say about the behavior of women, and can study how they respond to their own incentives. On the other hand, they can more accurately model the household budget constraint: because both husband and wife provide income and share household wealth, they can potentially insure each other against shocks to wages, health, or medical expenditures. A model that does not consider the presence of a working wife may overestimate the risk facing men. Moreover, the social security spousal benefit implies that men whose wife qualifies for this program can substitute their wage upon retirement for up to 150% the amount of pension they would have otherwise received. Once, again a model where the participation status of the wife is not considered may underestimate these men's incentives to retirement.

The other group of models dealing with couples' retirement stems from the observation that a significant number of spouses retire within less than a year from each other, independently of the age difference between them[3]. The study of this phenomenon, known as joint retirement, led to a series of reduced-form studies (Coile (1999) and Banks et al. (2010)) that showed that the proportion of spouses retiring together is larger than financial incentives alone can explain, and suggested the existence of complementarities in spouses' preferences. In particular, if spouses enjoy spending time together, it is possible that they derive a higher value from being retired when their partner is retired too. This complementarity in leisure would give spouses incentives to coordinate their retirement decisions.

The main structural papers that have accounted for the role of leisure complementarities are Gustman and Steinmeier (2004) and Maestas (2001). They find that complementarities are crucial to explain coordination in spouses' choices. The main drawback of these studies is that they make strong simplifying assumptions regarding the financial and stochastic environment in which individuals make retirement choices. Specifically, they assume perfect capital markets and no uncertainty. However, studies of individual retirement have suggested that the existence of credit constraints before individuals become eligible for a Social Security pension may explain the high frequency of retirement at age 62 (Rust and Phelan (1997)); and they have shown the crucial role that uncertainty regarding future income, health costs, and survival plays in determining individual retirement outcomes (Rust and Phelan (1997), French (2005), French and Jones (2007), De Nardi et al. (2009 and 2010)). It is not clear a priori how these simplifying assumptions on the factors that determine individual retirements interact with the estimation of the complementarity parameters. In the presence of correlation of shocks across spouses, for instance, they may lead to overestimation of its magnitude.

This chapter aims to bridge the gap between the two strands of the literature on couples' retirement by estimating the effect of leisure complementarities on spouses' retirement timing within a rich dynamic model of participation and saving decisions that

[3]Evidence of joint retirement of US couples is found in the New Beneficiary Survey (Hurd (1990a)), the National Longitudinal Survey of Mature Women (Gustman and Steinmeier (2000)), the Retirement History Study (Blau (1998)) and the Health and Retirement Study (Michaud (2003)). Banks, et al. (2010) find evidence of joint retirement of couples from the English Longitudinal Study of Ageing.

carefully accounts for the main financial incentives and sources of uncertainty facing older couples. The model includes a detailed specification of the social security rules, allows for limited borrowing, and accounts for uncertainty in future wage income, out of pocket medical expenditures, and survival. Each spouse's preferences are represented by their own utility function, and the substitutability between consumption and leisure is not constrained to being equal for husband and wife. Individuals within and across couples are heterogeneous in the persistent component of their wage offers, which is estimated from the data. In order to capture leisure complementarities, each spouse's utility is allowed to depend on the partner's participation status.

The model is estimated using a subsample of older individuals from the Health and Retirement Study (HRS). Estimation results show that leisure complementarities are positive and significant, and account for up to 8 percent of observed joint retirements. The social security spousal benefit is found to account for an extra 13 percent of them. These results imply that incentives for joint retirement play a crucial role in determining individual choices. Since these incentives cannot be captured in a model that takes one spouse's behavior as exogenous, this suggests that individual models of retirement are no longer an appropriate approximation of the average household's behavior, given the increasing number of working couples approaching retirement age.

The rest of the chapter is organized as follows: section 4.2 presents an overview of the main incentives to retirement facing individuals and couples, and how these are captured in the theoretical model. Section 4.3 describes the theoretical model. Section 4.4 reviews the procedure used to solve and estimate a stochastic, dynamic, Markov process with both discrete and continuous controls. Estimation results for the laws of motion of the exogenous variables are presented in section 4.5, and for the preference parameters in section 4.6. Section 4.7 concludes.

4.2 Overview

The objective of this chapter is to disentangle the role of financial incentives versus leisure complementarities in explaining joint retirements, that is, the observed tendency of spouses to retire within a short time from each other. In order to do this, I develop and estimate a structural model of couples' saving and retirement choices.

So as to accurately measure the share of joint retirements occurring in response to financial incentives, the model must replicate in a precise way the environment in which couples make participation and saving decisions. This section describes this institutional environment, which agents are assumed to take as given. It discusses the main incentives the regulatory environment gives for individuals to retire at specific ages and for couples to retire together. The section also explains how this environment leads to the choice of estimation sample.

4.2.1 Incentives to retirement from the individual perspective

One of the most important predictions of the life-cycle model is that households will accumulate assets through their working life in order to finance retirement. Given that the interest of this study is in older couples, we would expect most of them to have accumulated a significant amount of wealth by the time they are first observed, already in their fifties. Nevertheless, 55% of the couples interviewed in the first survey wave report a net value of financial wealth -which excludes housing wealth- of less than $10,000. Unless all these couples intend to use their primary residence to finance their retirement, it would seem that their savings are far too low to support them into old age. Financial savings, however, are only one of the several possible ways to finance retirement. The role of alternative sources of retirement funds, and the incentives for retirement at particular ages provided by each of them, is considered below.

Social Security

Social Security benefits represent a source of retirement income for most of the older population. In 2005, 90% of individuals aged over 65 received benefits from the Social Security, and for 65% of elderly households these benefits represented more than half their income[4].

Figure 4.3 in appendix 3.D shows the distribution of retirement ages for men and women between ages 51 and 70. The spikes in retirements at ages 62 and 65, which have been extensively documented in the literature, are noticeable for both genders. Part of the

[4]Social Security Administration. "Fast Facts & Figures About Social Security, 2007" http://www.ssa.gov/policy/docs/chartbooks/fast_facts/2007/fast_facts07.pdf

explanation for these spikes has been attributed to the Social Security rules, explained in detail in section 4.3.7 (Gustman and Steinmeier (1986), Rust and Phelan (1997), French (2005)).

The Social Security rules are carefully captured in the theoretical model in section 4.3. So as to simplify the dynamic program, however, the decision to apply for Social Security benefits is not considered explicitly. Instead, it is assumed that individuals start claiming the first year they are observed out of work after age 62. Figures 4.5 and 4.6 in appendix 3.D use the Social Security records of HRS respondents to compare the actual claiming age with the one assumed in the model. The two series are very close for men. For women, the assumed Social Security claiming date overpredicts the peak at age 62[5]. On the whole, however, the approximation seems quite reasonable.

Private Pensions

An important source of incentives to retirement are private pensions. In particular, defined benefit (DB) pensions give strong incentives to retirement at specific ages: after a certain number of years of service in a firm, or past the early or normal retirement ages, the rate of pension accrual is greatly reduced and can even become negative. For a large proportion of DB pension holders, these incentives are likely to dominate those provided by Social Security provisions (Lumsdaine et al. (1994)). Benefits from defined contribution (DC) pensions, on the other hand, are typically determined only by the amount of assets accumulated in the plan at the time of retirement, and they provide no specific incentives that encourage or discourage retirement at specific ages (Lumsdaine et al. (1996)). Nevertheless, most DC pensions, such as 401(k) plans or IRAs, specify an earliest withdrawal age. Withdrawing benefits from the plan before this age is strongly penalized. This may lead liquidity-constrained individuals to remain in work while their money is locked up in their DC pension plan.

Figure 4.7 in appendix 3.D shows retirement frequencies as a function of age for men with different pension types. It is clear that DB pension holders are much more likely than DC ones to retire before the Social Security incentives kick in at age 62. Moreover, part

[5]The discrepancy is mainly due to a significant proportion of women who start receiving benefits before the age of 62. It is possible for a non-disabled woman to claim benefits at age 60 or before in exceptional circumstances. She should be a widow who has not remarried or taking care of young children.

of the exit frequencies at ages 62 and 65 for individuals with a DB pension are likely to be due to their pension plan's characteristics, rather than Social Security provisions: the most common ages in the distribution of normal retirement ages for DB pension holders are 65 and 62, followed by 55, and the rest distributed between 56 and 60. The most common early retirement ages are 62 and 55 (Karoly et al. (2007)).

The tendency of DB pension holders to retire early is confirmed by table 4.4 in appendix 3.E, which shows descriptive statistics for men and women group by their type of pension coverage: Men who have a DB pension plan are 17 percentage points less likely than DC plan holders to be employed by the time they become entitled to Social Security benefits at age 62.

Figure 4.8 in appendix 3.D shows retirement frequencies for women, by pension type. Even though the difference is not so noticeable as for men, DB pension holders are still more likely to retire before the age of early Social Security entitlement than DC pension holders. According to table 4.4, women who have a DB pension plan are 6 percentage points more likely than those who have a DC pension plan to have retired by the time they become 62.

Introducing private pension incentives into a dynamic model implies adding a sufficient number of state variables to describe pension characteristics. In the case of DB pensions, these variables would have to include the early and/or normal retirement age, a measure of job tenure, and the wage. In a model of couples such as the one presented in section 4.3, separate state variables would have to be added for men and women, and this would render the programme computationally intractable.

Ignoring the role of DB pensions, on the other hand, would disregard an important retirement incentive. Using the sample of DB pension holders to estimate a model that does not account for DB provisions would create problems in fitting the behavior of those who retire before age 60 upon reaching their plan's early retirement age -and in the absence of any health, health cost or wage shock. Moreover, the model would likely attribute to Social Security incentives the retirement exits of individuals whose DB-plan early or normal retirement ages are 62 and 65.

In order to maintain a computationally-tractable number of state variables while still accounting for the main incentives to retirement of the individuals in the sample, I restrict the estimation sample to couples with no private pension or one or more DC plans. DC pension holdings are treated in the model as part of household wealth. While this can be a reasonable approximation for non-liquidity constrained individuals, it is possible that a minority of DC pension holders who would have otherwise retired may be obliged to remain in work until the earliest age at which their DC pension funds become available. The high participation rates of men past age 59 suggest that this is not likely to be an issue, while very few women in the sample have a substantial amount of assets in a DC plan.

A more important concern is the special tax treatment of DC plans. Most DC pension plans allow workers to defer income taxes on plan contributions until withdrawal. The tax-deferred nature of DC-plans is not accounted for in the model, which may lead to the corresponding increase in couples' willingness to save being wrongly attributed to other causes. This will be less of a problem to the extent that the incentives to save in a 401(k) crowd out rather than build on top of other types of savings.

Couples with no private pension and those where one or both of the spouses have a DC pension are considered together in the estimation sample in order to attain a reasonable sample size. It is important, though, to bear in mind that individuals who have no private pension have quite different characteristics from those with a DC plan. Table 4.4 in appendix 3.E shows that they tend to belong to poorer households, have worse health, less education and lower wages. The key assumption that allows to model these two groups together is that none of them face incentives from a pension plan to retire at particular ages. The model in section 4.3 is rich enough to account for other observable and unobservable differences between the two: differences in health, wages and household wealth are captured through the initial conditions for these variables. Part of the effect of education and unobservable characteristics such as ability is captured through the initial draw for the wage error term and the initial value of wealth.

Health Insurance

A source of incentives to retirement often considered in the literature is the type of health insurance coverage. Gustman and Steinmeier (1994), Rust and Phelan (1997), Blau and Gilleskie (2006), French and Jones (2007), and Van der Klaauw and Wolpin (2008) distinguish three types of individuals according to the type of health insurance coverage: those whose health insurance is tied to their job, and would lose their coverage if they retired -i.e. individuals with "tied" coverage-; those who can keep their health insurance even if they retire from their job before age 65 -individuals with "retiree" coverage-; and those with no work-related health insurance. They argue that individuals with tied coverage will have stronger incentives to remain in work until they become eligible for government-provided Medicare coverage at 65 than those with retiree or no coverage. Gustman and Steinmeier and Blau and Gilleskie find that the effect of health insurance on retirement behavior is small. Rust and Phelan find that the effect is large for the subsample of individuals without a private pension. However, their model ignores the role of savings as insurance against medical shocks, and is thus likely to overestimate the importance of health insurance. Finally, French and Jones estimate a dynamic model with savings and participation decisions using the HRS data and find that individuals whose health insurance is tied to the job leave the labor force on average half a year later than workers with retiree coverage.

None of these studies models explicitly the relationship between health insurance and pension type. However, it can be seen from table 4.4 that there is a correlation between the two: individuals with no pension are the most likely to have no health insurance; individuals with a DB pension plan are the most likely to have retiree coverage; and individuals with DC pension plans are the most likely to have tied coverage. In their paper, French and Jones acknowledge this correlation, but do not control separately for health insurance and pension type. Instead, given that people with retiree coverage are the most likely to have a DB plan, French and Jones assign to them the sharpest drops in pension accrual after age 59. In this way, they compound the effect of health insurance and pension type, and thus it is not clear what part of the later retirements of people with tied coverage is due to the type of health insurance, and what part is due to them being more likely to have a DC pension (which offers no incentives for early retirement, unlike the usual DB plan).

In the absence of a model that explicitly accounts for pension type, I choose not to control for health insurance type either. I therefore ignore any incentives that individuals with tied coverage may have to remain in work for longer than the rest. The estimate of French and Jones that those with retiree coverage and a DB pension retire half a year earlier than those with tied coverage and a DC pension is likely to be an upper bound on the effect of health insurance for individuals in my estimation sample, given that I drop all observations with a DB pension plan.

4.2.2 Incentives to retirement from the couple's perspective

A growing share of the retirement literature characterizes retirement as a decision concerning the couple, rather than the individual (Gustman and Steinmeier(2004), Blau and Gilleskie (2004), Coile (2004a, 2004b), Michaud (2003), Michaud and Vermeulen (2004)). This follows the observation that a significant share of spouses retire within less than one year of each other, independently of the age difference between them. Evidence of this phenomenon, known as joint retirement, has been found in surveys dealing with couples from several generations and countries, such as the New Beneficiary Survey (Hurd (1990a)), the National Longitudinal Survey of Mature Women (Gustman and Steinmeier (2000)), the Retirement History Study (Blau (1998)), the Health and Retirement Study (Michaud (2003)), and the English Longitudinal Study of Ageing (Banks, Blundell and Casanova (2007)).

Figure 7 shows the distribution of differences in retirement dates[6] for HRS couples whose members have retired by the year 2006. The sample used to draw each graph is selected according to the age difference between spouses.[7] The first graph shows the distribution of retirement date differences for couples where the husband is at least one year younger than the wife; the second graph shows couples where the husband is the same age as the wife; and so on. In all of the 6 graphs, the highest frequency corresponds to a retirement date difference of zero, that is, to spouses retiring on the same calendar year.

There are two main channels that link spouses' retirement decisions.[8] The first one

[6]The difference in retirement dates is defined as the husband's retirement date minus the wife's retirement date. Hence positive values indicate that the husband retired at a later calendar date than the wife.

[7]Age difference is defined as age of the husband minus age of the wife.

[8]A third potential cause of joint retirement that has been proposed in the literature is a correlation in

operates through the household budget constraint, and the second one comes directly from the preferences. The fact that spouses share resources through the household budget constraint can sometimes increase but also decrease the distance between their retirements. Consider, for instance, a couple of the same age where the husband intends to retire at age 65 and the wife intends to retire at age 62. A negative shock to the husband's wage the year his wife becomes 62 may lead her to keep working for one more year in order to compensate the decrease in total household income. This would result in both spouses retiring closer together. For a similar couple, the wife's retirement at 62, with the corresponding replacement of her wage by a (in almost every case) lower pension, would have an income effect on the husband, who may decide to work for one more year -hence increasing the distance between their retirement dates.

The Social Security rules offer some further cross-spouse incentives that also operate through the budget constraint. The Social Security spousal benefit establishes that the spouse with lower lifetime earnings -usually the wife- is entitled to the highest between her own pension and (up to) one half of her husband's full pension once both of them are retired. This increases the incentives to retirement for men whose wife qualifies for the benefit, as they will be replacing their wage with a pension that can be up to 50% higher than it would have been in the absence of the benefit. Since most wives with low accumulated earnings -and therefore a small amount of work experience- usually retire much earlier than their husband, the spousal benefit is likely to be one of the channels leading spouses to retire close to each other.

The second channel linking retirement decisions operates through the spouses' preferences: it is possible that husband and wife enjoy spending time together, which would mean that each one of them derives utility from sharing their retirement with their partner.

This chapter attempts to estimate the effect of leisure complementarities after appro-

spouses' unobserved taste for leisure. This correlation would increase the number of joint retirements in couples where husband and wife are the same age. In those cases, sharing a preference for early retirement would likely lead both husband and wife to stop working as soon as the option becomes financially viable -usually when qualifying for Social Security benefits at age 62. However, the effect of this correlation would not necessarily increase joint retirements of couples of different ages. If the husband is, say, 5 years older than the wife, and both of them want to retire as soon as it becomes financially affordable, the fact that he is eligible for Social Security benefits 5 years before his wife would likely lead to him retiring earlier than her. While it is unlikely that varying unobserved tastes for leisure play a large role in determining joint retirement, they likely remain a determinant of individual retirement timing.

priately controlling for the effects of financial incentives and uncertainty. The chapter bridges the gap between two strands of the couples' retirement literature: the one that focuses on accurately modeling the budget constraint and stochastic processes (Blau and Gilleskie (2006), Van der Klaauw and Wolpin (2008)) and the one that underlines the role of complementarities in leisure (Gustman and Steinmeier (2004), Maestas (2001)). The empirical results allow to compare the relative role of incentives that operate mainly through the budget constraint versus leisure complementarities as determinants of the large number of joint retirement observed in the data.

4.3 Theoretical Model

This section describes a dynamic stochastic model of labor supply and saving choices of households close to retirement age. Each household consists of two spouses ("husband" and "wife") with their own preferences. The model captures the sequential nature of the decision-making process, with households adjusting their behavior in every period as the uncertainty regarding spouses' wages, survival and medical expenditures unfolds.

At each discrete period t, given initial assets and husband and wife's wages and average lifetime earnings[9], households choose optimal consumption and spouses' participation status in order to maximize the expected discounted value of remaining lifetime utility.

Retirement status is defined as a function of the participation decision: a spouse who chooses not to participate in a period when he is above the social security early retirement age (ERA) is referred to as "retired". Retirement is not an absorbing state, as retired individuals can go back to work in any future period. Spouses' decisions to apply for social security benefits are not modeled separately from the participation decision. Individuals are assumed to start receiving social security pension benefits the first period in which they choose not to work after ERA. Benefit claiming is an absorbing state: social security entitlement is determined the first time individuals claim benefits, and it is not possible for them to accrue more pension in future periods, even if they go back to work.

The agents in the model are married couples who stay married until one or both spouses die. Decisions of widowed individuals are not explicitly modeled.

[9] Average lifetime earnings is the main variable used to determine pension entitlement at retirement.

4.3.1 Choice Set

At each discrete period t, households make both discrete choices -both spouses' participation status- and continuous ones -household consumption and savings.

It is useful to formalize the model explicitly separating continuous and discrete choices assuming, without loss of generality, that households make decisions in two steps: first, they make the discrete choices, that is, whether each of the spouses will work full time, part time or not at all. Then, they choose optimal household savings *conditional* on the discrete alternative.

Both types of choices are described in detail below. For ease of exposition, I will talk about the "husband" or "wife"'s choices when referring to household decisions concerning one of the spouses' variables, such as his or her hours of work. However, all decisions are made by the household, which acts as a sole individual who maximizes a unique welfare function.

Discrete choices

The discrete choice variables are each spouse's participation. As mentioned above, non-participation is not an absorbing state, and individuals can always go back to work after periods of inactivity. Therefore, the variables indicating participation status, P_t^i, can take on the values FT, PT or 0 in all periods:

$$\begin{cases} P_t^j = FT & \text{if spouse } j \text{ works full time in period } t \\ P_t^j = PT & \text{if spouse } j \text{ works part time in period } t \\ P_t^j = 0 & \text{if spouse } j \text{ does not work in period } t \end{cases}$$

where the superscript $j = m, f$ identifies the spouse, m being the husband or "male", and f being the wife or "female".

$\mathcal{D}^j$ is the set of discrete alternatives available to spouse j each period. It is defined as:

$$\mathcal{D}^j = \{PT, FT, 0\}, \qquad \text{for } j = m, f,$$

The set of 9 discrete alternatives available to the household each period is $\mathcal{D} = \mathcal{D}^m \times \mathcal{D}^f$. Elements of $\mathcal{D}$ are of the type $d = (d^m, d^f)$, where d^m refers to the husband's participation status, and d^f to the wife's. For example, $d_t = (PT, 0)$ indicates that the husband works part time and the wife does not work in period t.

Continuous choices

In each period t, households optimally choose savings, s_t, conditional on the discrete action d_t.

$\mathcal{C}_t$ is the choice set for the continuous control conditional on the discrete alternative d_t and the state spaces z_t and ε_t (described in section 4.3.2 below):

$$s_t \in \mathcal{C}_t(z_t, \varepsilon_t; d_t) \subset R_+$$

4.3.2 State Space

The state space in period t consists of variables that are observed both by the agent and the econometrician, and variables that are observed by the agent, but not by the econometrician. The vector of observed state variables is the following:

$$z_t = \{A_t, E_t^m, E_t^f, w_t^m, w_t^f, B_{t-1}^m, B_{t-1}^f, age_t^m, age_t^f\},$$

where A_t are household assets at the beginning of period t, E_t^j is a measure of spouse j's lifetime accumulated earnings, w_t^j is spouse j's hourly wage, B_{t-1}^j an indicator of whether spouse j has started claiming benefits before period t and age_t^j is spouse j's age in years.

The unobserved state variables are a vector of utility shocks associated to the discrete alternative chosen by the household:

$$\varepsilon_t = \{\varepsilon_t(d_t) | d_t \in \mathcal{D}\},$$

where $\varepsilon_t(d_t)$ affects the utility derived from alternative d at time t. The value of the vector ε_t is known by the agent when making decisions in period t.

4.3.3 Preferences

Household utility in period t is defined as the weighted sum of each spouse's utility plus an unobserved component, $\varepsilon_t(d_t)$, associated to the discrete choice and assumed known by the household:

$$U(d_t, s_t, z_t, \varepsilon_t, \theta_1) = \phi \; u^m(c_t, l_t^m) + (1-\phi)u^f(c_t, l_t^f) + \varepsilon_t(d_t), \tag{4.3.1}$$

where ϕ represents some household sharing rule assumed constant in time and θ_1 is the vector of preference parameters.

Within-period utility for each spouse, u^j, is assumed non-decreasing and twice differentiable in consumption, c_t , and own leisure, l_t^j. In the empirical part of the chapter, the function u^j is assumed to take the following form:

$$u^j \left(c_t, l_t^j; z_t, \theta_1 \right) = \frac{1}{1-\rho} \left(c_t(d_t)^{\alpha_1^j} l_t^j(d_t)^{(1-\alpha_1^j)} \right)^{(1-\rho)},$$

where ρ is the coefficient of relative risk aversion and α_1^j determines the share of consumption in spouse j's utility function.

Individual leisure, l_t^j, is given by:

$$l_t^j = L - h^j(d_t^j) + \alpha_2 I\{d_t^j = 0, d_t^k = 0\}, \quad \text{for } j \neq k,$$

where L is the leisure endowment and h^j the number of work hours associated to participation status d_t^j (see section 4.5.1). The indicator function multiplying the coefficient α_2 is equal to 1 when both spouses are out of work. This term is intended to capture the type of leisure complementarities found by Coile (2004a) and Banks et al. (2010), whereby spouses enjoy their retirement more when their partner is retired too. A positive (negative) α_2 will provide evidence of complementarity (substitutability) in spouses' leisure.

4.3.4 Budget Constraint

Households receive income from different sources: asset income, rA_t; husband's labor income, $w_t^m h_t^m$; wife's labor income, $w_t^f h_t^f$; husband and wife's social security benefits, ssb_t^m and ssb_t^f; and government transfers T_t. Post-tax resources are allocated between household consumption, c_t, and savings, s_t. The budget constraint can be written as:

$$c_t + s_t = A_t + Y(rA_t,\ w_t^m h_t^m,\ w_t^f h_t^f,\ \tau) + B_t^m \times ssb_t^m + B_t^w \times ssb_t^f + T_t, \tag{4.3.2}$$

where Y is the level of post-tax income, r is the interest rate, τ is the tax structure, w_t denotes the hourly wage rate (described in section 4.3.5), ssb_t denotes Social Security benefits (described in section 4.3.7), and T_t are government transfers (described below).

Next period's assets are determined by subtracting out-of-pocket medical, hc_t, from household assets. Hence the asset accumulation equation is:

$$A_{t+1} = s_t - hc_t, \tag{4.3.3}$$

Households cannot borrow against future labor of Social Security income. This is reflected in the following borrowing constraint:

$$s_t \geq 0$$

The borrowing constraint implies that the household net worth at the beginning of a period can be negative if the realization of health costs exceed savings[10].

Following Hubbard et al. (1995), government transfers are parameterized as:

$$T_t = \min\left\{c_{\min},\ \max\{0,\ c_{\min} - (A_t + Y_t + ssb_t^m + ssb_t^f)\}\right\}$$

Transfer payments guarantee a minimum amount of resources for the household in every period equal to $c_{\min}$. The transfer function captures the penalty on saving behavior that means-tested programmes such as Medicaid, Supplemental Security Income (SSI) or food stamps impose on low-asset households.

[10] French and Jones (2007) argue this is a reasonable assumption in view of the number of HRS households who report medical expense debt.

4.3.5 Wage Process

The logarithm of wages if modeled as a function the number of hours worked, observable state variables and a persistent error component:

$$\ln w_{it} = \varsigma h_{it}(d_t^i) + Z_{it}\beta^j + \upsilon_{it} \tag{4.3.4}$$
$$\upsilon_{it} = \upsilon_{it-1} + \zeta_{it}$$
$$\zeta_{it} \sim iid$$

The parameter ς is intended to capture the wage penalty associated to working part time. The estimation of the vector of coefficients β and the variance of the shocks to the persistent component is carried out separately for men and women and described in detail in section 4.5.2.

Involuntary unemployment is not considered, that is, in each period every individual receives a wage offer given by 4.3.4. In this context, shocks to wages can be interpreted as shocks to productivity.

4.3.6 Out of Pocket Medical Expenditures

Household i's out-of-pocket medical expenditures, hc_{it}, are modeled as a function of spouses' ages plus a random term ψ_{it}:

$$\ln hc_{it} = hc(age_{it}^m, age_{it}^f + \psi_{it}, \tag{4.3.5}$$
$$\psi \sim N(0, \sigma_\psi^2)$$

4.3.7 Social Security Benefits

The Social Security system provides disincentives to work past certain ages. The strength of the incentives can be a function of household characteristics -such as as wealth or the relative level of lifetime earnings between husband and wife-, as discussed below.

The level of Social Security benefits, ssb_t, is determined from a worker's lifetime earnings in several steps.[11] First, annual earnings are indexed to account for changes in the national average wage, and the 35 highest years of earnings are used to compute the average indexed monthly earnings (AIME). Appendix 3.B describes the computation of the variable E_t, which approximates AIME.

Second, a formula is applied to AIME to obtain the primary insurance amount (PIA). This formula is weighed in favor of relatively low earners, so that the replacement rate falls as the level of earnings rises.

Third, the PIA is adjusted according to the worker's age when claiming benefits for the first time. Individuals claiming at age 65 receive the full PIA. For every year between ages 65 and 70 that benefit application is delayed, future benefits rise by the equivalent to 5.5% per year. This rate is less than actuarially fair, and therefore generates an incentive to draw benefits by age 65. For every year before age 65 the individual applies for benefits, these are reduced by 6.7%, which is roughly actuarially fair. Individuals are ineligible to receive a Social Security pension before age 62. This gives individuals with low wealth an incentive to remain in work until that age.

Once a worker has claimed benefits, these will be paid for life. Benefits are adjusted every year for increases in the CPI.

Individuals who claim benefits and keep working are subject to the Social Security earnings test. If the labor income of a beneficiary below age 65 exceeds a threshold level of $7,440, benefits are taxed at a 50% rate. For beneficiaries aged between 66 and 70 who earn more than $10,200, benefits are taxed at a 33% rate. For every year of benefits taxed away, future benefits are increased by 6.7% for workers aged between 62 and 65 and by 4% for those aged from 65 to 70. Again, this is far from actuarially fair, and hence a further disincentive to work beyond age 65.

An important feature of the Social Security program is the structure of dependent benefits. Spouses are entitled to a benefit equal to up to one half of their partner's PIA (reduced if either the worker or the spouse claims benefits before 65) if this is higher than the benefit they would get based on their own record. The spousal benefit only becomes

[11] This section describes the Social Security rules that were in place in the year 1992. See the *Annual Statistical Supplement to the Social Security Bulletin* for subsequent years for information on changes to these rules.

available once the spouse reaches age 62 and the worker has claimed benefits. The majority of spousal benefit beneficiaries are women. The rule may give some men incentives to bring forward their claiming date in order to provide their wife with a pension once she becomes 62, leading to correlations in spouses' retirement decisions. Finally, widows or widowers are entitled to a benefit equal to the deceased spouse's PIA (reduced if either the worker or the deceased spouse claimed benefits before age 65), whenever this is higher than the benefit they would get based on their own record.

The formulae used to approximate Social Security benefits in the model, which take into account the features of the system just outlined, are described in detail in appendix 3.B.

4.3.8 Survival Probabilities

Survival rates are a function of age and sex. In particular, the probability that an individual who is alive in period t survives to period $t+1$ is:

$$s^j_{t+1} = s(age^j, j), \qquad j \in \{\text{m,f}\}$$

4.3.9 Terminal Value Functions and Bequest Function

Upon death of one spouse, the behavior of the surviving partner is not modeled. Their remaining lifetime utility is represented by the terminal value functions B^f or B^m -depending on whether the wife or the husband survives:

$$B^j(z_t) = \theta_j \frac{(W^j_t)^{\alpha_1(1-\rho)}}{(1-\rho)} \qquad j = m, f,$$

where W is the present discounted value of retirement wealth for the surviving spouse, computed as the sum of assets available upon the death of the spouse plus the present discounted value of the surviving spouse's Social Security benefit, which are equal to the highest between their own benefits and those of the deceased partner:

$$W^j_t = A_t + PDV_t(max(ssb^j_t, ssb^k_t)) \qquad j, k = m, f, \text{ and } j \neq k$$

If none of the spouses reaches period t alive, the household derives utility from assets bequeathed to survivors, A_t. The bequest function has the following form:

$$B^b(A_t) = \theta_b \frac{(A_t + K)^{\alpha_1(1-\rho)}}{(1-\rho)},$$

where K measures the curvature of the function. $K = 0$ implies an infinite disutility of leaving non-positive bequests, while for $K > 0$ the utility of a zero bequest is finite.

4.4 Model Solution

The objective of the paper is to use the observed realizations of household choices and states, $\{d_t, s_t, z_t\}$, to estimate the vector of unknown parameters $\theta = (\theta_1, \theta_2, \theta_3)$, which includes preference parameters, θ_1, and the parameters that determine the data generating process for the state variables, $(\theta_2,\ \theta_3)$.

It follows from the description in section 4.3 of the laws of motion for the state variables that households' beliefs about uncertain future states can be represented by a first-order Markov probability density function. There is an extensive literature dealing with the solution and estimation of stochastic Markov programs, but both the theoretical work and subsequent applications focus on discrete decision processes.[12] As the model described in the previous sections features both discrete (participation status) and continuous (savings) decisions, below we show how the solution procedure for discrete Markov processes introduced by Rust (1987, 1988) can be extended to account for the continuous control.

4.4.1 Optimization Problem

In order to solve the finite-horizon Markovian decision problem, households choose a sequence of decision rules $\Pi = \{\pi_0, \pi_1, ..., \pi_T\}$, where $\pi_t(z_t, \varepsilon_t) = (d_t, s_t)$, to maximize expected discounted utility over the lifetime. The value function is defined as[13]:

[12] see Eckstein and Wolpin (1989), Rust (1994), Miller (1997) and Aguirregabiria and Mira (2010) for surveys on the estimation of dynamic discrete choice models and Rust and Phelan (1997), Hotz and Miller (1993), Keane and Wolpin (1997) and Gilleskie (1998) for applications with discrete choice sets.

[13] For ease of exposition, the survival probabilities of both spouses are set equal to 1 in the description of the model solution.

$$V_t(z_t, \varepsilon_t, \theta) = \sup_{\Pi} E\left\{\sum_{j=t}^{T} \beta^{j-t}\left[U(d_t, s_t, z_t, \varepsilon_t, \theta_1)\right] \mid z_t, \varepsilon_t, \theta_2, \theta_3\right\}, \tag{4.4.1}$$

where the expectation is taken with respect to the controlled stochastic process $\{z_t, \varepsilon_t\}$, with probability distribution given by:

$$f(z_{t+1}, \varepsilon_{t+1}|z_t, \varepsilon_t, d_t, s_t, \theta_2, \theta_3) \tag{4.4.2}$$

Since this is a finite horizon problem, the feasible set of household choices is compact, and the utility function continuous, the value function $V_t(z_t, \varepsilon_t, \theta_1)$ defined in 4.4.1 always exists and is the unique solution to the Bellman equation given by:

$$V_t(z_t, \varepsilon_t, \theta) = \max_{d_t, s_t}\left[U(d_t, s_t, z_t, \varepsilon_t, \theta_1) + \beta EV_{t+1}(z_{t+1}, \varepsilon_{t+1}, d_t, s_t, \theta)\right], \tag{4.4.3}$$

where

$$EV_{t+1}(z_{t+1}, \varepsilon_{t+1}, d_t, s_t, \theta) = \int_y \int_\eta V_{t+1}(y, \eta) f(dy, d\eta|z_t, \varepsilon_t, d_t, s_t, \theta_2, \theta_3) \tag{4.4.4}$$

Solving for the optimal controls d_t and s_t in 4.4.3 requires solving a highly-dimensional problem. The presence of ε_t as a state variable adds 9 dimensions to the state space, and since it enters nonlinearly the function EV_{t+1}, 9-dimensional integrals need to be solved to integrate it out. The following assumption, which is key in the framework developed by Rust (1988) for the solution and estimation of discrete Markov processes, simplifies the solution of the household problem considerably[14]:

Conditional Independence Assumption (CI): The conditional probability density function for the state variables factors as

$$f(z_{t+1}, \varepsilon_{t+1}|z_t, \varepsilon_t, d_t, s_t, \theta_2, \theta_3) = q(\varepsilon_{t+1}|z_{t+1}, \theta_2) g(z_{t+1}|z_t, d_t, s_t, \theta_3)$$

CI implies two restrictions on the serial dependence of observable and unobservable

[14]The CI assumption has been widely used in the literature. See Rust (1994) and Aguirregabiria and Mira (2010) for a review.

states. First, z_{t+1} is a sufficient statistic for ε_{t+1}, which implies that any statistical dependence between ε_t and ε_{t+1} is transmitted entirely through the vector of observed states z_{t+1}. Second, the probability density of z_{t+1} depends only on z_t and not on ε_t.

Next, we make an assumption on the functional form of the density of ε. In particular, $q(\varepsilon|z, \theta_2)$ is a multivariate extreme value distribution:

$$q(\varepsilon|z, \theta_2) = \prod_{k \in \mathcal{D}} \exp\{-\varepsilon(k) + \theta_2\} \exp\{-\exp\{-\varepsilon(k) + \theta_2\}\},$$

where $\theta_2 = \gamma = 0.577216$ is Euler's constant.

Under the CI assumption and the extreme value distribution assumption, the integral EV_{t+1} with respect to ε_{t+1} has a closed-form solution. This eliminates the need to evaluate the 9-dimensional integrals numerically, and hence renders the problem computationally tractable. In what follows we drop ε_{t+1} from the conditioning set for EV_{t+1} to indicate that it has been integrated out using the functional form restrictions.

Substituting for the specification of the utility function given in 4.3.1 we can now re-write the Bellman equation as a two-stage problem:

$$V_t(z_t, \varepsilon_t, \theta) = \max_{d_t} \left[\max_{s_t} \left[u(k, s_t, z_t, \theta_1) + \beta EV_{t+1}(z_{t+1}, k, s_t, \theta) | d_t = k \right] + \varepsilon_t(d_t) \right], \quad (4.4.5)$$

where $u(d_t, s_t, z_t, \theta_1) \equiv \phi\, u^m(c_t, l_t^m) + (1 - \phi) u^f(c_t, l_t^f)$. Proceeding backwards, the solution for the optimal controls d_t and s_t can be computed in two stages: first, optimal savings are computed *conditional* on each discrete participation choice (inner maximization). Second, the discrete option that yields the highest value given the draw of the unobservable state is chosen by the household (outer maximization).

The solution of the inner maximization yields the vector of choice-specific value functions $r(z_t, \theta) \equiv \{r(z_t, k, \theta) \mid k \in \mathcal{D}\}$, where $r(z_t, k, \theta)$ represents the indirect utility function associated to the household participation status k:

$$r(z_t, k, \theta) = \max_{s_t} \{[u(k, s_t, z_t, \theta_1) + \beta EV_{t+1}(z_{t+1}, k, s_t, \theta)] \mid d_t = k\} \quad (4.4.6)$$

The outer maximization is a random utility model:

$$\max_{d_t}\{r(z_t, d_t, \theta) + \varepsilon_t(d_t)\} \tag{4.4.7}$$

As discussed in Rust (1987), 4.4.7 differs from the static random utility model (McFadden (1973, 1981)) through the addition of the term $EV_{t+1}(z_{t+1}, k, s_t, \theta)$ to the static utility $u(k, s_t, z_t, \theta_1)$ in the choice-specific value functions (4.4.6). The presence of the continuous control s_t adds a discrete-choice-specific maximization to Rust's framework.

Under the assumption that ε follows an extreme value distribution, the conditional choice probabilities are given by the multinomial logit formula:

$$P(k|z_t, \theta) = \frac{\exp\{r(z_t, k, \theta)\}}{\sum_{k\in\mathcal{D}} \exp\{r(z_t, k, \theta)\}} \tag{4.4.8}$$

The parameters of the model are estimated by matching moments based on the choice-specific probabilities in 4.4.8 simulated from the structural model to those observed in the data.

4.5 Data and First Stage Results

4.5.1 Data

For the estimation of the model, I use data from the Health and Retirement Study (HRS) for the years 1992 to 2008. The HRS is a longitudinal data set representative of non-institutionalized individuals over the age of 50 and their spouses. It provides extensive information on economic status -including comprehensive measures of wealth, income from work, private pensions, social security and other government transfers-; health; retirement; and demographics.

The HRS survey data can be matched to Social Security Administration (SSA) data for those respondents who gave permission to access their administrative records. I use the restricted SSA administrative data to obtain the measure of accumulated earnings used in the model, which serves to define the amount of social security pension accrued by an individual at every point in time.

The HRS contains information on 11,114 couples. Of those, I drop 1,231 couples who either marry or divorce during the sample period and 640 couples where at least one spouse receives social security disability insurance before age 62[15]. I also exclude the extremely wealthy from the sample, dropping 102 couples with more than \$1,250,000 in assets (1992 dollars).

The theoretical model presented in section 4.3 covers the main incentives for retirement of couples who do not have defined benefit pensions. For the estimation I use only couples where neither the husband nor the wife have a defined benefit pension. This reduces the sample to 6,243 couples.

When working with couples, rather than individuals, the age difference between the spouses becomes a crucial state variable. This is because couples where the husband is, say, a year older than the wife, solve a different optimization problem -in particular, they face a different intertemporal budget constraint- than couples where the husband is more or less than a year older; younger; or the same age as his wife. In the data I observe couples that are up to 30 years apart in age. In order to have a homogeneous sample, in my analysis I select only those spouses who are at most 10 years apart in age. This leaves a final sample of 5,633 couples and 32,448 couple-year observations. This sample is used to estimate the participation profiles, retirement and joint retirement frequencies, and asset profiles.

Due to computational limitations, I cannot solve and simulate the theoretical model for the whole distribution of age differences used in the estimation of profiles, i.e. from -10 to +10 years. Hence, for the estimation of the preference parameters I limit the sample to couples husband is from 0 to 5 years older than his wife. There are 3,595 such couples, that is, 64% of couples in my final sample are included within this range of age differences.

Wages are computed as annual earnings divided by hours, and are dropped if wages are less than \$3 per hour or greater than \$100 per hour in 1992 dollars. Individuals are defined as working full time if they work more than 32 hours per week and as working part time if they work between 6 and 32 hours per week. In the solution of the theoretical model, individuals working full time are assigned the median number of weekly work hours for

[15]Modelling the processes of marriage formation, divorce, and disability benefit determination is beyond the scope of this chapter. See Bergstrom (1997) and Weiss (1997) for a survey of the literature on household formation and dissolution and Buchinsky et al. (1999) for a review of the social security disability award process.

full-time workers, which is 45 hours for men and 40 hours for women. Individuals working part time are assigned the median number of weekly work hours for part-time workers, which is 20 hours for both men and women.

4.5.2 Wage process

The model of retirement presented in section 4.3 allows for individuals to work full-time, part-time and to be out of work at different points during their lifetime. No restriction is imposed on individuals' ability to go back to full-time work after spells of part-time work or full-retirement. This is done in order to accommodate the behavior of a small proportion of individuals who actually go back to work after retirement. However, the data show a considerable amount of persistence in the retirement decision. Most individuals who move into a part-time job never go back to full-time work; and most individuals who stop working never go back to work.

When matching these transitional patterns, I find that in the absence of any cost associated to switching from one work status to another, the model predicts that individuals move in and out of the labor force more often than they actually do in the data. Matching these transitions accurately, however, is crucial in the context of this chapter. In order to determine which couples are retiring jointly we need a clean measure of the retirement timing of each spouse, that is, the first period they are out of the labor force. This measure becomes very inaccurate if the simulated individuals keep switching in and out of the labor force.

In reality there are likely to be costs associated to switching work status. An individual who leaves her full-time job loses all the returns to tenure and firm-specific capital, and is unlikely to receive a comparable wage offer if she decides to go back to full-time work after a period of retirement or semi-retirement. I capture these costs in the model by assuming that individuals who work part-time or do not work at all during a period suffer a permanent wage depreciation. The different rates of wage depreciation associated to part-time work and retirement will be estimated directly from the structural model.

Therefore, I proceed as follows to estimate the wage process parameters: first, I follow the procedure outlined in chapter 3 to estimate the wage process of individuals working full-time. For the purposes of this chapter, the estimation is carried out pooling individuals with no pension or a DC pension. Estimates of the selection equation for married men aged 51 to 75 are reported in the first column of table 4.5 in appendix 3.E. Results for women are presented in the second column of the same table.

The estimates of the selection processes are used to generate inverse Mills ratios for each gender. These are included as regressors in the wage equation. Estimates for the wage equation for men and women are reported in columns 1 and 2 of table 4.6 in appendix 3.E, respectively.

The residuals from the wage regressions are used to estimate the variance of the wage shocks. Estimates for men and women are reported in table 4.1 below.

Table 4.1: Standard deviation of persistent component of wages.

	Men	Women
σ^2_ζ	0.016**	0.005**
	(0.002)	(0.001)

Finally, the rates of wage depreciation associated to part-time work and retirement are estimated from the structural model, together with the preference parameters, in section 4.6.

4.5.3 Health Expenditures

Health costs are assumed to follow the process in equation (4.3.5). The function $hc(.)$ is approximated as a polynomial on individual age.

Estimates of the polynomial coefficients are used in the dynamic programme to predict future health costs of sample individuals. In order to appropriately capture the evolution of health cost risk as individuals age, the estimation sample must include observations of health costs for individuals of all ages. However, individuals in the HRS cohort are rarely observed beyond age 75. Core[16] HRS individuals were aged 51 to 61 when interviewed for the first time in 1992, and 63 to 73 in 2004, the last year of the panel. The only way for an individual beyond age 75 to be present in the HRS cohort is if he or she is married to a younger, age-eligible spouse. Hence, in order to obtain estimates that are

[16] I denote as *core* individuals those who belong to a cohort based on their year of birth, and not just because they are married to an age-eligible spouse.

also representative of older individuals, I combine data from the HRS cohort with data from the AHEAD (Aging and Health Dynamics) cohort, which samples individuals born before 1923 and their spouses.

As explained above, I have selected from the HRS cohort only those couples where both spouses have either no private pension or a DC pension. I have no information on private pension type for AHEAD individuals. So as to obtain a comparable sample, I exclude AHEAD individuals who report to be receiving any private pension income. This eliminates from the sample those AHEAD couples where one of the spouses is receiving a DC pension. However, given the relatively recent expansion of this type of pensions, the number of such couples is unlikely to be large. On the other hand, the sample would include any AHEAD couple who were expecting to receive a DB pension in the future, but were not doing so during the sample years. Again, since AHEAD individuals are observed until they are aged 81 or over, this is unlikely to be a concern for a significant number of observations.

There are several respects in which individuals from the HRS and AHEAD cohorts may differ. An important one is pension coverage, which is more widespread in the younger cohort, especially for women. This is partly related to another important difference across cohorts: the accumulated work experience of younger women is noticeably higher than that of their older counterparts.

In the estimation of equation (.), the presence of cohort effects is accounted for by interacting all terms of the hc polynomial with cohort dummies. Time dummies are also included in the regression, in order to account for differences in the way out-of-pocket health costs are measured across waves.

Finally, I allow for changes in health costs after age 65, when all individuals become entitled to the public health insurance programme Medicare, by adding to the regressions a dummy indicating whether an individual is 65 years of age or older, and its interactions with other variables of interest.

Results of the separate regressions for men and women are shown in table 4.7 in appendix 3.E.

4.5.4 Remaining Calibrations of Exogenous Parameters

Gender-specific health transition probabilities, conditional on health status on the previous period, are calibrated to those observed in the data.

I take unconditional survival probabilities from the life table used by the US Social Security Administration[17] for the cohort born between 1930 and 1939 -the HRS sample includes individuals born from 1931 to 1941 and their spouses-. Survival probabilities conditional on health status are obtained applying Bayes' rule, separately for men and women.

$$prob(survival_t|M_{t-1} = good) = \frac{prob(M_{t-1} = good|survival_t)}{prob(M_{t-1} = good)} \times prob(survival_t),$$

where all probabilities except for the unconditional survival probability are calibrated from the data.

The means-tested consumption floor provided by transfers is set to \$633 per household, per month. This is the (means-tested) amount of Supplemental Social Security Income that a couple aged 65 or older and on income support would have received in 1992.

4.6 Estimation of Preference Parameters

4.6.1 Initial Conditions

To generate the initial conditions I take random draws from the empirical joint distribution of household assets, male and female wage fixed effects and lifetime earnings for couples where the husband is 55 to 60 years old and the wife is 0 to 5 years younger than the husband.

4.6.2 Parameter Estimates

I first estimate a version of the model where the parameters measuring the leisure complementarities (α_2^m and α_2^f) are restricted to being equal to 0. Results from this estimation

[17] "Life Tables for the United States Social Security Area 1900-2100". Social Security Administration. Office of the Chief Actuary. August 2005.

are presented in column 1 of table 4.2. The results indicate that the share of consumption in the husband's utility function, α_1^m, is considerably larger than in the wife's utility function (α_1^f).

Regarding the wage process parameters, the results indicate that husbands' and the wives' wages depreciate by almost 10% and 11%, respectively, per year working part-time. Their wages depreciate by around 20 and 22 percentage points per year spent out of work. These depreciation costs explain why most people who start working part time don't go back into full time work, and most people who stop working don't go back into work. Notice that the depreciation associated with part-time work for elderly individuals need not be as high for younger individuals, as for the former the switch from full-time into part-time work usually implies a move from their career job into a bridge job and semi-retirement.

Table 4.2: Preference and Wage Process Parameter Estimates

Parameter and definition		Specification	
		(1)	(2)
α_1^m	Consumption share, male U function	0.5102	0.5274
			(0.0061)
α_1^f	Consumption share, female U function	0.4295	0.4334
			(0.0043)
α_2	Value of shared retirement		0.0891
			(0.0079)
δ_{PT}^m	Male's wage depreciation per year working PT	0.9051	0.9258
			(0.0383)
δ_{PT}^f	Female's wage depreciation per year working PT	0.8933	0.9219
			(0.0334)
δ_R^m	Male's wage depreciation per year of retirement	0.8092	0.8609
			(0.0436)
δ_R^f	Female's wage depreciation per year of retirement	0.7795	0.7841
			(0.0336)
Value GMM criterion		0.2058	0.1404

Next, I estimate a version of the model where no restriction is imposed on the leisure complementarity parameter. Results for this estimation are presented in column 2 of table 4.2. The first noticeable point regards the differences in estimates for the parameters that are common to the previous specification. In particular, the consumption shares in both spouses's utility functions are larger, and the wage depreciation rates smaller, in the presence of leisure complementarities. This suggest that, in the restricted model, the timing of those retirement that are induced by leisure complementarities was attributed to spouses' higher taste for leisure relative to consumption and a higher cost of re-entry into the labor force after retirement.

The parameter measuring leisure complementarity is positive and significant. The estimated value of 0.891 implies that each spouse gets an extra amount of leisure equal to 9% of the leisure endowment, or 360 extra hours per year, by sharing retirement with their partner.

Figure 4.1 shows the simulated versus the true profiles for the moments I match in the estimation process. Overall, the simulated profiles appear consistent with the data. The two graphs on the top row show that the model predicts very closely total male and female participation. The graphs on the second row of Figure 4.1 compare the simulated rates of full-time and part-time participation for men and women with the actual ones. The model predicts these rates quite closely for men, although it substantially underpredicts part-time participation for women. This could be due to two things: the number of hours worked when employed part- and full-time has been set equal to the median hours worked by part- and full-time workers, respectively, for men and women. There may exist a fixed cost of work for women that does not exist (or is lower) for men. Adding this cost as a fixed number of extra hours lost when working for women would likely decrease the rate of full-time and increase the rate of part-time participation for women, increasing the overall fit. Another possibility is that the part-time wage premium, which has been set equal to 25% for both men and women is actually lower for women. A lower part-time wage premium would also lead women to choose to work part-time more frequently.

The graph on the left of the third row of figure 4.1 shows the retirement age distribution for men between ages 55 and 69. The graph on the right is the equivalent for women. The model captures the spikes at ages 62 and 65 for both men and women, but it substantially overpredicts retirements for both sexes at age 65. One possible reason for this is that the estimated version of the model does not account for the role of health. If bad health increases the cost of work, it can lead to earlier retirements for some individuals.

Finally, the graph on the last row of figure 4.1 shows the distribution of differences in retirement dates between husbands and wives. The bar at the center of the histogram measures the proportion of couples where the husband retires within a year of his wife, i.e. the *joint* retirements. The model does a good job of predicting the proportion of joint retirements. However, it underpredicts the proportion of couples where the husband retires at an earlier date than the wife, while it overpredicts that of couples where the wife is the first to retire.

4.6.3 The Role of Complementarities

To offer a sense of the importance of complementarities in determining joint retirements, I experiment with the following changes to the model. First, I restrict the complementarity parameter to being equal to 0. Results from this experiment are shown on the third series in figure 4.2. Taking away the extra value that spouses get from sharing their retirement decreases predicted joint retirements by 3.77 percentage points. Next, I change the social security function and eliminate the spousal benefit, which gives the spouse with the lower lifetime earnings (usually the wife) the right to supplement her pension until her benefits are equal to up to a half those of her husband. In this case, the predicted percentage of joint retirements decreases by a further 5.42 percentage points.

These experiments suggest that, while leisure complementarities play an important role in leading spouses to retire together, the effect of the social security spousal benefit leads to an even larger share of joint retirement.

Another point worth mentioning in relation to figure 4.2 is that both eliminating the leisure complementarities and the spousal benefit leads to an increase in the proportion of couples where the husband retires earlier than the wife. This suggests that both incentives for joint retirement act by either anticipating the retirement of the wives or delaying the retirement of the husbands.

4.7 Conclusions

In this chapter, I present a stochastic dynamic model of older couples' participation and savings decisions.

The model accounts in a detailed way for the main financial incentives and sources of

Figure 4.1: Simulated Profiles vs. True Profiles.

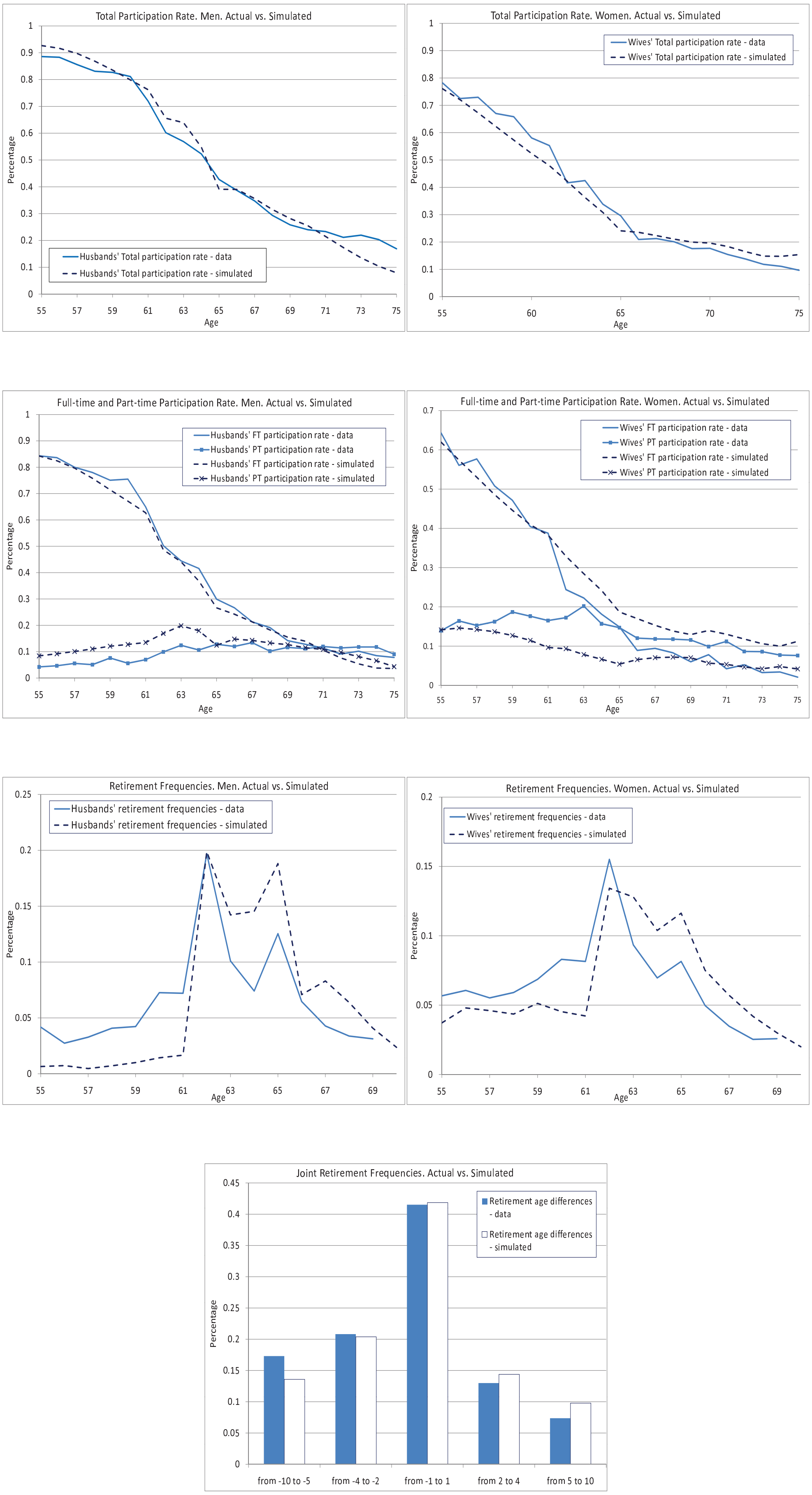
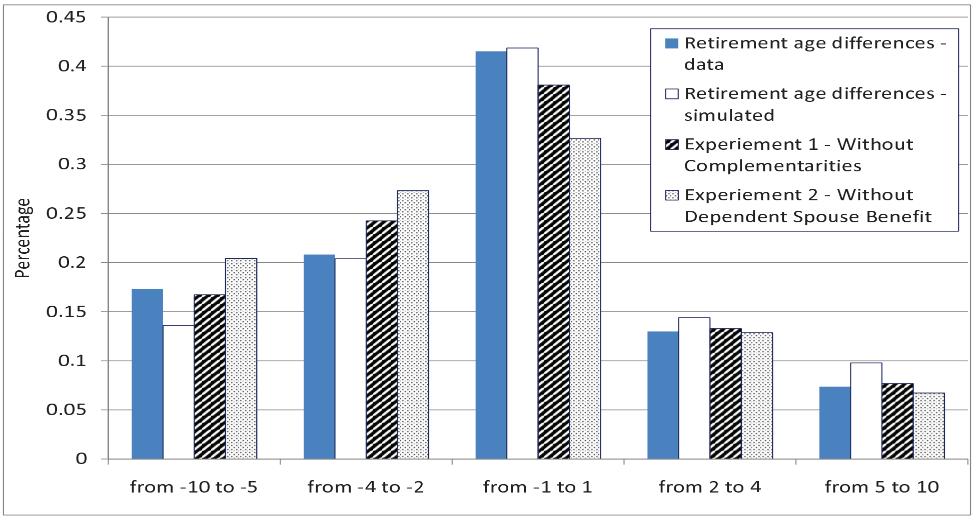


Figure 4.2: Joint Retirement Frequencies. Data, Simulation, and Experiments.



uncertainty for couples approaching retirement. Couples are heterogeneous in household wealth, wages and lifetime earnings. They face uncertainty in wage income, survival, and out-of-pocket medical expenditures.

The model allows for interactions in spouses' leisure. In particular, spouses may enjoy retirement more (complementarity) or less (substitutability) when their partner is retired too.

Estimation results show evidence of leisure complementarities. When both partners are retired, each one enjoys an extra amount of leisure equal to 9% of the leisure endowment, or 360 hours per year.

The model shows the importance of accurately accounting for incentives to joint retirement acting through the budget constraint in order to accurately estimate the role of complementarities. The social security dependent spouse benefit alone is responsible for almost twice as many joint retirements as the existence of leisure complementarities. These retirements would likely be attributed to complementarities in a framework where the role of social security was not appropriately modeled.

4.8 Appendix 3.A. Mathematical Appendix

Computation of the integral with respect to out-of-pocket medical expenditures.

In order to solve period t's problem, we need an approximation to the expected value of V_{t+1}. This expected value is taken with respect to health status in $t+1$, survival into $t+1$, health costs in period t[18] and, when the husband is younger than 75 and/or the wife younger than 70, wages in period $t+1$. In this section I describe the steps involved in the computation of the expected value with respect to health costs.

$$E_{hc^m,hc^f}\widehat{V}_{t+1}(z_{t+1}, x_{t+1} \mid z_t, x_t) \tag{4.8.1}$$

Recall that the probability that health costs are positive, and the logarithm of health costs have been modeled as follows:

$$p(hc_{it} > 0) = p^1_{it} = X_{it}\beta_1 + \psi^1_{it}$$

$$\begin{aligned} \ln hc_{it} &= X_{it}\beta_2 + \psi^2_{it}, \\ \psi^2_{it} &\sim N(0, \sigma^2_{\psi^2}) \end{aligned}$$

Hence the positive health costs are lognormally distributed:

$$hc_{it} \mid X_{it} \sim \log N(X_{it}\widehat{\beta}^2, \widehat{\sigma}^2_{\psi^2})$$

Omitting the conditioning on the state variables that are not relevant to the solution of this integral, (A1) can be re-written as follows:

[18] It is assumed that the realisation of the medical cost draw happens at the end of the period, after households have made their consumption and work decisions.

$$E_{hc^m,hc^f}\widehat{V}_{t+1}(z_{t+1},x_{t+1}\mid z_t,x_t)=$$
$$+(1-p_{it}^{1,m})\times(1-p_{it}^{1,f})\times\widehat{V}_{t+1}(hc_{it}^m=0,hc_{it}^f=0)+$$
$$+(1-p_{it}^{1,m})\times p_{it}^{1,f}\times\int_0^\infty\widehat{V}_{t+1}(hc_{it}^m=0,hc_{it}^f)f(hc_{it}^f\mid X_{it})dhc^f+$$
$$+p_{it}^{1,m}\times(1-p_{it}^{1,f})\times\int_0^\infty\widehat{V}_{t+1}(hc_{it}^m,hc_{it}^f=0)f(hc_{it}^m\mid X_{it})dhc^m+$$
$$+p_{it}^{1,m}\times p_{it}^{1,f}\times\int_0^\infty\int_0^\infty\widehat{V}_{t+1}(hc_{it}^m,hc_{it}^f)f(hc_{it}^m\mid X_{it})f(hc_{it}^f\mid X_{it})dhc^m dhc^f.$$

Below I describe in detail the computation of the integral with respect to the husband's health costs. The value of the integral with respect to the wife's health costs is computed in a symmetric way, while the double integral is solved using a two-dimensional Gauss-Hermite integration rule.

Define K as:

$$K\equiv\int_0^{+\infty}\widehat{V}_{t+1}(hc_{it}^m)f(hc_{it}^m\mid X_{it})dhc^m$$

Since hc_{it}^m is lognormally distributed,

$$K=\int_0^{+\infty}\widehat{V}_{t+1}(hc_t^m)\frac{1}{hc_{it}^m\widehat{\sigma}_{\psi^2}^m\,(2\pi)^{1/2}}\exp\left\{-\left(\frac{\ln hc_t^m-X_{it}\widehat{\beta}_2^m}{2^{1/2}\widehat{\sigma}_{\psi^2}^m}\right)^2\right\}dhc^m$$

Using the following change of variable,

$$z_{it}=\frac{\ln hc_{it}^m-X_{it}\widehat{\beta}_2^m}{2^{1/2}\widehat{\sigma}_{\psi^2}^m},$$

yields

$$K\equiv\int_{-\infty}^{+\infty}\widehat{V}_{t+1}\left(\exp\{2^{\frac{1}{2}}\widehat{\sigma}_{\psi^2}^m z_{it}+X_{it}\widehat{\beta}_m^2\}\right)\frac{1}{\pi^{1/2}}\exp\left\{-z_{it}^2\right\}dz_1$$

The value of K is approximated using Gauss-Hermite quadrature.

$$K \approx \frac{1}{\pi^{1/2}} \sum_{j=1}^{P} \widehat{V}_{t+1} \left(\exp\{2^{1/2} \widehat{\sigma}^{m}_{\psi^2} \xi_j + X_{it} \widehat{\beta}^{2}_{m}\} \right) \omega_j,$$

where $\{\xi_j, \omega_j\}_{j=1}^{P}$ are the abscissae and weights of a one-dimensional Gauss-Hermite integration rule with P points, which can be found in standard references (e.g. Abramowitz and Stegun, 1964).

4.9 Appendix 3.B. Social Security function

Individual benefits

Benefits depend on indexed lifetime earnings. For each year of work, there is a maximum amount of earnings, from which payroll tax is deducted, which will contribute to the pension. E_t is the measure of lifetime earnings used in the model:

$$E_t \equiv \begin{cases} \sum_{j=0}^{t} \omega_j e_j^* & \text{if} \quad t \leq R \\ \sum_{j=0}^{R} \omega_j e_j^* & \text{if} \quad t > R \end{cases},$$

where $t = 0$ is the first year of earnings, R is the first year of receipt of Social Security benefits (subject to the restriction $R \geq 62$), ω is the weight used by the Social Security administration to index yearly earning, and e_t^* is defined as the minimum between yearly earnings $e_t = w_t \times h_t$ and maximum taxable earnings for that year, $e_t^{\max}$:

$$e_t^* = \min\{e_t,\ e_t^{\max}\}.$$

In order to avoid the need to keep track of every individual's whole earnings history, Average Indexed Monthly Earnings ($AIME_t$) are approximated as a function of E_t as follows:

$$AIME_t = \frac{E_t}{12 \times \max\{(t-25), 35\}}$$

Full retirement entitlement, also known as Primary Insurance Amount (PIA_t) is obtained from $AIME$ according to the Social Security formula, re-scaled by the weight κ :

$$\begin{aligned} PIA_t &= \kappa_t \left[0.90 \times \min\{AIME_t,\ b_0\} + 0.32 \times \min\{\max\{AIME_t - b_0, 0\},\ b_1 - b_0\} + \right. \\ &\left. +0.15 \times \max\{AIME_t - b_1,\ 0\}\right], \end{aligned}$$

where κ_t is calibrated to give an individual retiring at each possible age with the maximum possible accumulated earnings exactly the same pension she would have been awarded under the 1992 Social Security rules[19]. The bendpoints for the year 1992 are $b_0 = \$387$ and $b_1 = \$2,333$.

Benefit entitlement is determined as a function of the PIA in the period in which an individual claims benefits, PIA_R:

$$ssb_t = f(PIA_R, age_t, w_t h_t),$$

where f accounts for the actuarial adjustments for individuals who claim benefits before or after age 65, and the earnings test.

Benefits lost through the earnings test translate into increases in future benefits. This is captured in the model through increases in the value of PIA_R.

Spouses and Widowed individuals

In periods when both spouses are claiming benefits, the spouse with lowest PIA receives benefits ssb_t equal to the highest amount between her individual entitlement and entitlement based on 50% of her partners' PIA.

Individuals who become widowed can claim benefits based on their individual entitlement or that of their deceased partner.

[19]The Social Security benefit approximation just described yields a very accurate fit for individuals with the highest possible pensions. Consequently, the highest weight used in the model is equal to 1.0517, and the lowest to 0.9915.

4.10 Appendix 3.C. Taxes

This section describes the tax function applied to couples' income in the model. Households pay federal and payroll taxes on income. Due to the great cross-sectional variation in state taxes, those are not accounted for here. I used the rates applying to married couples filing jointly. Also, I use the standard deduction, and hence do not allow households to defer medical expenses as an itemized deduction. The tax rates and exempt amounts used below are those corresponding to the year 1992.

Payroll Tax

The payroll tax is a proportional tax imposed on employees, which is used to finance the Social Security's OASDI programme and Medicare's hospital insurance programme. The social security tax rate for employees is 6.2% of earnings up to an upper limit of \$55,500. The Medicare tax rate for employees is 1.45% of earnings, and it is uncapped.

Defining individual annual earned income as

$$e_t^i \equiv w_t^i \times h_t^i, \quad \text{for } i = m, f,$$

each spouses' payroll tax contribution is given by:

$$\tau^P e_t^i = (0.062) \times \min\{\$55,500, e_t^i\} + 0.0145 \times e_t^i, \text{ for } i = m, f$$

Federal Income Tax

The income tax is a progressive tax on labor and nonlabor income. The standard deduction for a married couple filing jointly was \$6,000 in 1992. Additionally, each spouse was entitled to a further deduction of \$700 if aged 65 or over.

Defining household income subject to federal income tax as

$$I_t \equiv (1 - \tau^P)e_t^m + (1 - \tau^P)e_t^f + rA_t,$$

generates the following level of post-income tax for a couple where both spouses are below age 65:

Table 4.3: Federal Income Tax Structure

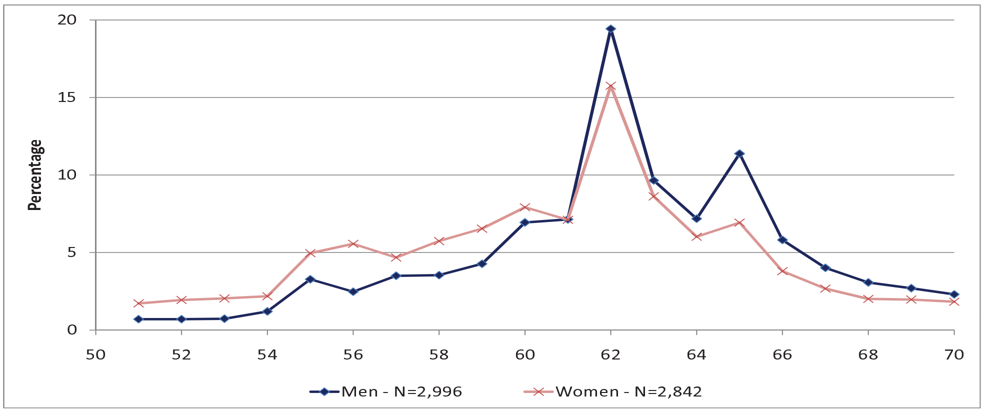
Taxable income (I) (in dollars)	Post-tax Income (in dollars)	Marginal rate
$0 - 6,000$	Y	0.00
$6,000 - 41,800$	6,000 + 0.85(Y-6,000)	0.15
$41,800 - 92,500$	36,430 + 0.72(Y-41,800)	0.28
$92,500$ and over	72,934 + 0.69(Y-92,500)	0.31

Denoting the federal income tax structure by the vector τ^I, households' post-tax income is given by:

$$Y(rA_t, e_t^m, e_t^f, \tau^P, \tau^I) = (1 - \tau^I)I_t$$

4.11 Appendix 3.D. Figures

Figure 4.3: Retirement frequencies for married men and women at ages 51 to 70.



Retirement frequency at age j defined as the proportion of all retirements observed between ages 51 and 70 that takes place at age j.

Figure 4.4: Differences in spouses' retirement dates as a function of age difference between them.

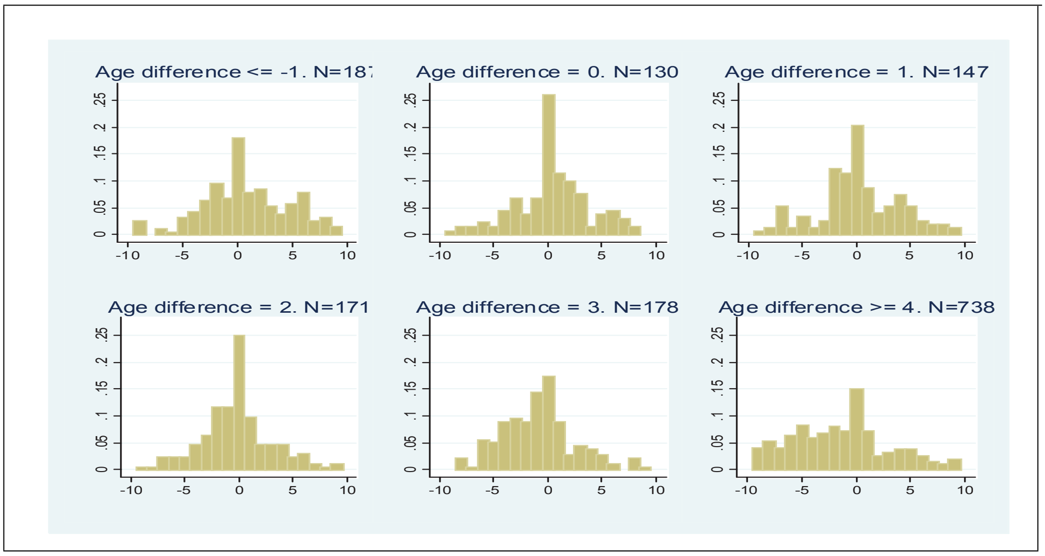


Figure 4.5: Comparison of actual and assumed Social Security claiming date. Men.

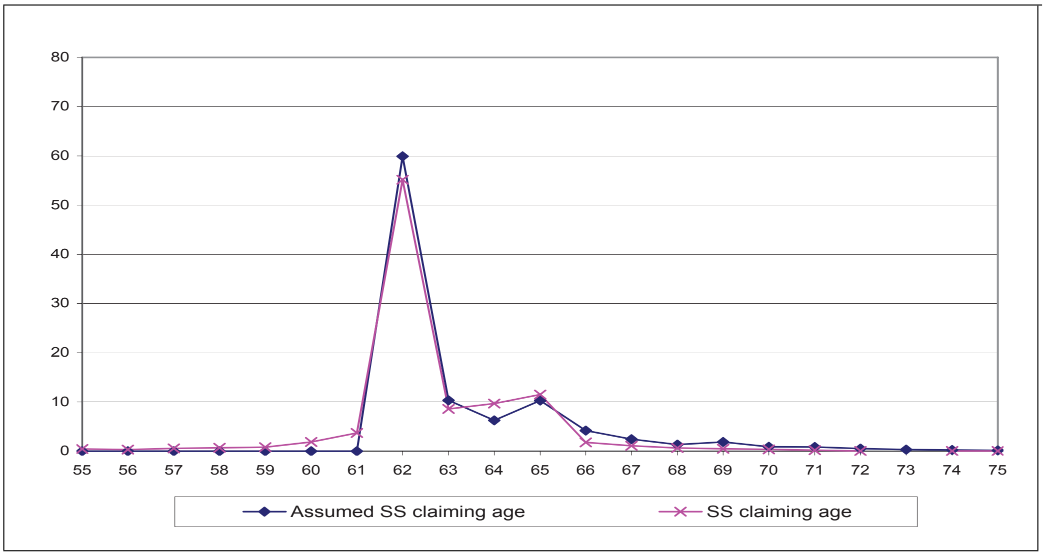


Figure 4.6: Comparison of actual and assumed Social Security claiming date. Women.

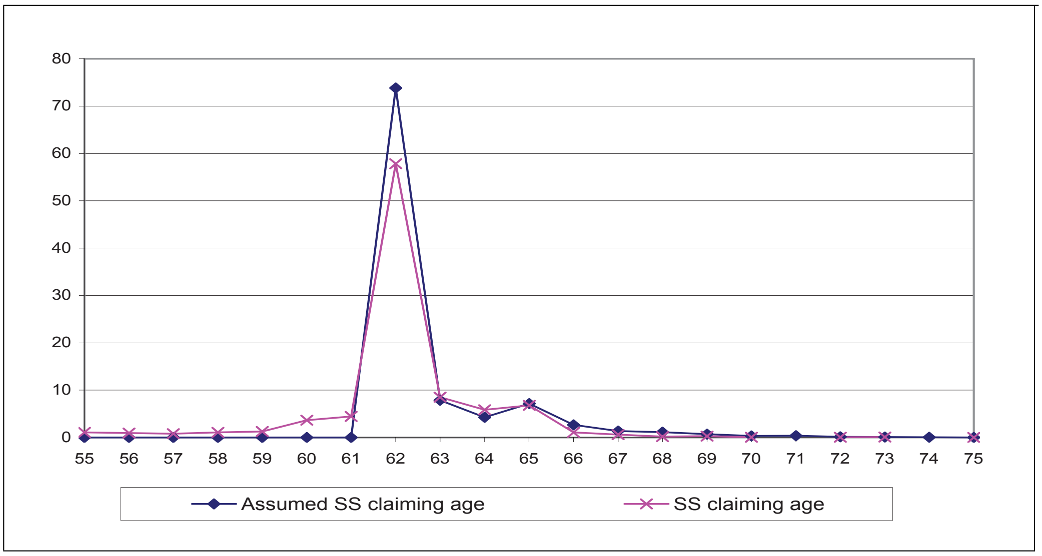


Figure 4.7: Retirement frequencies by pension type. Men.

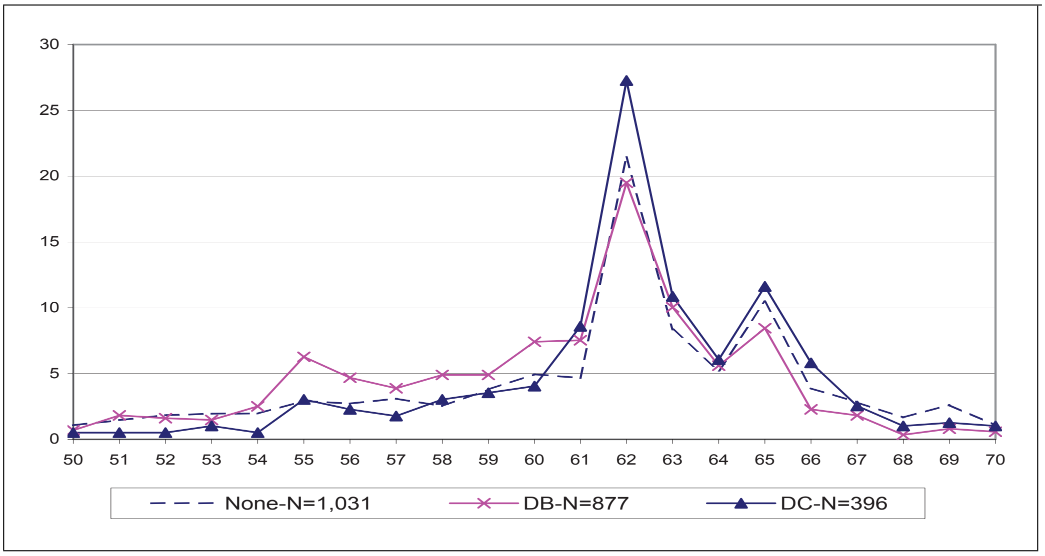
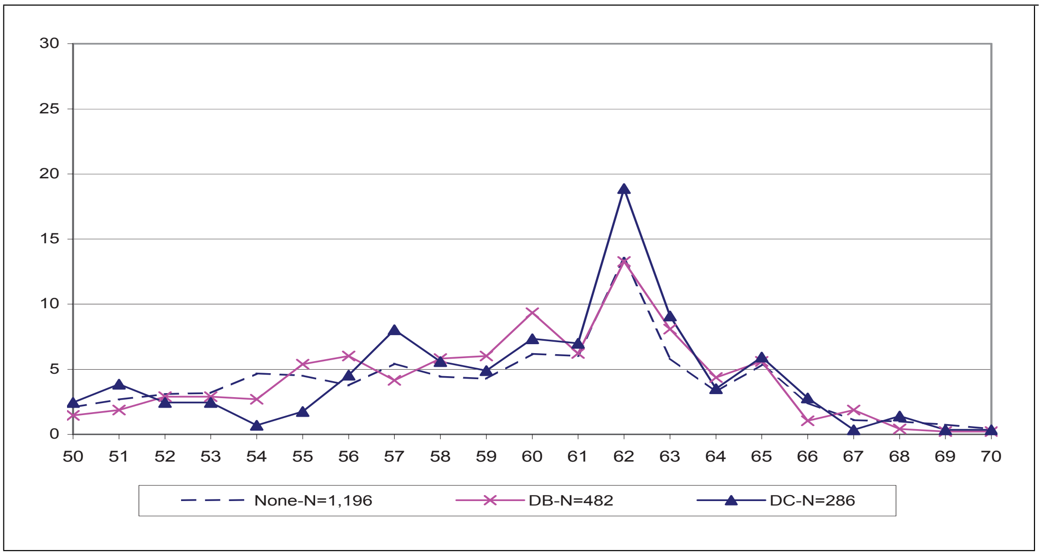


Figure 4.8: Retirement frequencies by pension type. Women.



4.12 Appendix 3.E. Tables

Table 4.4: Descriptive statistics by pension type.

	Men			Women		
	None	DC only	DB only	None	DC only	DB only
Percentage population [1]	39.59	27.24	14.34	52.23	18.39	12.08
Employment						
% working at age 61	76.89	60.70	77.68	44.27	56.83	62.58
Average log wage in 1992 dollars [2]	2.29	2.56	2.56	1.98	2.39	2.28
	(0.84)	(0.62)	(0.66)	(0.71)	(0.59)	(0.47)
Health insurance						
% with retiree health coverage [3]	10.67	32.25	27.22	7.13	31.75	19.43
% with tied health coverage [3]	5.83	11.87	20.56	5.12	16.74	17.88
% with no empl. health insurance [3]	51.23	22.39	27.78	66.92	33.91	44.59
Median health costs per period	293.34	301.17	304.03	417.23	416.52	365.96
Average health costs per period	961.11	876.20	777.21	1,202.55	1,065.71	919.15
	(3,883)	(2,706)	(1,816)	(4,502)	(3,415)	(2,404)
Health Status						
% in bad health	25.67	19.48	17.74	23.59	16.00	12.96
Total wealth in 1992 dollars [4]						
Median	113,000	127,500	127,000	110,000	148,000	142,750
25^{th} percentile	41,000	65,550	63,648	44,000	75,500	72,925
Financial wealth in 1992 dollars [5]						
Median	50,000	60,450	71,000	48,200	82,000	82,575
25^{th} percentile	8,200	19,000	19,200	9,800	24,400	25,000
Demographics						
Average age	62.81	62.73	61.68	58.36	58.51	57.68
% College education	35.30	36.04	41.30	27.54	46.06	38.59
% High-School graduates	33.32	40.97	36.02	42.84	40.46	47.09
N (couple-year observations)	10,031	6,903	3,634	13,234	4,661	3,060

NOTE. - [1] Percentages do not sum to 100 because of individuals for whom it is not possible to derive pension type. [2] For participating individuals only. [3] Percentage measured with respect of individuals who report type of health insurance. Due to concerns about the measurement of health insurance type in the first two waves, reported figures correspond to wave 3. [4] Wealth measure includes housing but excludes private pension holdings. [5]Includes value of checking and saving accounts, stocks, mutual funds, investment trusts, CD's, Government bonds, Treasury bills and all other savings minus the value of debts such as credit card balances, life insurance policy loans or loans from relatives. It does not include housing wealth or private pension holdings.

Table 4.5: Estimates of selection equation for married men and women.

	Men	Women
$\text{age}_{rt}/10$	-0.453	0.052
	(0.543)	(0.677)
$\text{age}^2_{rt}/100$	-0.035	-0.080
	(0.045)	(0.059)
d62_{rt}	-0.309**	-0.231**
	(0.043)	(0.053)
d65_{rt}	-0.258**	-0.135
	(0.053)	(0.074)
bad_h_{rt}	-0.206**	-0.157**
	(0.047)	(0.056)
wealth_{rt} \$(0000)	-0.004**	-0.003**
	(0.001)	(0.001)
d62_{st}	-0.127**	-0.014
	(0.038)	(0.034)
DB_{st}	0.003	-0.103*
	(0.040)	(0.042)
edu1_r	-0.219**	0.189**
	(0.038)	(0.042)
$\text{edu1}_r \times \text{DC}_r$	0.574**	0.661**
	(0.048)	(0.052)
edu2_r	-0.120**	-0.082*
	(0.036)	(0.039)
$\text{edu2}_r \times \text{DC}_r$	0.498**	0.878**
	(0.049)	(0.047)
$\overline{\text{age}}_r$	0.972	1.875**
	(0.513)	(0.457)
$\overline{\text{age}}^2_r$	-0.080*	-0.135**
	(0.041)	(0.039)
$\overline{\text{bad\_h}_r}$	-0.434**	-0.325**
	(0.062)	(0.072)
$\overline{\text{wealth}}_r$ (\$0000)	0.000	-0.003**
	(0.001)	(0.001)
mother_educ_r	0.027*	-0.045**
	(0.012)	(0.014)
constant	1.369	-4.422*
	(1.844)	(1.907)
N	17,139	18,312

NOTE. - Robust standard errors in parentheses. * indicates the coefficient is significant at 5%. ** indicates significance at 1%. Both regressions include year and cohort dummies and a measure of the unemployment rate at period t for men/women aged 55 and older in order to control for economy-wide effects. Dummies of the form dage_j are equal to 1 if the individual is older than age_j. Dummies of the form dage_j^{sp} are equal to 1 if the spouse is older than age_j. The dummy bad_h is equal to 1 if the individual is in fair or poor health. The dummies redu1 and redu2 indicate whether the individual has at least some college or is a high school graduate, respectively.

Table 4.6: Estimates of wage equation for married men and women.

	Dependent variable: $\ln w_{rt}$	
	Men	Women
age_{it}	2.234**	1.435*
	(0.560)	(0.642)
$age_{it}^2/100$	-0.216**	-0.136*
	(0.053)	(0.064)
bad_h_{it}	-0.061*	-0.049
	(0.028)	(0.032)
$edu1_i$	0.222**	0.438**
	(0.037)	(0.050)
$edu1_{it}\times$ DC	0.303**	0.212*
	(0.059)	(0.097)
$edu2_i$	0.075*	0.093*
	(0.034)	(0.044)
$edu2_{it}\times$ DC	0.200**	0.348**
	(0.056)	(0.116)
$\overline{age}_{it}$	0.009	-0.213
	(0.377)	(0.415)
$\overline{age}_{it}^2/100$	-0.010	0.009
	(0.030)	(0.034)
$\overline{bad\_h}_{it}$	-0.313**	-0.231**
	(0.050)	(0.063)
$\overline{wealth}_{it}$	0.003**	0.002**
	(0.000)	(0.001)
mother_educ$_r$	0.060**	0.001
	(0.011)	(0.014)
$\widehat{\lambda}_{it}^0$	0.401**	0.347*
	(0.105)	(0.172)
$\widehat{\lambda}_{it}^{DC}$	0.107**	0.108**
	(0.040)	(0.037)
constant	-3.490	-1.410
	(1.796)	(2.208)
N	6,218	3,663
R^2	0.273	0.378

NOTE. - Standard errors (in parenthesis) obtained from 2,500 bootstrap replications, accounting for estimation of inverse Mills ratios in first stage. * indicates the coefficient is significant at 5%. ** indicates significance at 1%. The regressions include year and cohort dummies and a measure of the unemployment rate at period t for men/women aged 55 and older in order to control for economy-wide effects. Dummies of the form dage_j are equal to 1 if the individual is older than age_j. The dummy bad_h is equal to 1 if the individual is in fair or poor health. The dummies redu1 and redu2 indicate whether the individual has at least some college or is a high school graduate, respectively.

Table 4.7: Estimates of parameters from health cost process.

	pr($hc_t > 100$)	Dependent variable: $\ln hc_t$
$\text{age}_{ht}/10$	-1.341	0.935*
	(0.809)	(0.458)
$\text{age}^2_{ht}/100$	0.099	-0.068
	(0.062)	(0.035)
$\text{age}_{wt}/10$	1.383**	0.363*
	(0.199)	(0.157)
$\text{age}^2_{wt}/100$	-0.102**	-0.021
	(0.017)	(0.013)
bad_h_{ht}	-0.023	0.216**
	(0.043)	(0.025)
bad_h_{wt}	-0.080	0.276**
	(0.046)	(0.028)
w2	-0.145*	0.003
	(0.074)	(0.046)
w3	0.254**	0.422**
	(0.078)	(0.046)
w4	0.091	0.283**
	(0.076)	(0.044)
w5	0.067	0.402**
	(0.079)	(0.045)
w6	0.174*	0.633**
	(0.085)	(0.047)
w7	0.248**	0.738**
	(0.090)	(0.050)
w8	0.360**	0.613**
	(0.100)	(0.052)
c1	-0.535**	-0.361**
	(0.087)	(0.055)
c2	0.061	-0.115*
	(0.091)	(0.046)
c4	0.039	-0.068
	(0.070)	(0.037)
c5	-0.014	-0.038
	(0.130)	(0.064)
constant	1.438	2.538
	(2.554)	(1.413)
σ_ψ		1.086
		(0.07302)
N	13,609	12,776

NOTE. - Robust standard errors in parentheses. Standard error for the estimate of σ_ψ obtained from 2,500 bootstrap replications. * indicates the coefficient is significant at 5%. ** indicates significance at 1%.

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